

AD-A054 648

NAVAL MEDICAL RESEARCH INST BETHESDA MD  
MANAGEMENT OF WAR INJURIES TO THE JAWS AND RELATED STRUCTURES.(U)  
APR 78 J F KELLY, P W CONNOLE, W R HIATT

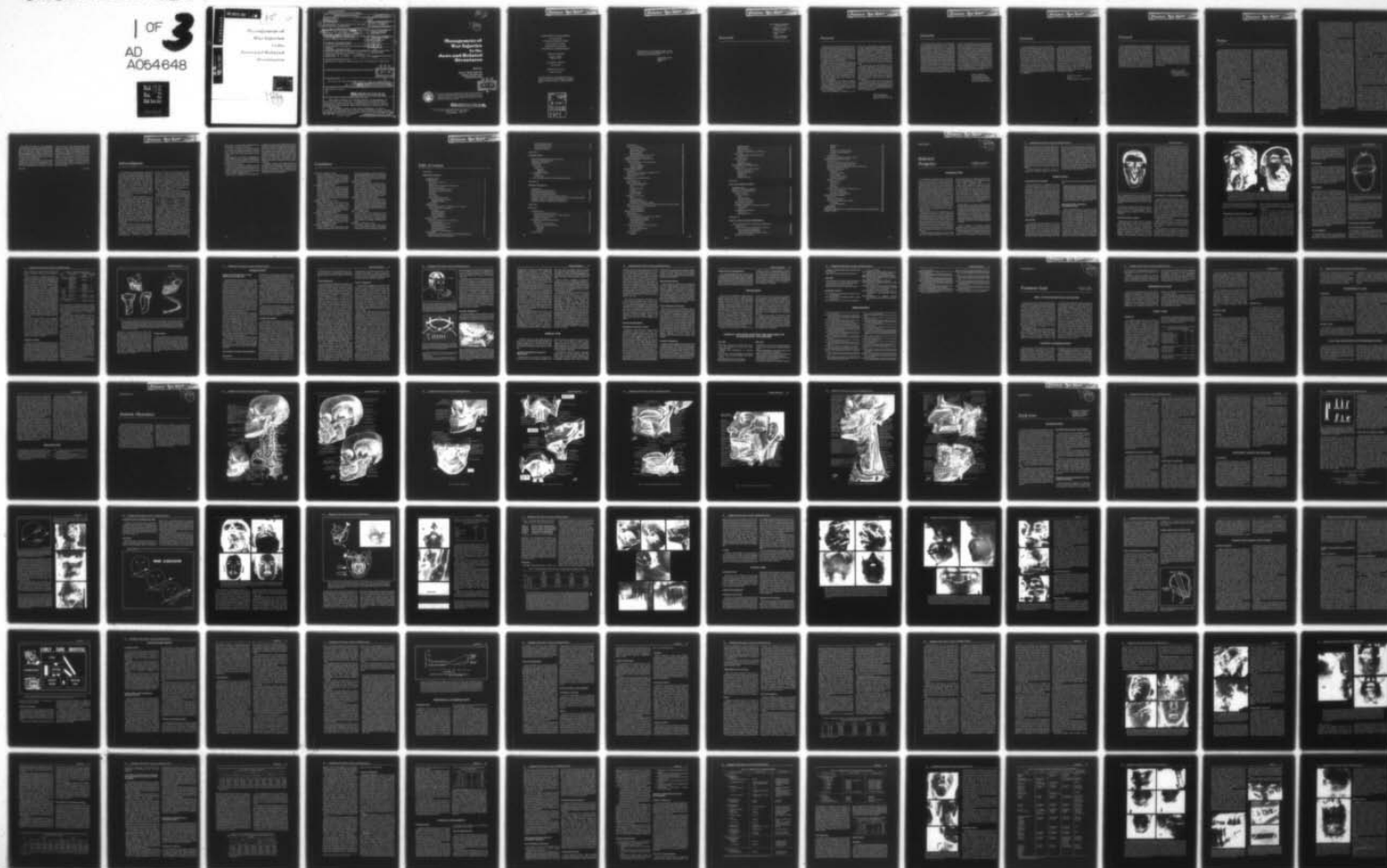
F/G 6/21

UNCLASSIFIED

NMRI-78-23

NL

1 OF 3  
AD  
A054648







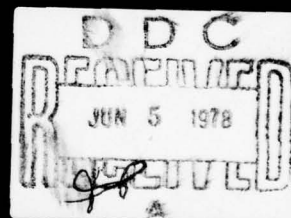
AD A 054648

AD NO. \_\_\_\_\_  
DDC FILE COPY

FOR FURTHER TRAN *alt*

**Management of  
War Injuries**

**To The  
Jaws and Related  
Structures**



UNCLASSIFIED

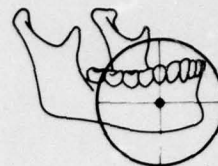
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) NMRI-78-23	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER (9)
4. TITLE (and Subtitle) (6) MANAGEMENT OF WAR INJURIES TO THE JAWS AND RELATED STRUCTURES.		5. TYPE OF REPORT & PERIOD COVERED Medical Research Progress Report.
6. PERFORMING ORG. REPORT NUMBER		7. CONTRACT OR GRANT NUMBER(s) (16) M0095PN
8. AUTHOR(s) James F. Kelly, <del>Robert</del> Peter W. Connole, W. Robert Hiatt, Elgene G. Mainous, Eugene J. Messer, Henry J. Sazima, Thomas E. Stump, Bill C. Terry and Robert G. Triplett		9. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS M0095PN 001-0032 Report No. 5 63706N
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Medical Research Institute Bethesda, Maryland 20014		10. REPORT DATE (17) Apr 1978
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research and Development Command Bethesda, Maryland 20014		12. NUMBER OF PAGES 320
13. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Bureau of Medicine & Surgery Department of the Navy Washington, D. C. 20372 (12) 282p.		14. SECURITY CLASS. (of this report) UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release and sale; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) D D C RECEIVED JUN 5 1978 RECEIVED		
18. SUPPLEMENTARY NOTES A For sale by the Superintendent of Documents. Stock no. 008-045-00018-6 \$12.00 (21) ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Maxillofacial injuries War Jaw ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This book presents the salient aspects of management of maxillofacial war injuries. A historical overview of these injuries is presented to place maxillofacial surgical care in perspective and includes the allied experience from World War I through Korea. The treatment goals in the total management of these injuries are outlined from initial care following injury through		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE  
S/N 0102-LF-014-6601UNCLASSIFIED 249 650  
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) RB

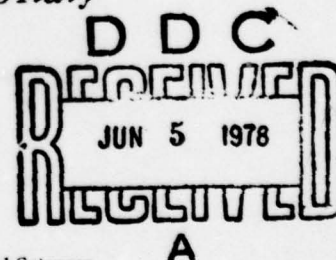
2 2



# Management of War Injuries To The Jaws and Related Structures

Edited by

James F. Kelly, DDS, MS  
Captain, Dental Corps  
United States Navy



This textbook was prepared and published under the auspices of the Dental Sciences Department, Naval Medical Research Institute, Bureau of Medicine and Surgery, Department of the Navy, USA. The opinions and assertions in this publication are those of the authors and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

**ORIGINAL CONTAINS COLOR PLATES: ALL DDC  
REPRODUCTIONS WILL BE IN BLACK AND WHITE**

For sale by the Superintendent of Documents, U.S. Government Printing Office  
Washington, D.C. 20402  
Stock No. 008-045-00018-6

\$12.00



NOT  
Preceding Page BLANK - FILMED

MANAGEMENT OF WAR INJURIES  
TO THE JAWS  
AND RELATED STRUCTURES  
with an appendix entitled  
RESEARCH IN ACQUIRED  
CRANIOFACIAL DISFIGUREMENT

ASSISTANT EDITOR

Robert G. Triplett  
CDR DC USN

TECHNICAL EDITOR

Doris Chaney

SECRETARIAL STAFF

Shirley J. Starnes

Financial support for this publication was provided in part by the National Institute of Dental Research, National Institutes of Health, (DHEW), USA.

ACCESSION for	
NTIS	Write Section <input checked="" type="checkbox"/>
DDP	Text Section <input type="checkbox"/>
UNAN	<input type="checkbox"/>
J. \$ 12.00	
BY	
DISTRIBUTION/AVAILABILITY CODES	
Dist.	AVAIL. and/or SPECIAL
A	24

NOT  
Preceding Page BLANK - FILMED

But always in our ears ring the ominous words  
of Plato, that wisest of all philosophers, "only the  
dead have seen the last of war!"

Douglas MacArthur  
*Reminiscences*  
1964



NOT  
Preceding Page BLANK - FILMED

By WILLARD P. ARENTZEN  
VADM MC USN

ROBERT W. ELLIOTT, JR.  
RADM DC USN

DAVID B. SCOTT  
DDS

CHARLES E. BRODINE  
CAPT MC USN

## *Forewords*

---

## Foreword

---

During war and its aftermath, treatment of the wounded soldier has always assumed, for a transient time, a preeminent position in the literature of trauma. But as the harsh memories of war fade, the medical lessons learned in conflict and the insights briefly gained are often forgotten. Valid treatment modalities are lost to future generations of combat surgeons and are irretrievable for application on new battlefields.

Equally serious are the false perceptions of therapeutic effectiveness that arise as the shifting theaters of war cause a wide dispersal in time and place between the beginning and the end of a curative effort. How often have combat surgeons wondered about the effectiveness of a treatment regimen whose results can only be evaluated in a clinical setting far from the original source of care? Unfortunately, many impressions of treatment efficacy fail to survive the broader perspective of hindsight.

An estimated 10% to 15% of all war wounds involve the highly functional and anatomically complex maxillofacial area. In this book, an outstanding group of Navy oral surgeons offer what may well represent the definitive study of treatment of maxillofacial injuries.

Here the principles of treatment are enu-

merated in a well designed, evaluative prospective study. Beginning with the battlefield injury, the authors follow patients through the early and intermediate phases of treatment; ultimately, definitive therapy is carefully and fully integrated with investigations in bone transplantation and soft tissue reconstruction. The underlying principles evolved in this discussion fully recognize the certitude that even the earliest efforts must respect the next step in the therapy cycle.

The authors also stress the importance of administrative planning to ensure that treatment is provided under the best possible circumstances. Precise personnel planning and organization of treatment facilities are essential and are discussed in some detail here. So are the organization of patient evacuation systems, prompt dispersal of patients, and recall and evaluation mechanisms.

A well-trained surgical team, aware of the lessons learned in previous wars and supported by administrative programs functioning at top efficiency, can achieve an unchallengeable level of professionalism. The result is the end all healers seek: better patient care.

Willard P. Arentzen  
Vice Admiral MC USN  
Surgeon General of the Navy

## Foreword

---

All who have been exposed to the experiences of war appreciate the pathos of the wounded. Those who are in a position to treat war casualties and assist them in their return to a happy and productive life are faced with a demanding, but often rewarding, challenge. This is particularly true in relation to the management of the orally injured as they present complex problems of dental and medical rehabilitation that greatly influence the functional and psychological integrity of the afflicted individual. The dental officers who have authored this text recognized the need to analyze and document the results of oral-facial casualty care in order to assure that the results of their experiences would be passed on to future generations of clinicians in a meaningful format. They have prepared a publication that not only

narrates and critically reviews treatment modalities but also addresses the numerous war-related factors that influence the care of the battle casualty. Of particular note is the repeated emphasis on the necessity for inter-professional cooperation to assure optimal long-term results. Both medical and dental clinicians contributed to the treatment results illustrated in the text, thus corroborating the desirability of coordinated, harmonious patient management. It is hoped that this book will serve as a valuable reference source for both battle casualty and civilian oral-facial trauma management and will exemplify the positive contributions that can be made under the auspices of federal health care organizations even in the negative environment of war.

Robert W. Elliott, Jr.  
Rear Admiral DC USN  
Assistant Chief for Dentistry  
and Chief, Dental Division  
Bureau of Medicine & Surgery



## Foreword

---

Acquired disfigurement of the craniofacial region has received little attention by the research community. Even though the resources devoted to the care of the afflicted are extensive, trauma has been called the "neglected disease" of modern society. The causes for maxillofacial trauma are many and produce a broad range of injuries. Thus preventive and treatment measures require many different approaches and critical study.

In recent years the National Institutes of Health have recognized the need for more research focused on this health problem. Similarly, the advancement of basic research knowledge must be accompanied by a commitment to narrow the gap between scientific discovery and clinical application.

The National Institute of Dental Research is pleased to cooperate with the Naval Medical Research Institute, Department of the Navy, in the publication of this book in order to make available to the clinician and clinical researcher the knowledge gained from the treatment of casualties. This superb documentation of acute and longitudinal care of maxillofacial injuries should contribute significantly to the treatment of millions of citizens who will suffer from physical impairment due to trauma. Additionally, it is hoped that basic scientists will identify clinically applicable questions which can be addressed through their studies, and a chapter on this subject has been included.

David B. Scott, D.D.S.  
Director  
National Institute of Dental Research

## Foreword

---

Severe maxillofacial injury is terribly damaging to the victim's functional and psychological integrity. Under the best circumstances, satisfactory management of such injuries requires careful coordination of early treatment through late reconstructive surgery and a high degree of inter-professional cooperation among medical, dental and surgical specialists. Provision of similar care to combat casualties is an even greater challenge. The structure of the military casualty management system, i.e., successive echelons of evacuation and treatment, requires that utmost attention be paid to the patient's status at each

and every stage. This book fulfills an essential need in that it prescribes procedures for the inter-echelon coordination so essential to optimal care of maxillofacial injuries. The book stands as a testimony to the wisdom and foresight of those individuals who initiated the long-term study more than a decade ago, to the dedication of the contributing dental and medical clinicians, and to the skill and perseverance of the editor. It will serve as a valuable reference source to the military and civilian dental and medical communities.

Captain C. E. Brodine  
Commanding Officer  
Naval Medical Research and  
Development Command

## Preface

---

At the beginning of the Vietnam conflict few surgeons serving on active duty could provide guidance in the treatment of complex war wounds that was based on wide personal experience. Although journal articles and textbook chapters were available concerning various aspects of war casualty treatment, no contemporary single-source document existed that dealt solely with the total management of jaw-injured patients including early through late care. In this environment surgeons of all disciplines found themselves relearning the lessons of casualty management just as their predecessors did in previous wars. In addition, treatment concepts that had been developed since World War II and the Korean conflict were being applied to Vietnam casualties and the need to investigate their efficacy and validity became readily apparent.

*The primary impetus for this text was the apparent need to compile and report data concerning the treatment of oral and maxillofacial war casualties occurring in Vietnam in order to establish a contemporary perspective for such management.* To accomplish this, a long-term survey investigation of such injuries was conducted within the Dental Sciences Department of the Naval Medical Research Institute (NMRI) and has provided the basis for this publication. The survey investigation depended on the cooperation of clinicians in all the Federal Services and in some instances civilian practitioners. Selected cases were identified at treatment facilities in Vietnam and investigators at NMRI were provided with a documentation of their treatment. The management of these patients was followed prospectively through all phases of casualty care including early treatment in Vietnam, intermediate care at facilities along

the medical evacuation routes, and late care (reconstruction-rehabilitation) at a primary military medical institution as well as at other Federal or civilian facilities. In addition, some patients were identified at the time of late care and were included in the survey from that time forward with retrospective investigation of their early and intermediate care. A total of 204 casualties were included in the survey, although long-term follow-up for all patients was not possible as evidenced by the number (N) of cases included in the various data analyses that will be presented.

*The conclusions set forth in this publication are drawn not only from the survey data but also from the clinical experience of the authors that was acquired in the military hospitals in which they served.* Although the authors were primarily responsible for individual chapters they also provided input to other sections of the text where appropriate.

The publication is meant to provide a research and clinical perspective to the management of casualties and is not primarily intended as a technique primer. An attempt has been made to extract those data most pertinent to the long-term results of treatment. The data presented and the treatment described represent those aspects of casualty management which in the opinion of the authors are most significant in relation to the jaw-injured patient. In most instances, descriptions of treatment have not been presented in a detailed manner; rather, the references made to previously published accounts of therapy are meant to guide the reader to accurate and contemporary resumes that present more detailed descriptions of the particular matter under consideration. It is recognized that what is recommended practice today may be inappropriate in



*the future, but hopefully what has been compiled in this text will be useful and meaningful for at least several decades. The authors unanimously concur that despite the technologic advances in biomedical science that have occurred during this century the basic principles of maxillofacial surgery still remain essentially intact, and it is really the opportunity to provide a wider range of treatment options that has changed the perspective for casualty management.*

This publication exists because of the efforts of numerous clinicians and research scientists as well as the administrative support provided by the Bureau of Medicine and Surgery (BUMED) over the several years that the maxillofacial casualty study (MFCS) has been in effect. The MFCS had its origins in conjunction with the investigations of Captain Phillip J. Boyne, DC, USN (RET.), during his tour of duty at NMRI. Dr. Boyne and his associates, including Captain Harvey W. Lyon, DC, USN (RET.), developed a particulate cancellous bone marrow grafting system that depended on the demonstrated osteogenic potential of bone marrow elements. The first MFCS study cases were acquired in an attempt to investigate the clinical application of this bone grafting system. Lieutenant Commander Allan B. Luke, DC, USN (Deceased), and Captain Charles Myers, DC, USN (RET.), of the Dental Sciences Department, NMRI, were responsible for sustaining the casualty study during its infancy, following the retirement of Dr. Boyne. Without their dedicated interest this publication would never have materialized. During the editors initial involvement with the MFCS, Captain Tracey D. Cuttle, MC, USN (RET.) as Commanding Officer and Commander Gaspar W. Anastasi, MC, USN as Chief, Plastic Surgery Service, Naval Hospital, Boston (Chelsea), were extremely understanding and cooperative in fostering the concept of a long-term casualty study. Captain John D. Cagle, DC, USN, provided valuable assistance with data collection and analysis during his tour at NMRI and was responsible for compiling most of the case reports from the MFCS records. Two of the authors, Captain Bill C. Terry, DC, USN (RET.), and Captain Henry J. Sazima, DC, USN, were the principal advisors and supporters of this study over the years and as a result of their vision and enthusiasm were greatly influential in providing the encouragement and motivation necessary to continue the investigation.

A series of Dental Officers who served as Chief of the United States Navy Dental Corps, Bureau of Medicine and Surgery, provided the basic support to the casualty investigation. Rear Admiral Frank Keyes, DC, USN(RET.), approved the concept of the initial protocol, and his successor Rear Admiral Edward Raffetto, DC, USN(RET.), strongly supported the project in its initial phase when he was Inspector General for the Dental Corps and assured its continuity by vigorously supporting it during his tenure as Chief. Rear Admiral Jack P. Arthur, DC, USN(RET.), understood the necessity for completing the project and assured the cooperation necessary for the initiation of this publication. The text was completed during the tenure of Rear Admiral Robert W. Elliott, Jr., DC, USN, who strongly supported the project and encouraged the thorough and timely completion of the work.

The Staff of NMRI and the Naval Medical Research and Development Command (NMR&DC) were closely associated with this project and were unwavering in their support. Captain Charles E. Brodine, MC, USN, who was greatly instrumental in implementing and overseeing the Navy medical department research efforts in Vietnam, was a source of counsel and encouragement prior to and after assuming his duties as Commanding Officer NMR&DC. Captain Kenneth W. Sell, MC, USN, during his tenure as Commanding Officer, NMRI, provided the administrative support that directly resulted in this publication and also reviewed and approved the manuscript. The dynamic, intelligent, and far-sighted leadership of Captains Brodine and Sell served as a strong motivation to all those involved with the many aspects of casualty care research.

Captain Gordon H. Rovelstad, DC, USN(RET.) (1969-74), and Captain Herman D. Tow, DC, USN (1974-76), served in a pivotal role as directors of the Navy Dental Research Program and coordinated the support of BUMED and the NMR&DC. Captain Tow also held the position of Chairman, Dental Sciences Department, NMRI, from 1970-74, and in this capacity provided an environment in which it was possible to fully implement the casualty investigation. In addition Captain Robert W. Longton, DC, USN, serving as Chairman, Dental Sciences Department, NMRI, carefully directed the administrative support necessary to assure publication of the manuscript.

The section of Chapter IV concerning hypovolemic shock was reviewed by Captain Clifford M. Herman MC USN, Head, Experimental Surgery and Physiology Division, Experimental Medicine Department, NMRI and Thomas W. Evans DDS MD, Columbus, Ohio, both of whom took time from their busy schedules to assist with this aspect of the publication.

Lastly and most importantly are the contributions of the co-authors. It would not have been possible to prepare this type of publication without the knowledgeable and informed contribu-

tions of these men. *Their personal experience lends a degree of credence to the text which is of particular importance in relation to the management of war casualties.* It is a credit to each of them that they recognized the significance of the casualty treatment with which they were involved and were willing to devote the time and effort to preparation of a manuscript. As a result, their experiences have been passed on to those surgeons who in the future will have to deal with the complicated and often tragic circumstances of war casualty treatment.

July 1977

J. F. Kelly

## Acknowledgments

The foundation of this publication is the MFCS data that were acquired through the cooperation of numerous clinicians from all the federal services as well as the civilian community. In addition to the authors, Colonel D.B. Osbon, DC, USA (RET.), formerly of Lettermen Army Medical Center, as well as Colonel R.C. Gerhard, DC, USA (RET.), and Colonel L.H. Guernsey, DC, USA (RET.), formerly of Walter Reed Army Medical Center unselfishly contributed a significant amount of case documentation to the MFCS and through these records thoroughly and graphically depicted the results of their exceptional surgical care.

Certain other surgeons manifested an extremely cooperative and sustained relationship with the Maxillofacial Casualty Study and as a result of their notable treatment efforts and careful documentation also made very significant contributions to the data that is presented in the text. These include: C. C. Alling, Colonel, DC, USA (RET.), G.W. Anastasi, M.D., R.D. Baker, Captain, DC, USN (RET.), H.S. Kramer, Captain, DC, USN (RET.), J.S. Lindsay, Commander, DC, USN, R.B. Maw, Captain DC, USN, T.W. McKean, Captain, DC, USN, R.A. Middleton, Captain, DC, USN (RET.), R.M. Phillips, DDS, H.S. Samuels, Captain, DC, USN, H.O. Scharpf, Captain, DC, USN, K.R. Spint, DDS, and L.W. Stark, DDS.

The following clinicians contributed case documentation, or were involved with the patient care, that is presented in the figures included in *Chapters I through VI*: P. Abbott, J. M. Alley, A. E. Amato, G. W. Anastasi, R. Annis, S. L. Bahn, R. D. Baker, R. S. Baumgarten, K. W. Beasley, B. Blankenship, L. L. Bowen, P. J. Boyne, J. V.

Brown, S. S. Byers, G. W. Carroll, J. H. Charles, B. Ciola, V. Cozza, M. R. Cummings, A. DeFreece, B. J. Devos, Dr. Estep, J. F. Flood, Dr. Greco, T. J. Jost, J. Judson, O. R. Koski, H. S. Kramer, Dr. Lahey, J. S. Lindsay, E. G. Mainous, R. B. Maw, T. W. McKean, E. J. Messer, R. Middleton, P. J. Mulligan, R. A. Newman, Dr. Paszkowsk, G. Rooney, H. O. Scharpf, J. Seashore, M. T. Shervheim, L. Slagle, E. W. Small, T. E. Stump, W. E. Sugg, Jr., A. A. Swanson, B. C. Terry, J. W. Walden, and J. Upton.

The data for the *case reports* were collected from numerous surgeons over a long duration. The following clinicians are those who provided treatment and/or documentation of cases included in this section: P. L. Abbott, C. C. Alling, G. W. Anastasi, J. T. Anderson, S. Bahn, R. D. Baker, J. R. Bohanan, P. J. Boyne, A. A. Bregman, J. V. Brown, D. Castner, F. C. Cerine, M. R. Cummings, R. C. Curreri, R. DeChamplain, B. J. Devos, Dr. Gay, R. C. Gerhard, L. Getter, R. Gordon, L. A. Guernsey, W. R. Hiatt, C. Horton, C. C. Johnson, R. Kelsey, E. Kirschner, J. Koutrakos, H. S. Kramer, J. S. Lindsay, E. G. Mainous, R. B. Maw, T. W. McKean, V. T. McKee, E. J. Messer, F. E. Miller, R. J. Miller, P. J. Mulligan, H. E. Neeley, R. A. Olson, D. B. Osbon, G. Pedersen, R. M. Phillips, G. E. Rooney, J. E. Salem, H. S. Samuels, H. J. Sazima, H. O. Scharpf, T. Scott, D. Shelton, E. W. Small, D. M. Smith, R. Smith, S. Smith, K. R. Spint, L. W. Stark, T. E. Stump, T. M. Sullivan, B. C. Terry, C. W. Thompson, R. Walsh, C. J. White, F. T. Wigand (Deceased), J. W. Wood, and J. S. Zack.

If there are individuals who have contributed to the management of cases presented in this text but whose names do not appear, it is because we



did not have a record of their contribution and not because of intentional omission.

The Editor recognizes the important contributions that were made by members of the staff at the *Naval Medical Research Institute* without whose efforts this work would not have been possible.

Photographic Department: Raymond E. Wilder, HM2 Charles N. Hall, and HM2 Ronald A. Monroe provided hundreds of x-ray and photographic prints from which the final art work for the text were chosen.

Graphic Arts Department: Nolan Laxey and Victoria Somers provided tables and illustrations.

Library: Karen Patrias and Ernestine V. Gendleman assisted in literature search and provided a variety of library support services.

Dental Sciences Department: Fay Smith de-

veloped the casualty study filing system, monitored data collection, and provided excellent administrative assistance; Shirley Starnes labored over endless hours of manuscript preparation, implemented the computerized data collection and follow-up system, and exhibited patient and friendly negotiations with authors, patients, and others who collaborated in preparation of the publication; Tim Mikels developed initial sketches; and Nellie Cox implemented early data collection.

Invaluable expertise and unprecedented cooperation for the preparation of the manuscript for publication was provided by the *Defense Printing Service* through the Navy Publication and Printing Service; the editor and contributors are deeply grateful for this assistance.

## Contributors

---

**PETER W. CONNOLE, D.D.S.**

Captain, Dental Corps, United States Navy. Chairman, Department of Oral Surgery, National Naval Dental Center, Bethesda, Maryland. Oral and Maxillofacial Surgery Advisor, Naval Advisory Group, Saigon, December 1970–December 1971.

**W. ROBERT HIATT, D.D.S.**

Captain, Dental Corps, United States Navy (Retired). Professor and Chairman, Department of Oral Surgery, School of Dentistry and Kansas City General Hospital and Medical Center, University of Missouri-Kansas City. Chief, Dental Service and Oral Surgery, United States Naval Hospital, Guam, Marianas, 1966–1969.

**JAMES F. KELLY, D.D.S., M.S.**

Captain, Dental Corps, United States Navy. Chairman, Department of Dentistry and Oral Surgery, National Naval Medical Center. Head Oral and Maxillofacial Surgery Division, Naval Medical Research Institute, Bethesda, Maryland, 1970–1976.

**ELGENE G. MAINOUS, D.D.S.**

Captain, Dental Corps, United States Navy (Retired). Professor and Chairman, Department of Oral Surgery, School of Dentistry, University of Mississippi, Jackson. Oral Surgeon, Hospital Ship, *U.S.S. Sanctuary*, February 1968–February 1969.

**EUGENE J. MESSER, D.D.S.**

Captain, Dental Corps, United States Navy. Chairman, Department of Dentistry and Di-

rector of Oral Surgery Graduate Education, Naval Regional Medical Center, Great Lakes, Illinois. Chief, Dental Service and Oral Surgery, United States Naval Hospital, Guam, Marianas, 1969–1972.

**HENRY J. SAZIMA, D.D.S.**

Captain, Dental Corps, United States Navy. Special Assistant for Dental Affairs, Department of Defense, Washington, D.C. Chief, Dental Department and Senior Oral Surgeon, United States Naval Support Activity Hospital, Danang and Oral and Maxillofacial Surgery Advisors—Naval Advisory Group, Saigon, December 1969–December 1970.

**THOMAS E. STUMP, D.D.S., M.S.**

Captain, Dental Corps, United States Navy. Chairman, Department of Dentistry and Director of Oral Surgery Graduate Education, Naval Regional Medical Center, Portsmouth, Virginia. Oral Surgeon, Hospital Ships, *U.S.S. REPOSE* and *U.S.S. SANCTUARY*, January 1970–February 1971.

**BILL C. TERRY, D.D.S.**

Captain, Dental Corps, United States Navy (Retired). Professor of Oral Surgery, School of Dentistry, University of North Carolina, Chapel Hill. Oral Surgeon, Hospital Ship, *U.S.S. REPOSE*, December 1966–December 1967.

**ROBERT G. TRIPLETT, D.D.S.**

Commander, Dental Corps, United States Navy. Clinical Sciences Division, Naval Medical Research Institute, Bethesda, Maryland.

## Table of Contents

### CHAPTER I

#### *Historical Perspective*

INTRODUCTION .....	1
WORLD WAR I .....	2
MAXILLOFACIAL WOUNDS .....	2
BALLISTICS .....	2
RESUSCITATION AND EARLY TRANSPORTATION .....	2
WOUND COMPLICATIONS .....	3
TREATMENT AT THE BASE HOSPITAL .....	3
METHODS OF FRACTURE FIXATION .....	4
RADIOLOGY .....	5
ANESTHESIA .....	5
FLUID THERAPY .....	5
SECONDARY RECONSTRUCTION .....	5
<i>Factors Effecting Reconstruction</i> .....	5
<i>Mandibular Grafting</i> .....	6
CONCLUSION .....	7
WORLD WAR II .....	8
MEDICAL PREPAREDNESS AT THE BEGINNING OF THE WAR .....	8
ADVANCES IN PATIENT MANAGEMENT .....	8
<i>Resuscitation</i> .....	8
<i>Anesthetic Management</i> .....	9
<i>Wound Management</i> .....	8
<i>Fracture Management</i> .....	9
<i>Secondary Management</i> .....	10
KOREAN WAR .....	11
LOGISTIC SUPPORT OF CASUALTY TREATMENT .....	11
WOUND MANAGEMENT .....	12
<i>Debridement and Primary Closure</i> .....	12
<i>Delayed Wound Closure</i> .....	12
<i>Fracture Reduction and Fixation</i> .....	12
<i>Anesthetic Management</i> .....	12
<i>Reduced Overseas Hospitalization</i> .....	13
CONCLUSION .....	13
SURGICAL ADVANCES AFFECTING THE TREATMENT OF	
MAXILLOFACIAL WAR INJURIES .....	13



1914-1919 WORLD WAR I .....	13
1939-1945 WORLD WAR II .....	13
1950-1952 KOREAN WAR .....	14
INTERBELLUM ADVANCES .....	14

## CHAPTER II

### *Treatment Goals*

ORAL AND MAXILLOFACIAL CASUALTIES .....	17
LOGISTIC CONSIDERATIONS .....	17
THERAPEUTIC GOALS .....	18
EARLY CARE .....	18
LOGISTICS .....	18
PATIENT CARE .....	19
<i>Initial Care</i> .....	19
<i>Definitive Care</i> .....	19
INTERMEDIATE CARE .....	20
LOGISTICS .....	20
PATIENT CARE .....	20
LATE CARE (RECONSTRUCTION-REHABILITATION) .....	20

## CHAPTER III

### *Anatomic Illustrations*

OSTEOLOGY .....	24
MUSCLES OF MASTICATION (I) .....	25
MUSCLES OF MASTICATION (II) .....	26
MUSCLES OF FLOOR OF MOUTH .....	27
MUSCLES OF TONGUE AND FLOOR OF MOUTH .....	28
LATERAL FACE WITH NEUROVASCULAR AND MUSCULAR RELATIONS .	29
ARTERIAL SUPPLY TO OROFACIAL REGION (I) .....	30
ARTERIAL SUPPLY TO OROFACIAL REGION (II) .....	31

## CHAPTER IV

### *Early Care*

INTRODUCTION .....	33
FACTORS INFLUENCING TREATMENT .....	33
DESIRABLE CHARACTERISTICS OF THE COMBAT SURGEON .....	33
COORDINATION OF EVACUATION .....	34
TREATMENT FACILITIES .....	34
WOUNDING AGENTS AND WOUNDS .....	35
BALLISTICS .....	35
TYPES AND PATTERNS OF INJURY .....	35
CLASSIFICATION OF MISSILE WOUNDS .....	38
<i>Penetrating</i> .....	38
<i>Perforating</i> .....	42
<i>Avulsive</i> .....	44
INITIAL CARE .....	44

INTRODUCTION .....	44
AIRWAY MANAGEMENT .....	44
<i>Assessment of the Airway</i> .....	44
<i>Artificial Airway Assistance</i> .....	44
<i>Altered Consciousness</i> .....	47
<i>Respiratory Diagnosis</i> .....	47
<i>Effect of Facial Fractures on the Airway</i> .....	48
OTHER ADJUNCTIVE INITIAL CARE .....	48
TRIAGE AND PATIENT EVALUATION .....	49
TRIAGE CONCEPTS .....	49
PATIENT MANAGEMENT IN THE TRIAGE AREA .....	50
<i>Primary Procedures</i> .....	50
<i>Sequence of Management</i> .....	50
<i>Priority of Treatment</i> .....	51
HYPOVOLEMIC SHOCK .....	52
CLASSIFICATION .....	52
MECHANISMS AND PHYSIOLOGIC MANIFESTATIONS .....	52
CLINICAL MANIFESTATIONS .....	52
MANAGEMENT .....	53
PRESURGICAL CONSIDERATIONS .....	55
INTRODUCTION .....	55
STATE OF READINESS .....	56
INITIAL OVERALL MANAGEMENT .....	56
<i>Total Patient Assessment</i> .....	56
<i>Airway</i> .....	56
<i>Control of Hemorrhage</i> .....	57
<i>Vital Signs</i> .....	57
<i>Intravenous Infusion</i> .....	57
<i>Laboratory Studies</i> .....	57
PRESURGICAL EVALUATION .....	58
<i>History</i> .....	58
<i>Physical Examination</i> .....	58
<i>Radiographic Examination</i> .....	63
<i>Documentation of Examination Findings</i> .....	65
ANALYSIS OF EXAMINATION FINDINGS IN MAXILLOFACIAL CASUALTY STUDY PATIENTS .....	66
ADDITIONAL PREOPERATIVE CONSIDERATIONS .....	66
<i>Preliminary Wound Care</i> .....	66
<i>Anesthetic Management</i> .....	68
SURGICAL MANAGEMENT .....	69
INTRODUCTION .....	69
WOUND PREPARATION .....	69
CONTAMINATED WOUNDS AND ANTIBIOTIC THERAPY .....	70
<i>Factors Effecting Contamination</i> .....	70
<i>Contaminating Microorganisms</i> .....	70
<i>Antimicrobial Therapy</i> .....	70
<i>Control of Contamination</i> .....	71
GENERAL PRINCIPLES OF WOUND MANAGEMENT .....	71
<i>Inside-out—Bottom-up</i> .....	71
<i>Recovery of Foreign Material</i> .....	71
<i>Neck Exploration</i> .....	73
HARD TISSUE .....	73
<i>Principles</i> .....	73

<i>Mandibular Injuries</i> .....	74
<i>Midfacial Injuries</i> .....	78
<i>Stabilization of Fractures</i> .....	80
<i>Analysis of Fracture Reduction in MFCS Cases</i> .....	82
SOFT TISSUE .....	82
<i>Principles of Primary and Secondary Closure</i> .....	82
<i>Wound Closure</i> .....	83
SPECIALIZED TISSUES .....	85
<i>Salivary Gland</i> .....	85
<i>Facial Nerve</i> .....	86
<i>Ophthalmologic Injuries</i> .....	86
POSTSURGICAL CONSIDERATIONS .....	87
INTRODUCTION .....	87
SIGNIFICANT ASPECTS OF MANAGEMENT .....	87
<i>Operative Considerations</i> .....	87
<i>Immediate Postoperative Care</i> .....	87
<i>Supportive Care</i> .....	88
<i>Complications</i> .....	89
<i>Evacuation Procedure</i> .....	89

## CHAPTER V

### *Care at Intermediate Facilities*

INTRODUCTION .....	95
RATIONALE OF MANAGEMENT .....	96
PROTOCOL OF MANAGEMENT .....	96
HISTORY OF INJURY .....	96
CLINICAL EVALUATION .....	97
<i>Airway</i> .....	97
<i>Wound Evaluation</i> .....	97
<i>Additional Considerations</i> .....	98
RADIOGRAPHIC EVALUATION .....	99
LABORATORY EXAMINATION .....	99
SECONDARY TREATMENT OF MAXILLOFACIAL INJURIES .....	100
<i>Skeletal Fracture</i> .....	100
<i>Soft Tissue</i> .....	101
NONOPERATIVE MANAGEMENT .....	102
<i>Fluid Therapy</i> .....	102
<i>Management of Fever</i> .....	102

## CHAPTER VI

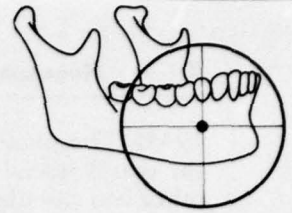
### *Late Care (Reconstruction-Rehabilitation)*

WOUND MANAGEMENT AND SPECIAL PROBLEMS .....	105
INTRODUCTION .....	105
CLINICAL EVALUATION AND TREATMENT OF WOUNDS .....	105
<i>Airway Assessment and Management</i> .....	106
<i>Wound Evaluation and Management</i> .....	106
<i>Alignment and Stabilization of Osseous Fragments</i> .....	109
RESTRICTIVE JAW FUNCTION .....	110



<i>Introduction</i> .....	110
<i>Ankylosis</i> .....	111
<i>Trismus</i> .....	111
<i>Jaw Exercisers and Physical Therapy</i> .....	111
<i>Anatomic Locations of Restriction</i> .....	111
<i>Summary</i> .....	113
SALIVARY GLAND .....	113
CONCOMITANT INJURIES AND MEDICAL DISEASE .....	114
BONE GRAFT RECONSTRUCTION .....	116
INTRODUCTION .....	116
EVOLUTION OF MANDIBULAR BONE GRAFTING .....	116
CRITERIA OF SUCCESSFUL RECONSTRUCTION .....	117
PROCEDURAL FORMAT FOR RECONSTRUCTION-REHABILITATION .....	117
ANALYSIS OF BONE GRAFT CASES .....	118
TECHNICAL MANAGEMENT .....	121
<i>Introduction</i> .....	121
<i>Preoperative Evaluation</i> .....	123
<i>Control of Sepsis</i> .....	124
<i>Selection of Critical Dentition</i> .....	126
<i>Soft Tissue Considerations</i> .....	130
METHODS OF GRAFTING .....	133
<i>Introduction</i> .....	133
<i>Iliac Crest Grafts</i> .....	133
<i>Rib Grafts</i> .....	136
<i>PCM Grafts</i> .....	136
COMPLICATIONS OF BONE GRAFT RECONSTRUCTION .....	140
<i>Donor Site Complications</i> .....	140
<i>Recipient Site Complications</i> .....	140
<i>Assessment of Unsuccessful Grafts</i> .....	144
PREPROSTHETIC SURGERY .....	144
INTRODUCTION .....	144
DEFINITION AND PURPOSE .....	146
RATIONALE FOR PREPROSTHETIC SURGERY .....	146
<i>Vestibuloplasty</i> .....	146
<i>Bone Graft Augmentation</i> .....	148
CONCLUSION .....	151
CASE REPORTS .....	155
APPENDIX—RESEARCH IN ACQUIRED CRANIOFACIAL DISFIGUREMENT .....	245
SUBJECT INDEX .....	263

## CHAPTER I



# Historical Perspective

By ROBERT G. TRIPLETT  
JAMES F. KELLY

## INTRODUCTION

The evolution of surgical therapy for deformities of the jaws and face has been significantly influenced by experience gained during periods of armed conflict. In fact, for most of history, the principal school of surgery has been the field of battle. Not only have innovative new procedures been developed but respect has been engendered for those older methods found basically sound and therapeutically effective. The observations of Henry E. Sigerist, a medical historian, concerning the effects of war on biomedical science are appropriate in this regard. "The major immediate contribution of war to medicine is negative—but war, on the other hand, is also a challenge and a stimulus to medicine, both technically and socially. It provides opportunities for [justified] experimentation on a tremendous scale, such as would never be available in times of peace." (Sigerist, 1943).

If a *period of war* is viewed retrospectively it can be divided into three phases in relation to biomedical scientific progress: Phase 1: A latent, negative, initial incubation period, which during World Wars I and II lasted almost 2 years. Phase 2: An interim stage of approximately the same duration in which advances are rapid, diverse, and often uncoordinated. Phase 3: A terminal phase during which there is consolidation of ideas, application of developments to clinical practice, and proliferation of additional scientific research (Porritt, 1953 [a]).

Formal surgical research efforts in combat hospitals were not initiated until the Korean war, but

numerous structured investigations of both medical and surgical therapy were carried out during previous conflicts (Hardaway, 1967).

The earliest *antiinfective agents*, the sulphonamides and penicillin, were studied extensively in war casualties and, as we know, their effects virtually revolutionized the treatment of not only war wounds but a vast number of other medical and surgical diseases. Although these medications were effective in modifying numerous concepts of wound care, they did have limitations; and lessons were learned during application of these "miracle" medicines as evidenced from the following remarks of Stout (1954 [a]).

Sulphonamides were expected to do too much to assist the surgeon, and it was not until the dramatic discovery of the remarkable bacteriostatic effects of penicillin on wound organisms that surgeons would turn their attention to early closure of wounds. The principles [of wound closure] were not new or strange. They were relearned slowly, and sometimes laboriously, by a new generation of surgeons. They will have to be learned again possibly by another generation of surgeons who may have more powerful bacteriostatics and possibly improved techniques in other ways, but the *cardinal principles* will remain.

Another example of evolutionary surgical treatment during war is the *concept of wound debridement*. The wide debridement of wounds was first initiated during the Napoleonic War by Larrey (1776–1842) who was inspector general of the medical staff of Napoleon's armies (Schwartz,



1944). The principles of wound debridement in the maxillofacial area were found to differ from other less vascular parts of the body, and as early as the Crimean War (1854–55), the following astute observations were made: "In fractures of the bones of the face from gun shot, we made an exception to the general rule of removing fragments which are nearly detached. The large supply of blood which is sent to every structure in the region enables pieces of bone to resume their full connection in a way that would be fatal to similarly placed portions in other parts" (MacLeod, 1862).

A fallacy frequently advanced is that war surgery and traumatic surgery are the same—

they are not. *War surgery depends on many extenuating circumstances besides surgical knowledge and skill.* Fitness of the troops, prevalence of disease, adequacy of logistic support, severity of the battle, and availability of evacuation are among the conditions that influenced treatment more than competence of the surgeon (Ogilvie, 1953 [a]). One must keep this premise foremost in mind when judging the surgical care rendered during periods of armed conflict. Most advances in the treatment of maxillofacial injuries that have modern implications evolved during and since World War I; thus this discussion will concentrate on events from that time forward.

## WORLD WAR I

### MAXILLOFACIAL WOUNDS

During World War I maxillofacial injuries reached almost epidemic proportions as a result of trench warfare. The nature of these circumstances and the type of wounds were well described by Converse (1942) when comparing World War I and II injuries: [During World War I] "... the combatant was protected by the trench. His head was protected by a steel helmet and only his face was exposed. Patients suffered only maxillofacial injuries which were very severe because the machine gun bullet or bomb fragment which hit the face, penetrated to the facial bones, causing an explosive destruction of soft tissues of the face and facial bones." The severity of these wounds was substantiated by data from the Surgeon General of the Army which indicated that *over 3,000 of approximately 8,000 wounds of the face among the American Expeditionary Forces proved fatal* (Blair, 1943).

### BALLISTICS

The *principles of modern ballistics* were just as applicable during World War I as they are today. Tissue damage was often extensive even though missile velocities were not as great as at present. Mechanisms of tissue damage by high velocity missiles had not been thoroughly investigated, but experienced surgeons were aware that *damage often extended well beyond the visibly injured tissues*

as evidenced by the observations of Roberts (1919 [a]).

Gunshot wounds received in battle present varying qualities depending on the projectile which causes them. Bullets from a rifle inflict a different injury from that caused by machine gun bullets; shrapnel *missiles damage tissue in a way unlike that shown in traumatism from shells, mortars and grenades.* The shape and character of the wound is often modified by the size, shape, velocity and deviation in contour of the missile. The projectile may have obtained from prior contacts and from obstructions through which it has passed a new capacity for harm.

### RESUSCITATION AND EARLY TRANSPORTATION

With maxillofacial injuries reaching such magnitude in both severity and numbers, the traditional *methods of resuscitation and transportation* proved inadequate. During the early stages of the war numerous maxillofacial casualties died en route to the treatment facilities, not only from the severity of their wounds but also because of medical inexperience in dealing with this type of wounded patient. Initially it was thought acceptable to transport such patients in a supine position; thus if they became unconscious during transport they experienced respiratory obstruction and often expired. To obviate these morbid complications *it became the practice for maxillofacial patients to be transported sitting up or in a prone position to protect the airway.* This difficulty in maintain-



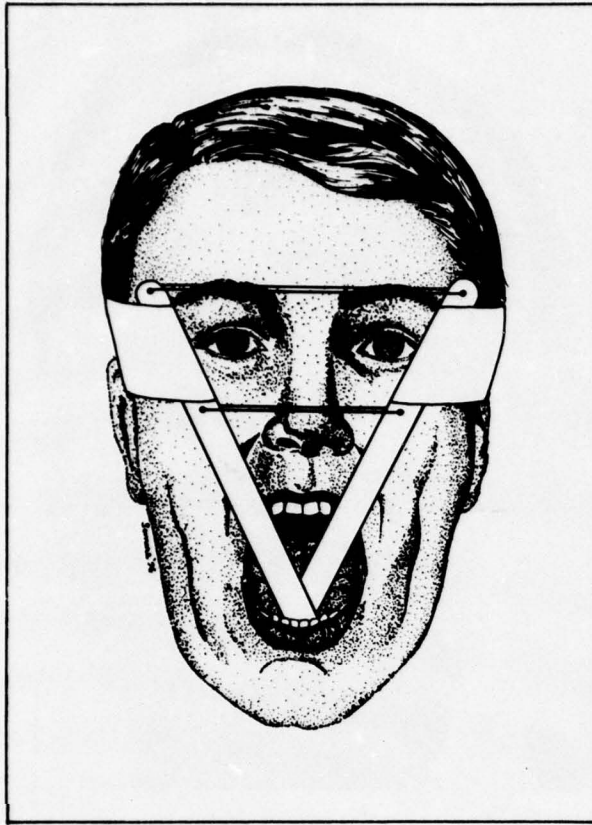


Figure 1.—Diagrammatic illustration of emergency airway splint employed during World War I. The splint was designed to hold the mandible forward to obviate airway obstruction during transportation of patients with maxillofacial injuries. It was simply constructed of tongue blades and orthodontic wire. [From McGee, R. P. (1919): Reprinted with the permission of the *Journal of the American Medical Association*.]

ing an airway during evacuation led to development by McGee (1919) of an emergency splint to hold the jaws in a forward position with the mouth open (Figure 1) (Blair, 1943; Ivy and Eby, 1924 [a]).

### WOUND COMPLICATIONS

During periods of battle activity, advanced mobile hospitals were moved to forward positions and sometimes patients were received as early as 2 hours after injury; however, maxillofacial wounds could not be satisfactorily cleansed and debrided in those mobile hospitals because of inadequate equipment, supplies, and technical support. The total lack of experience in the treatment of maxillofacial wounds by personnel

in the advanced aid stations resulted in limited treatment consisting essentially of first aid. As a result, *sepsis was present in virtually all such patients* on arrival at the base hospital and was the chief factor which delayed and complicated maxillofacial wounds. In addition to infection, management was further complicated by patients arriving at the base hospital at widely varying intervals after injury (days to months). During this time they were frequently transferred from one facility to another where maxillofacial experience was limited and thus received uncoordinated and usually ineffectual treatment (Ivy and Eby, 1924 [b]). The complications that developed in these circumstances contributed to increased scar contracture and bone loss, which added to the complexity of management (Figure 2). As a result, experienced surgeons at base hospitals strongly urged that in the advanced treatment facilities every effort be made to conserve bone, mucous membrane, and skin and to approximate the remaining tissues to as nearly normal position as possible. In avulsive defects it was advised that mucosa be sutured to skin to protect raw surfaces and reduce the extent of sepsis and scar contracture (Ivy and Eby, 1924 [c]), a treatment principle which has withstood the test of time.

### TREATMENT AT THE BASE HOSPITAL

In the base hospital debridement consisted essentially of irrigation and removal of nonvital and necrotic tissue. Various chemical medicaments were tried for cleansing maxillofacial wounds such as physiologic salt solutions, potassium permanganate, di-chloramine T., Carrel-Dakin solution, and bismuth iodoform paraffin paste (BIPP). It was finally realized that the type of solution or mixture was of little consequence and that the principal therapeutic benefit resulted from the frequency of irrigation (Ivy and Eby, 1924 [d]; Stout, 1945 [b]).

Teeth were removed if it was thought that they would contribute to sepsis in any way, a premise predicated on the experience with delayed union and infection associated with retained dental structures.

Open reduction of compound fractures was discouraged because experience had shown that this procedure was invariably unsuccessful since infection and necrosis resulted. In essence, early fixation and immobilization were recognized as

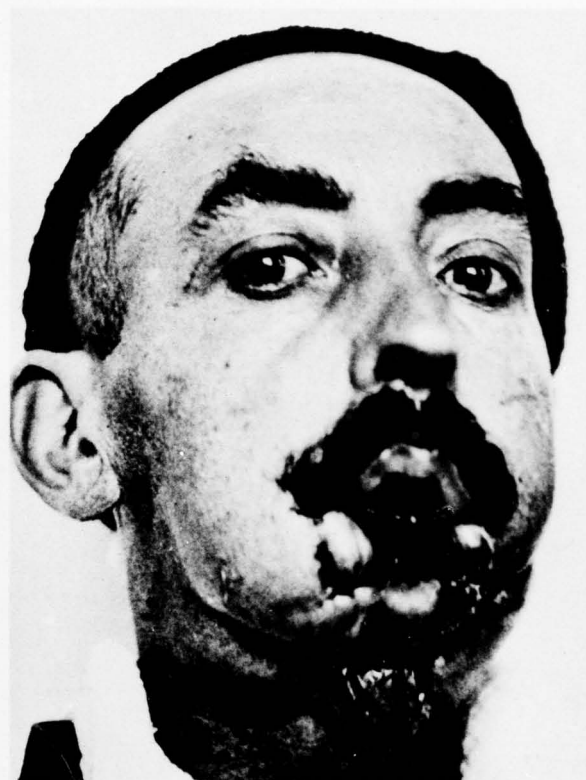


Figure 2.—(Left) Patient with severe maxillofacial injury shown at the time of arrival at the American Ambulance Hospital, Paris, France, several weeks after initial injury. He was admitted with untreated wounds complicated by gross sepsis and necrosis. (Right) Appearance of the same patient approximately 1 year following injury. A large tissue deficiency still exists. A mandibular splint, and a circumferential ligature are still being employed in an attempt to stabilize the mandibular fragments at this very late interval. Of interest is the placement of the circumferential ligature which overlies the skin of the face. Limited experience with this type of fixation had been gained at this time. [Reprinted with permission of Mr. Charles J. Simpson from cases of Dr. Hunter W. Scarlet.]

prerequisites to proper healing and delayed fixation was viewed as the major contributing cause of prolonged sepsis and exaggerated facial deformity.

#### METHODS OF FRACTURE FIXATION

*The concept of interdental occlusion as the key to proper reduction was elucidated at this time.* Previously, various authors, including Imbert and Real (1918), had advocated approximation of bone fragments without regard for resulting malocclusion presuming the mandibular joint would be able to compensate for functional losses that resulted. This type of treatment was found grossly inadequate, as reflected by the statement of Roberts (1919 [b]): "It is allowable to sacrifice proper dental articulation for union of fragments

only when the resulting malocclusion of teeth will be slight. Surgery has outgrown the day when any sort of solid union is satisfactory after mandibular fracture."

Methods of fixation for facial fracture were not entirely new developments of World War I. Many of these techniques conformed to, or were modifications of, older types such as the capped splint of Hullihen, the open-bite splint of Gunning (1866), the interdental splints of Bean and Gunning (Ivy and Eby, 1924 [e]), and the interlocking plane of Gilmer (1887). All manner of bandages, molded splints, and hollow caps were constructed from a variety of materials such as pasteboard, wire, felt, leather, gutta percha, and gauze stiffened with gypsum. All of these devices were utilized in an attempt to bandage the jaws together. External bandages such as the four-tailed (Figure 3) and the Barton types were also used,

sometimes as the only method of immobilization. Interdental wiring was developed and refined, thus greatly simplifying immobilization, but the results achieved by the various techniques depended more on the application of sound principles of reduction and fixation than on any specific method (Blair, 1943).

## RADIOLOGY

In the mobile hospital *roentgenographic examinations* were usually confined to fluoroscopic examination for foreign bodies. Radiographic prints were not usually available for fracture interpretation in the advanced facilities. More thorough examinations including stereoscopic views were available in the larger base facilities. Radiology, however, was in its infancy and the quality of films and interpretations were frequently tentative (Roberts, 1919 [c]).

## ANESTHESIA

Anesthesia was a yet undeveloped science during World War I and as a result the surgical teams were required to be versatile, proficient, and swift. *Local anesthesia (procaine) was usually employed for management of maxillofacial injuries in the advanced hospitals.* When procaine alone was insufficient it was supplemented with nitrous oxide-oxygen particularly for patients in traumatic shock (Beecher, 1955 [a]). While general anesthetic agents such as chloroform, ether, and nitrous oxide-oxygen were available, the *nitrous oxide-oxygen combination with local anesthesia* was thought to be superior because it was associated with a lesser incidence of such complications as bronchitis, pneumonia, and nephritis. *Ether* was the next most common agent employed for maxillofacial operations, but its administration was associated with a *high incidence of airway and pulmonary complications* thus necessitating the almost routine use of tracheostomy. (Ivy, 1943; Roberts, 1919[d]; Beecher, 1955[b]).

## FLUID THERAPY

*Oral administration of water and rectal administration of salt solutions were the accepted treatments for resuscitation of severely injured patients* (Cannon,

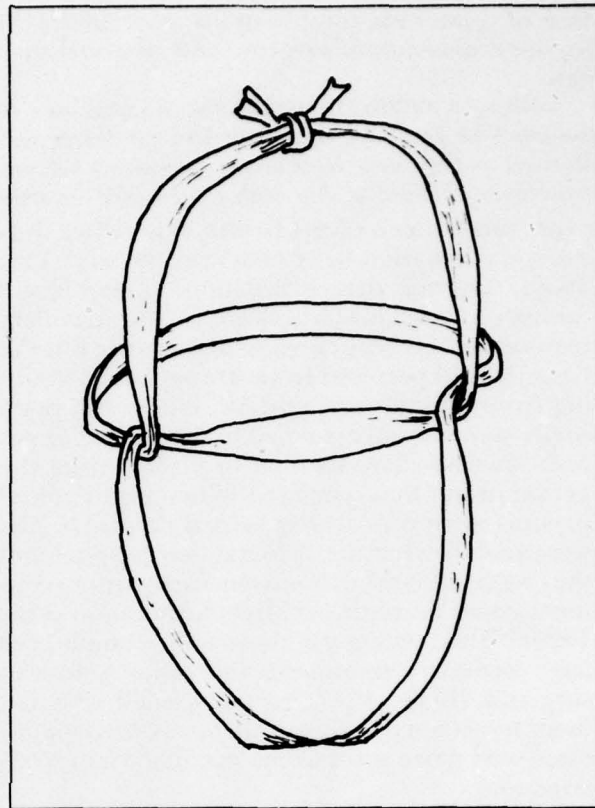


Figure 3.—Illustration of a four-tailed bandage that was used extensively as a first-aid splint in World War I to immobilize the mandible. [From Fry, et al. (1943): Reprinted with the permission of Blackwell Scientific Publications Ltd.]

1927 [a]). Intravenous crystalloid solutions were available though they were not routinely used at this time. Blood transfusions became an accepted clinical procedure during World War I but were administered infrequently, and usually not more than one "pint" was transfused at a time. There was a high incidence of transfusion reaction. Various solutions such as "gum salt" with viscosities similar to blood were also investigated (Beecher, 1955 [c]; Cannon, 1927 [b]).

## SECONDARY RECONSTRUCTION

### Factors Effecting Reconstruction

*Reconstructive treatment of maxillofacial injuries was essentially an undeveloped science prior to 1914.* Surgeons charged with this phase of care were required to be innovative, imaginative, and persevering in order to achieve success in the



face of numerous complications associated with logistics, anesthesia, surgery, and postoperative care.

Late evacuation of maxillofacial casualties to facilities in England or in the United States was limited as *there were rigid orders prohibiting patients from going aboard a ship with jaws locked together in any way* because of the British experience during the evacuation by sea early in the war (Eby, 1920). During that evacuation, a significant number of casualties who were in intermaxillary fixation became seasick while crossing the English Channel and perished from strangulation resulting from aspiration of emesis. As a result, not a single casualty was returned to the United States with intermaxillary fixation in place during the period of war that remained. When maxillofacial patients were transferred to America their jaws were mobilized at the embarkation hospital and they were allowed to function freely until treatment could be resumed after debarkation (Eby, 1920). This procedure obviously complicated later secondary treatment, and some American surgeons (Blair, 1941) recommended that patients be retained in Europe to assure less complicated and more satisfactory maxillofacial reconstruction.

Reconstructive procedures were performed under both regional and general anesthesia. Many of the bone graft operations were accomplished under regional anesthesia (local block and spinal) in an attempt to reduce the anesthetic complications associated with open-drop ether. Reconstructive efforts, therefore, were not undertaken lightly and skeletal reconstruction was initiated only after prolonged conservative methods of treatment had been unsuccessful (Ivy and Eby, 1924 [f]).

### Mandibular Grafting

Surgery to *restore mandibular continuity* was not performed until all sources of infection had been eradicated and at least 6 weeks had elapsed after the closure of sinuses and wounds (Ivy and Eby, 1924 [g]). Bone grafting of the mandible, the only reported site in which grafts were placed, was accomplished by various methods. Solid tibial block grafts (free tibial and tibial osteoperiosteal) (Figure 4) and pedicle grafts from the mandible were the most commonly used systems. In one series compiled by Ivy and Eby (1924 [h]) from

TABLE 1.—World War I Bone Grafts

Series	Type of graft	Successful [%]	Undetermined [%]
I. Ivy and Eby (1924)	Mandibular pedicle (N=34)	29 [85.29]	0
	Tibia-cortex and osteoperiosteal (N=55)	39 [70.91]	0
	Rib (N=6)	6 [100.00]	0
	Ilium (N=7)	5 [71.43]	0
	Bovine (N=1)	0 [00.00]	0
Total	(N=103)	79 [76.70]	
II. Hayes (1920)	Tibia (N=27)	17 [62.96]	4 [14.81]
	Rib (N=4)	3 [75.00]	0
Total	(N=31)	20 [64.52]	4 [12.90]
Combined total of both series (N=134)		99 [73.88]	4 [02.99]

U.S. Army data, an overall success rate of 76.7% (79 of 103) was documented. In Hayes (1920) series, 64.5% (20 of 31) was successful. A compilation of these data shows an overall success rate for bone graft reconstruction of mandible of 73.9% (Table 1).

*Stabilization of the grafted mandible* was accompanied by either intermaxillary fixation or monoarch splinting. If general anesthesia was used, intermaxillary fixation was not employed. Occasionally, however, an open-bite type of splint was used that permitted both access to the upper airway and intermaxillary fixation. Postoperative fixation was usually prolonged (3–6 months).

In considering these reports of mandibular grafting, it must be understood that the *criteria for success* were not necessarily the same as apply today. Restoration of continuity was the principal objective for successful grafting and such shortcomings as lack of masticatory function or marginal esthetics did not necessarily signify failure. The *basic principles* that Hayes (1920) followed in treating his graft patients included: 1) elimination of sepsis before grafting, 2) utilization of aseptic surgical techniques, 3) avoidance of oral communications, 4) firm splinting for segments, and 5) not using general anesthesia if intermaxillary fixation was necessary. Except for caution concerning the general anesthesia, *these principles are still basic* to the performance of bone grafting in the maxillofacial area.

To improve esthetics, *soft tissue procedures* were employed following reconstruction of the bony



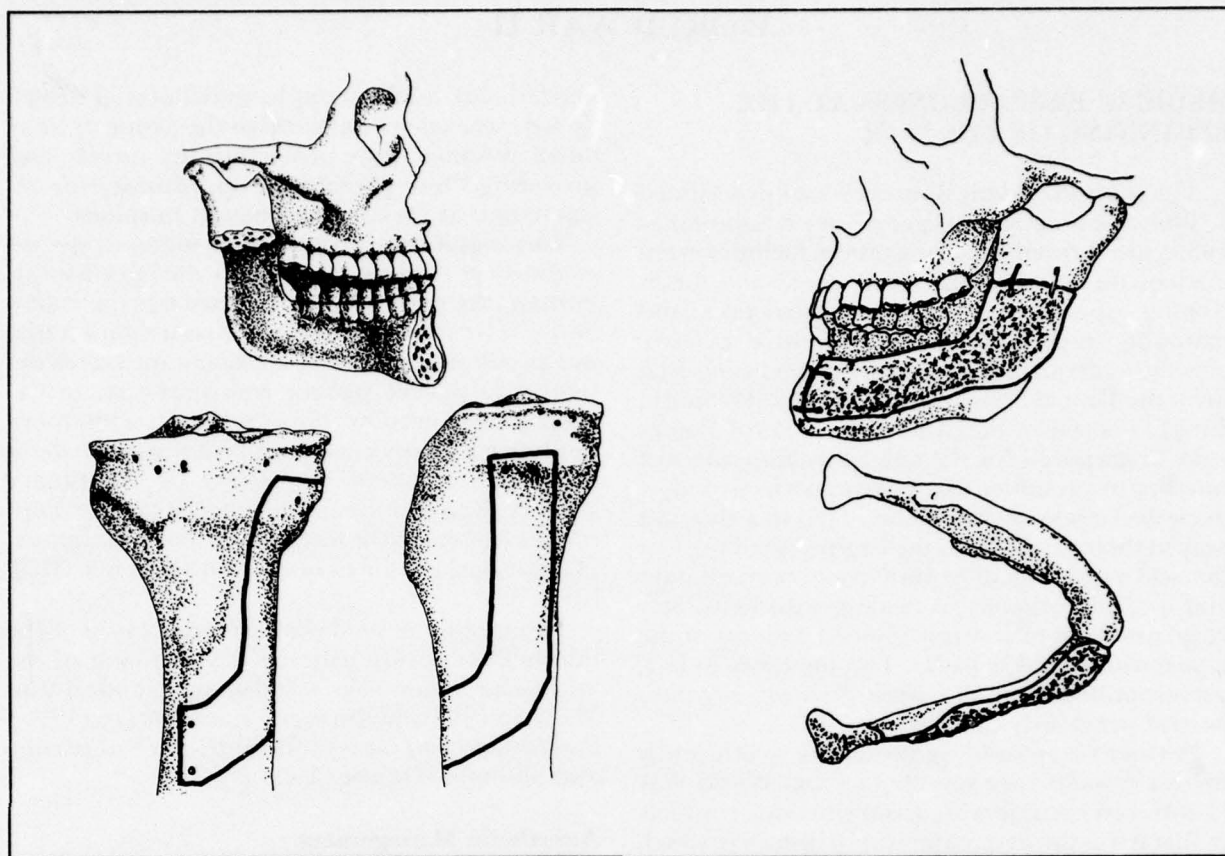


Figure 4.—Outline of a scheme for the utilization of bone from the upper end of the tibia in the repair of extensive defects of the mandible. *Upper left*) Diagram representing an avulsive defect of the left mandible. *Lower left*) Outline of graft to be taken from left tibia, a medial view. *Lower middle*) Anterior view of proposed graft. *Upper right*) Lateral view of the graft in place. *Lower right*) Inferior view of the graft in place—although it was possible to morphologically reconstruct the mandible with this type graft, morbidity and scarring at the donor site were important factors which restricted its selection. Additionally, the graft consisted primarily of cortical bone and healing was therefore necessarily prolonged with patients remaining in fixation from 3 to 6 months.

framework. In those instances in which bone grafting was not possible soft tissue surgery was the only type of reconstruction performed. Various flap designs and skin grafts were introduced and modified in an effort to achieve satisfactory results. Esser (1917) conceived the idea of the buried free skin graft, which became known as the "epithelial inlay" and was used to replace lost mucous membrane. Skin grafting techniques were further modified and improved by Gillies who made innumerable contributions to the treatment of maxillofacial injuries (Ivy and Eby, 1924 [i]; Converse, 1942).

## CONCLUSIONS

This was the first time in recorded history that a universal attempt had been made to accomplish reconstructive surgery in patients who had sustained maxillofacial battle injuries. Under these circumstances the *results obtained were truly remarkable*. It is a testimony to the intelligence and skill of the surgeons that many of the principles they derived are still applicable to maxillofacial reconstruction.

## WORLD WAR II

### MEDICAL PREPAREDNESS AT THE BEGINNING OF THE WAR

Although President Roosevelt had proclaimed a "limited national emergency" on 8 September 1939, the Armed Forces medical facilities were inadequate even for peacetime needs and forthcoming appropriations for construction and manning were aimed at a defensive posture grossly inadequate for the unforeseen events that drew the United States into World War II (Smith, 1956). Therefore the American Medical Forces were ill prepared for the task of treating the vast number of casualties that were to occur in widely dispersed areas of the globe. This was due not only to their small size at the beginning of the war but also to the lack of experience of both military and civilian surgeons in dealing with extremely large numbers of severely injured patients of the type encountered in battle. The situation, in fact, corresponded with the *phase I (latent, negative) interval* previously described (p. 1).

Further compounding the ability to efficiently deliver casualty care was the fact that World War II differed considerably from previous conflicts in that it was the first major war in history in which the *number of fighting men was actually less than the number of men supplying them*. This, of course, was due to the extensive logistic support necessary to conduct war on two major fronts such as the European and Pacific theaters. The long exhaustive marches and the spells in the trenches subject to constant bombardment that characterized World War I were absent, but the *complexities of logistic support existed and had an equally significant effect on battle casualty management*.

Additionally, in 1939 military surgical methods were essentially those of 1918 and as such were 20 years out of date. Also outmoded were the concepts of the "... ponderously moving casualty clearing stations and the permanently immobile station hospitals." (Porritt, 1953 [b] and Ogilvie, 1953 [b]).

### ADVANCES IN PATIENT MANAGEMENT

#### Resuscitation

Many of the valid axioms of World War I were

heeded and, as an example, maxillofacial *casualties were now safely transported* in the prone or head down position, thus protecting the airway and providing these patients an opportunity for resuscitation at forward evacuation hospitals.

Very significant progress was made in the *development of resuscitative measures* during this war. Perhaps the most notable advance was the evolution of a treatment protocol for resuscitation that was predicated on initial lifesaving measures designed to permit patient transportation to the hospital, followed by, but continuous with, more definitive therapy aimed at preparing the patient to safely withstand the stress of emergency surgery. Recognition of the *essential unity of resuscitation and operation* was one of the most important surgical advances of the war (Beecher, 1955 [d]).

The treatment of shock had progressed in the interbellum period with the development of the *continuous intravenous infusion* by Hendon and Matas in 1926 and the ready *availability by 1939 of banked blood* and blood substitutes such as plasma and albumin (Ogilvie, 1953 [c]).

#### Anesthetic Management

*Anesthesiology* was well advanced as a specialty at this time and the opportunities for safe, uncomplicated surgery under general anesthesia were much greater than at the time of World War I. *Sodium pentothal* had been introduced (Jarman and Abel, 1936) and its use became standardized in the Mediterranean theater after earlier difficulties of administration had been corrected. Development and introduction of the *carbon dioxide absorber* (Waters, 1924) and the evolution of *nasotracheal intubation* techniques (Magill, 1920 and Robatham, 1920) contributed significantly to the reduction in morbidity and mortality associated with general anesthesia. Endotracheal intubation and the employment of effective suction devices were advances particularly applicable for reducing complications associated with anesthesia for maxillofacial surgery. No statistical data exist, but it can be inferred from perusal of the literature that the incidence of tracheostomy in the anesthetic management of maxillofacial injuries was greatly reduced in comparison to World War I. Additionally, recognition of the



need for continuous, uninterrupted (pre-, intra-, and post-operative) monitoring of maxillofacial patients further reduced morbidity and mortality.

### Wound Management

The importance of *debridement* was again overlooked at the beginning of the war but it was soon relearned, and this concept assumed a proper role in wound management. In fact the British adopted the concept of specialized teams to manage battle casualties in order to assure proper implementation of debridement principles. It was their impression that, "... when the early surgery [debridement] was not done by the specialist team the incidence of bone gap was exactly the same but late bone infection was nearly three times as common." (Parsons, 1953). Late infection, which delayed healing and complicated treatment, was viewed as being directly related to improper primary wound debridement. As experience with maxillofacial wounds was gained, it was learned that debridement in this area required careful, experienced judgment thus further supporting the British concept of specialized teams to manage battle casualties.

*Primary closure* of wounds was discouraged in the early stages of the war although with the advent of penicillin it was employed at any time during the first 24 hours following injury. Out-moded principles do not succumb easily, however, and even after 1944 many of the older surgeons were adamantly opposed to early primary wound closure because of their previous experience during the preantibiotic era. Despite this occasional reluctance, it became the consensus that primary closure of facial wounds was desirable and was directly dependent upon the skill with which debridement, drainage, and closure were accomplished (Bricker, 1955 [a]).

In those instances in which maxillofacial wound closure could not be accomplished in the immediate postinjury period because of the large number of casualties with higher treatment priorities, *delayed primary closure* was employed even as late as 72 hours post injury. When dealing with these patients, it was thought advisable to await the opportunity for definitive skeletal and soft tissue management rather than to accomplish early expeditious soft tissue closure over untreated underlying fractures. Availability of

chemotherapy and general appreciation of the established principles of wound management were key factors in assuring that infection was less frequent and more localized than that described during World War I (Bricker, 1955 [b]).

### Fracture Management

Various splints and appliances were again used for *fixation and immobilization of fractures*. The American surgeons usually employed simplified wiring techniques, such as *continuous loop or arch bars*, when adequate dentition was available and *acrylic or vulcanite splints* in edentulous cases. The British preferred *metal cap splints* but also used interdental wiring extensively when treating patients in the advanced area. The *Gunning splint* was used most commonly for fractures of the edentulous jaws. Retention and stabilization of these splints were enhanced by *alveolar and circumferential wiring* techniques introduced by Fry et al. (1943) and *pyriform rim wiring* introduced by Thoma (1943).

Before 1942, midfacial fractures were treated without intermaxillary fixation by a *Kingsley splint* (1880) (Figure 5) secured to a head cap thus immobilizing the maxilla independent of the mandible. This type of treatment was replaced by the method of Fry et al. (1943), which involved the use of *intermaxillary fixation alone or in conjunction with a plaster or strap head cap* and splint extension if traction was needed to reduce displaced or unstable fractures. Plaster head caps were difficult to apply by other than skilled and experienced individuals and they frequently became unstable during critical periods of treatment. A more satisfactory method of *cranial fixation* was needed and Crawford (1943) described a *metal headband appliance* (Figure 6) that he had cast from fragments of a propeller blade. This creation had numerous advantages such as elimination of movement, facilitation of craniofacial traction, applicability over scalp wounds, and ease of application. The Crawford cranial headband eventually replaced plaster or strap head caps for the external skeletal treatment of facial fractures.

At about the same time, a non-war-related development was described by Adams (1942) in which he introduced the concept of *internal suspension wiring* for the treatment of midfacial fractures. This method was slowly adopted, and it was not until after the war that its usage was wide-



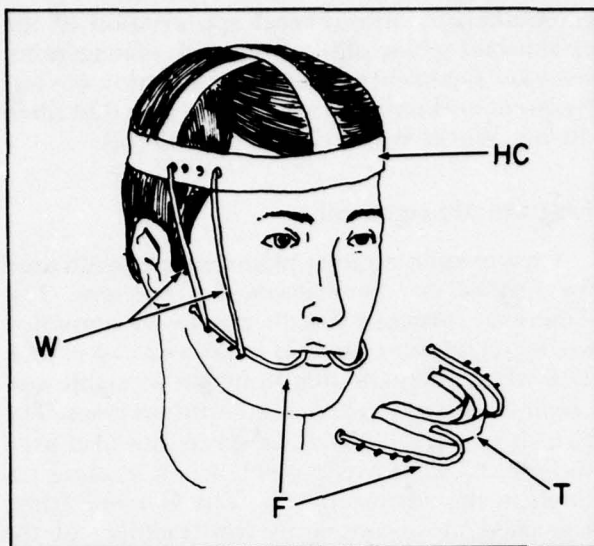


Figure 5.—Example of a Kingsley splint that was fabricated from an impression tray. The tray portion (T) of the oral splint was seated onto the upper arch by means of impression compound and the splint was secured with wires (W) that extended from the flanges (F) of the splint to the head cap (HC) apparatus after the fracture had been reduced. [From Fry, et al. (1919): Reprinted with the permission of Blackwell Scientific Publications Ltd.]

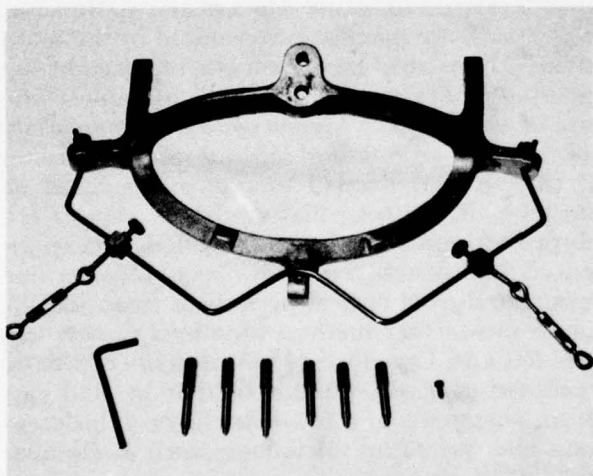


Figure 6.—Crawford headband of the type that was introduced in July 1943. The appliance was lightweight, 10½ oz., easy to apply, and much less cumbersome and more stable than previous cranial fixation devices. [From Crawford, M. J. (1943): Reprinted with the permission of the U.S. Navy Medical Bulletin.]

spread and the need for head frame devices was eliminated in all but the most comminuted, unstable injuries.

Roger Anderson *external skeletal-pin fixation devices* had been previously used for treating or-

thopedic injuries, and innovative adaptations for use in maxillofacial injuries were devised by a number of surgeons (Figure 7) (Clouston, Converse, Fairbanks, Stout, Waknitz, and Walker, 1941-43).

After this type of fixation was introduced for maxillofacial injuries, it was extensively used in early care for reduction and fixation in the absence of immobilization thus allowing evacuation by sea or air without fear of the previously described hazards of motion sickness. The weight of these devices was substantial and, as a result of torque forces developed by the appliance during masticatory movements, osteolysis occurred around the pins and they often became loose and ineffective. Dissimilar and/or biologically incompatible metals were also used in fabrication, which further contributed to osteolysis and failure (Fry, 1953 [a]). The basic concept of treatment embodied in the Roger Anderson fixation device was sound, however, and more effective modifications were later developed.

### Secondary Management

*Evacuation of patients with maxillofacial wounds who required reconstructive treatment was more expeditiously accomplished as compared to that in World War I because of improved modes of*

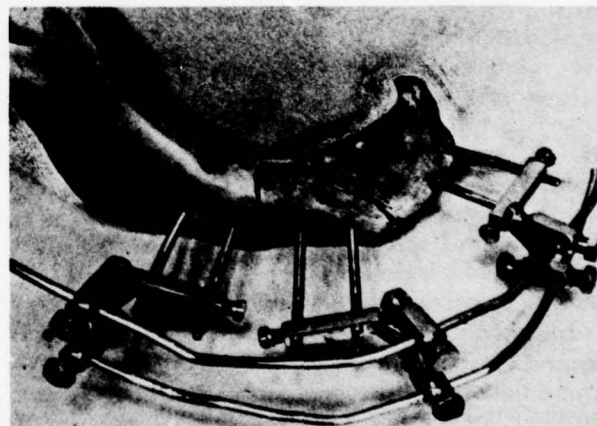


Figure 7.—Illustration of an early maxillofacial adaptation of the Roger Anderson pin fixation device. The device was heavy (> 2 lbs.), cumbersome, and failed frequently as a result of the loosening and/or infection of the bone at the pin site. Unless intermaxillary fixation was used in conjunction with treatment in dentulous cases, malocclusion often resulted. Its greatest advantage was its ability to effectively control edentulous fragments, especially the proximal ramus. [From Thoma, K. H. (1942): Reprinted with the permission of the C. V. Mosby Co.]

transportation and a better understanding of the management requirements of maxillofacial casualties during the process of transfer. In the European theater patients were evacuated to 10 medical centers in England that were staffed and equipped to treat maxillofacial injuries (Bricker, 1955 [c]). Patients from the Pacific theater were evacuated to either Hawaii or the Continental United States (CONUS) for treatment.

One important lesson learned from World War I and aptly applied during World War II was *the need for formal communication between various disciplines* concerned with the care of maxillofacial casualties. During the war of 1914–18 expertise in the treatment of facial injuries was shared by too few surgeons, for whatever reasons, with the inevitable result “. . . that unless the wound fell into those hands, not only were they badly treated or not treated at all but many of the patients died, quite unnecessarily, from asphyxia.” (Fry, 1953 [b]). As a result of improved communications major mistakes involving maxillofacial care were avoided and the casualties were afforded more consistent treatment.

The *majority of bone grafts* for reconstruction of maxillofacial injuries were of the *corticocancellous, one piece, block variety*. The principal anatomic site of bone recovery was the iliac crest, which had, since World War I, become the most frequently used donor site for maxillofacial bone grafting. These block grafts were slowly revascularized and required at least 3 months of immobilization to obtain stability. In addition, it was thought that because of their compact nature

they were more susceptible to infection though no specific data exist to substantiate this observation (Mowlem, 1944). Cancellous chip grafts were introduced at this time by Mowlem (1944) and gained acceptance during the later stages of the war.

*Improved fixation, availability of antiinfective agents, and use of more viable graft material (i.e., cancellous component) contributed to the overall success of reconstruction.* It should be noted that successful reconstruction was associated with fewer complications and was accomplished with greater ease than during World War I.

*Skin grafting techniques* were improved during the period following World War I. A calibrated knife, which was the first practical instrument that allowed calibration of skin grafts and thus regulation of thickness, was developed by Finochietto in 1920 (Converse, 1974). Subsequently, Blair and Brown (1929) described the split-thickness graft which broadened the applicability and effectiveness of skin grafting and Padgett (1939) introduced the first dermatome which greatly facilitated graft retrieval—this instrument was utilized almost exclusively for taking skin grafts during the second World War. Split-thickness skin grafts were employed in reconstruction of facial injuries in a variety of ways. For example, the split-thickness graft was used to restore lost vestibular depth in patients who had undergone bone grafting procedures to facilitate wearing of oral prosthetic appliances and in conjunction with flaps to establish a “mucosal” lining for the oral cavity.

## KOREAN WAR

At 0400 on Sunday, 25 June 1950, the North Korean army swept across the 38th parallel triggering the Korean war. American forces were rapidly mobilized and on 1 July the first American combat unit landed in Korea (Reister, 1973 [a]).

### LOGISTIC SUPPORT OF CASUALTY TREATMENT

Hospital support was austere during the first months of the war and adequate surgical care

could not always be rendered in-country; therefore, early air evacuation to Japan became routine. By October 1951, however, sufficient skilled surgeons were available to organize specialty teams, which were located in various mobile medical facilities and Fixed Evacuation Hospitals in Korea (Reister, 1973 [b]).

Two logistic innovations of this war were highly instrumental in saving countless lives—the Mobile Army Surgical Hospital (MASH) and, most importantly, the concept of *early evacuation by helicopter*. Casualties were sorted at medical



clearing stations and then transported to MASH or Fixed Evacuation Hospitals where they underwent definitive treatment within hours of injury. These facilities were staffed by surgical teams composed of those specialists necessary to manage the various types of wounds encountered. Such rapid evacuation of the severely injured patients improved their opportunity for survival, as is evidenced by Army data indicating that 40% of 10,000 casualties was admitted to medical care within 1 hour following wounding and 70% within 3 hours. This early care, along with other improved medical procedures, *reduced the mortality rate* from wounding from 4.5% experienced in World War II to 2.5% in Korea (Reister, 1973 [c]).

The patients transported by helicopter were placed in specially designed litters that were secured in place outside the cabin and therefore were inaccessible during flight. To obviate airway complications in the maxillofacial patient during this type of transportation, tracheostomy was performed at the medical clearing station if there was any question of airway jeopardy. The number of maxillofacial injury cases receiving tracheostomy (10%) was therefore increased compared with World War II (2%) (Chipps et al., 1953).

## WOUND MANAGEMENT

### Debridement and Primary Closure

*Debridement*, which proved so vital in wound management during previous conflicts, was scrupulously applied. *Primary closure* of these injuries was routinely employed for the first time and *when properly applied* this significantly improved not only patients' morale, but also reduced infection, facilitated healing, and reduced scarring. Chipps et al. (1953) reported that in their series of more than 1,000 maxillofacial war injuries 30% of the primary closures involving the mouth broke down. They attributed these failures to: 1) tight closure of wounds without provision for deep tissue drainage, 2) inadequate use of bandages, 3) failure to treat the oral surface of the wound, 4) secondary hemorrhage, 5) secondary manipulation of the repaired wound, and 6) inadequate chemotherapy. The *success of primary wound closure* was stated as being directly propor-

tional to the attention paid to standard surgical principles of debridement, hemorrhage control, proper suturing, maintenance of drainage, adequate use of bandages, and administration of adequate chemotherapy.

### Delayed Wound Closure

In those instances in which wound breakdown occurred, *delayed primary closure was performed* after the wound had been prepared by use of effective antibiotics, continuous wet dressings, and redebridement. The process of wound preparation rarely exceeded 5-7 days. Closure by direct approximation of wound edges, skin grafting, or suturing mucosa to skin across a defect generally accomplished the desired results. No such complex closure methods as pedicled flaps were attempted (Chipps et al., 1953).

### Fracture Reduction and Fixation

*Open reduction* of fractures with direct osseous wiring was another method of treatment used on a large scale for the first time during the Korean war. Although *immobilization techniques* varied somewhat, the most simple technique consistent with satisfactory results was considered to be the method of choice—continuous loop wiring with elastic traction was the most popular. Semirigid arch bars were also commonly employed, particularly with avulsive injuries, because of the improved stability they provided (Oddo, 1953). External skeletal-pin fixation, which had fallen into disrepute during and after World War II, was further improved with the introduction of the biphasic appliance by Morris (1949). This appliance will be discussed in more detail in later chapters.

### Anesthetic Management

*Sodium pentothal supplemented with nitrous oxide and oxygen* was the anesthetic of choice and endotracheal intubation was utilized in all maxillofacial injuries except those in which tracheostomies were performed (Oddo, 1953). Whenever possible, nasotracheal intubation was utilized to give the surgeon unrestricted access to the mouth and to allow reduction and immobilization of the fractured facial bones by intermaxillary fixation.



### Reduced Overseas Hospitalization

*As a result of the application of the sound principles that had evolved up to the time of Korea, the casualties were afforded an increased opportunity for satisfactory wound treatment.* During this conflict the average patient spent 35 days in overseas military facilities before evacuation to the United States, which is in sharp contrast to World Wars I and II where

months or even years elapsed before evacuation to CONUS. The reason for this shortened overseas hospitalization included the following: improved early care including primary closure of wounds (which resulted in more rapid healing), improved fixation, and perhaps most important, the general availability of air evacuation to CONUS (Reister, 1973 [d]).

## CONCLUSION

There has been deliberate, albeit sporadic, progress in the treatment of maxillofacial war injuries during this century. The *meaningful advances have evolved slowly and laboriously* with frequent retrial of therapies that have been modified to meet the perceptions of the various surgeons. Underlying the manner in which surgical progress has occurred are the human attributes of surgeons, such as activism, ready adaptation of an early position of advocacy for new therapies, and a traditional adherence to the value of testimonial evidence (Spodick, 1973). During the past decade or two a notable interest and an increase in scientific inquiry have pervaded the surgical world; it is anticipated that future progress will be less sporadic and the validity of evolving therapies will be established sooner and more conclusively than in the past.

Perhaps the most persistent truism that has

surfaced in the review of the history of maxillofacial war injuries is the *paramount importance of interdisciplinary communication and cooperation* in the treatment of these complex injuries. While there will always be a few men of uncommon vision and skill from each generation, it falls on the majority of surgical clinicians to achieve an atmosphere of mutual respect and cooperation characterized by a willingness to learn and share with others in the management of war-injured patients.

It is apparent that in time of war there is a need for surgeons trained in the treatment of conditions affecting the maxillofacial area to unite in a common effort to better achieve the common goal of optimal patient care. Failure to attempt such unification will invariably result in ineffective utilization of manpower and a compromise in the management of casualties.

## SURGICAL ADVANCES AFFECTING THE TREATMENT OF MAXILLOFACIAL WAR INJURIES

### 1914-1919

- Protection of the airway in facial fracture patients with emergency splinting and correct body positioning.
- Irrigation and debridement of orofacial wounds.
- Early fixation and immobilization of skeletal fractures with practical methods of interdental wiring.
- Successful bone-graft reconstruction.
- Skin grafting for oral reconstruction.

### 1939-1945

- Antiseptic therapy that permitted primary wound closure and greatly reduced postinjury sepsis.
- The use of biologically compatible stainless-steel wire for direct fracture reduction.
- Improved techniques of dental, interdental, and direct wiring for treating facial fractures.
- Application of external skeletal-pin fixation to the treatment of jaw fractures.
- Craniofacial suspension of midfacial fractures

utilizing a skeletal headband (synonymous with head frame).  
 -Cancellous chip bone graft reconstruction.

#### 1950-1952

-Successful rotary and fixed wing evacuation of war casualties on a routine large-scale basis.  
 -Routine primary closure of wounds.  
 -Routine open reduction of skeletal fractures.

#### Interbellum Advances

1911 Procaine local anesthesia introduced in the United States.  
 1920 Development of calibrated knife for skin graft recovery.  
 1920 Introduction of eyelet dental wiring for

fracture reduction.

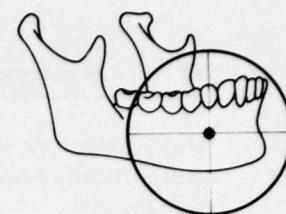
1923 Application of intermaxillary elastic traction for reduction of facial fractures.  
 1929 Split-thickness skin grafting introduced.  
 1929 Introduction of Risdon dental wiring for fracture reduction.  
 1938 Sulfonamide therapy introduced.  
 1939 Dermatome (Padgett) employed for skin graft recovery.  
 1942 Introduction of internal suspension wiring for treatment of facial fractures (civilian development non-war related).  
 1944 Development of dental acrylic resins for construction of oral prostheses (non-war related).  
 1949 Development of biphasic external skeletal-pin fixation for jaw fracture reduction.

## BIBLIOGRAPHY

- Adams, W. M.: Internal wiring fixation of facial fractures. *Surgery* 12 (4):523-540, 1942.
- Beecher, H. K.: Resuscitation of men severely wounded in battle. *Surgery in World War II. General Surgery*, Vol. 2, Washington, D.C., Historical Unit, Army Medical Service, 1955, pp [a] 53, [b] 54, [c] 21, and [d] 6.
- Blair, V. P.: Unpublished correspondence. Personal file of Dr. R. H. Ivy, Archives Army Medical Historical Unit, 1941.
- Blair, V. P.: Relation of the early care to the final outcome of major face wounds in war surgery. *Milit Surg* 92:12-17, 1943.
- Blair, V. P., and Brown, J. B.: Use and uses of large split skin grafts of intermediate thickness. *Surg Gynecol Obstet* 49:82, 1929.
- Bricker, E. M.: *Plastic Surgery: Surgery in WW II. Activities of Surgical Consultants*, Vol. 2, Washington, D.C., US Govt Print Off, 1955, pp [a] 530, [b] 531, and [c] 519.
- Cannon, W. B.: Wound shock. *The Medical Department of U.S. Army in the World War. Part I*, Vol. 11, Washington, D.C., US Govt Print Off, 1927, pp [a] 193, and [b] 194.
- Chippis, J. E., Canham, R. G., and Makel, H. P.: Intermediate treatment of maxillofacial injuries. *US Armed Forces Med J* 4:951-976, 1953.
- Converse, J. M.: War injuries of the face. *Trans Am Acad Ophthalmol* (1941) 46:250-55, May-June, 1942.
- Converse, J. M.: *Kazanjian and Converse's Surgical Treatment of Facial Injuries*, 3rd ed. Baltimore, Williams and Wilkins Company, 1974, p 536.
- Crawford, M. J.: Appliances and attachments for treatment of upper jaw fractures. *US Nav Med Bull* 41:1151, 1943.
- Eby, J. D.: Intermaxillary wiring. *J Am Dent Assoc* 7:771-82, 1920.
- Esser, J. F.: Studies in plastic surgery of the face. *Ann Surg* 65:297, 1917.
- Fry, W. K.: *Maxillofacial Injuries: History of the Second World War: Surgery*. London, Her Maj Stat Off, 1953, pp [a] 369 and [b] 375.
- Fry, W. K., Shepherd, P. R., McLeod, A. C., and Parfitt, G. J.: *The Dental Treatment of Maxillo-Facial Injuries*. England, Blackwell Scientific Publications Ltd., 1943, p 345.
- Gilmer, T. L.: A case of fracture of the lower jaw with remarks on treatment. *Arch Dent* 4:388, 1887.
- Gunning, T. B.: Simple interdental splint. *Richmond Med J* 1:318, 1866.
- Hardaway, R. M.: Surgical research in Vietnam. *Milit Med* 132:873-887, 1967.
- Hayes, G. B., ed.: *Maxillofacial Surgery: Histories of 146 Selected Cases of Facial Wounds Treated at the American Ambulance, Paris, France (1914-1917)*, 1920. Unpublished.
- Imbert, L., and Real, P.: *Fracture of Lower Jaw*. London, Univ. of London Press, 1918.
- Ivy, R. H.: Surgery of the face, mouth and jaws, thirty years ago and now. *J Oral Surg* 1:95-99, 1943.
- Ivy, R. H., and Eby, J. D.: *Maxillofacial Surgery. (Surgery)*, Part 2, Vol. II, The Medical Department of U.S. Army in the World War. Washington, D.C., US Govt Print Off, 1924, pp [a] 400, [b] 402, [c] 397, [d] 407, [e] 398, [f] 429, [g] 429, [h] 452, and [i] 470 and 462.
- Jarman, R., and Abel, A. L.: Intravenous anaesthesia with pentothal sodium. *Lancet* 1:422, 1936.
- Kingsley, N. W.: *Treatise on Oral Deformities*. New York, D. Appleton and Company, 1880, p 377.
- McGee, R. P.: The maxillofacial surgeon in a mobile hospital. *JAMA* 73:1114-1118, 1919.
- MacLeod, G. H. B.: *Notes on Surgery of War in Crimea*. Philadelphia, J. B. Lippincott and Company, 1862, pp 198-201.
- Magill, I. W.: Forceps for intratracheal anesthesia. *Br Med J* 2:670, 1920.
- Morris, J. H.: Biphasic connector, external skeletal splint for reduction and fixation of mandibular fractures. *Oral Surg* 2:1382-1398, 1949.
- Mowlem, R.: Cancellous chip bone grafts. *Lancet* 2:746-748, 1944.
- Oddo, S. G.: The management of maxillo-facial injuries at the mobile army surgical hospital level. *Milit Bull, US Army-Far East* 1:73-75, 1953.
- Ogilvie, W. H.: General introduction: Surgery in war-time. *History of the Second World War: Surgery*. London, Her Maj Stat Off, 1953,

- pp [a] 3, [b] 5, and [c] 7.
- Padgett, E. C.: Calibrated intermediate skin grafts. *Surg Gynecol Obstet* 69:799, 1939.
- Parsons, L.: *Maxillofacial Injuries in the Mediterranean Theater of Operation*. Ft. Detrick, Maryland, US Army Med Historical Unit. Unpublished, 1953.
- Porritt, A.: *Treatment of War Wounds, History of the Second World War: Surgery*. London, Her Maj Stat Off, 1953 pp [a] 9-10 and [b] 10.
- Reister, F. A.: *Battle Casualties and Medical Statistics: U.S. Army Experience in the Korean War*. The Surgeon General, Department of the Army. Washington, D.C., US Govt Print Off, 1973, pp [a] 55, [b] 83, [c] 83, and [d] 71.
- Robatham, S.: Intratracheal anesthesia by the nasal route for operations of the mouth and lips. *Br Med J* 2:590, 1920.
- Roberts, J. B.: *War Surgery of the Face*. New York, William Wood and Company, 1919, pp [a] 63-64, [b] 226, [c] 113, and [d] 237.
- Schwartz, L. L.: The development and the treatment of jaw fractures. *J Oral Surg* 2:193-221, 1944.
- Sigerist, H. E.: War and medicine. *J Lab Clin Med* 28:531, 1943.
- Smith, C. M.: *The Medical Department Hospitalization and Evacuation*. Zone of Interior. Washington, D.C., US Govt Print Off, 1956, p 3.
- Spodick, D. H.: The surgical mystique and the double standard: Controlled trials of medical and surgical therapy for cardiac disease, analysis, hypothesis, proposal. *Am Heart J* 85:579-83, 1973.
- Stout, T. D.: *War Surgery and Medicine—Official History of New Zealand in the Second World War, 1939-45*. Wellington, New Zealand, War History Branch, Department of Int Affairs, 1954, pp [a] 38-39 and [b] 3.
- Thoma, K. H.: A new method of intermaxillary fixation for jaw fractures in patients wearing artificial dentures. *Am J Oral Surg* 29:433-441, 1943.
- Waters, R. M.: Clinical scope and utility of carbon dioxide filtration in inhalation anesthesia. *Curr Res Anesth* 3:20, 1924.





## CHAPTER II

# Treatment Goals

By BILL C. TERRY  
JAMES F. KELLY

## ORAL AND MAXILLOFACIAL CASUALTIES

The management of oral and maxillofacial war injuries presents complex therapeutic and logistic problems as exemplified in the preceding chapter. In the remainder of this text the nature and magnitude of the problems encountered in the Vietnam conflict will be reviewed and treatment goals identified and discussed. A *long-term maxillofacial casualty study (MFCS)* initiated by the Navy Medical Department during the Vietnam period serves as the basis for this analysis. This ongoing study is a documented appraisal of maxillofacial treatment, emphasizing masticatory or jaw injuries, and includes the early, intermediate, and late phase of casualty management as well as long-term follow-up.

Although the involvement of the United States in the Vietnam conflict spanned the period from January 1961 to March 1973, substantial combat forces (> 25,000) were not present until 1965 when U.S. troop strength reached almost 200,000. During the period of 1 January 1965

through 31 March 1973, U.S. military troop levels in the Republic of Vietnam totaled 2,594,200. Of this number 303,649 or 12% sustained war-related injuries of which 153,309 or 6% required hospitalization (U.S. Department of Defense, 1973). *Maxillofacial casualties* reportedly represent between 10 and 15% of war injuries (Tinder et al., 1969), thus the total number of maxillofacial injuries in Vietnam can be estimated at between 30,365 and 45,547. One factor influencing the incidence of oral and maxillofacial injuries was discussed by Maughon (1970). He evaluated the nature of wounds resulting in killed in action in 2,600 Vietnam casualties and made the following observation. "The large number of head and neck wounds [46.6%] was impressive, especially those where a single wound or small fragment was the only apparent injury. There is no question in my mind that the enemy was an expert marksman in these instances and deliberately aimed for the face or neck."

## LOGISTIC CONSIDERATIONS

Since the cases in the MFCS were managed against the logistic background of the Vietnam conflict (1961-73), a description of those circumstances is necessary to establish a perspective for the environment in which treatment was accomplished. Climate, geography, and military capability may preclude an exact application of these experiences to future situations, yet certain

principles stand out as basic to the management of maxillofacial injuries under any circumstances.

Understanding the fact that the *care of battle injuries was dependent on the logistics of the military situation* in effect at the time was extremely important. This was particularly true with maxillofacial casualties because they frequently involved prolonged and complex treatment carried out within

the framework of existing logistic patterns that were usually predicated on nonmaxillofacial considerations.

Logistic considerations influenced treatment and treatment goals through all stages of care. These considerations primarily included distribution of health care personnel and organiza-

tion of treatment facilities at all levels, planning and operation of an evacuation system, dispersal of patients according to their therapeutic, psychologic, and social needs, coordination and documentation of care, and institution of an effective recall and follow-up system to provide continuing therapy as long as required.

## THERAPEUTIC GOALS

The overall therapeutic goal in the clinical management of patients with maxillofacial war injuries, in addition to immediate lifesaving treatment, was to optimally restore all vital and secondary functions associated with the orofacial complex. This included reestablishment and maintenance of masticatory and communicative abilities as well as acceptable cosmetics. Such rehabilitation was a demanding challenge for the

surgeon and all other personnel associated with care of these patients.

Treatment goals may be logically discussed according to the *intervals of treatment—early, intermediate, and late*. The patients experienced different but overlapping needs during each period. These intervals will be discussed individually with the knowledge that they were logistically and therapeutically inseparable.

## EARLY CARE

### LOGISTICS

During the early phase there was usually one or more rapid medical evacuations by various means. Early patient transport was critical and was accomplished by stretcher, motor vehicle, helicopter, boat, or a combination of these. Transport vehicles usually did not have medical support materials or personnel aboard. The first transfer was most frequently to an established secondary field care center. Further evacuation was often necessary to a conveniently located fixed hospital facility, but multiple early transfers to different treatment facilities were minimized. Whenever possible an attempt was made to rapidly evacuate a severely injured patient by helicopter directly from the field of battle to an alerted definitive care hospital.

Essentially all *early care, by definition, took place in South Vietnam* or in hospital ships in the adjacent coastal waters. The early phase of treatment was considered concluded at the time of evacuation of the patient from the war zone hospital, normally by air, to an intermediate staging hospital in Japan, the Philippines, Guam, or Hawaii. This med-

ical evacuation of patients from the war zone was performed by specially configured transport aircraft that normally carried medical support materials and nursing personnel.

TABLE 2.—*Hospital Admission and Medical Evacuation Intervals (Days) for MFCS Patients*

	Mean	Range
Date of injury (DOI) to discharge, early facility (N=157)	7.75	1- 36
Discharge early to admission, intermediate facility (N=39)	1.64	1- 7
Admission to discharge, intermediate facility (N=105)	17.42	2-209
Discharge intermediate to admission late facility (N=62)	3.15	1- 10
Total, DOI to admission, late facility (N=154)	24.55	1-216
Admission to discharge, late facility (N=138)	268.96	2-799
Total, DOI to discharge, late facility (N=138)	289.26	22-858



The time interlude of the early phase for MFCS patients was usually rather short although it did fluctuate depending on many variables such as patient condition, general patient load, location and tempo of battle activities, availability of treatment facilities and personnel, and availability of evacuation transportation. The mean duration of early care hospitalization was 7.75 days, whereas the range was from 1 to 36 days (Table 2).

*The general goal at the early treatment facilities was to evacuate from Vietnam those patients in need of long-term or special care as soon as initial and early acute care was completed and the patient was sufficiently stabilized to tolerate air evacuation procedures. It should be noted that in Vietnam, as with all wars, logistics were evolutionary and depended on the location and tempo of battle activity, which were continually changing (White, 1968; 1971).*

## PATIENT CARE

### Initial Care

The early phase of treatment began with the initial care that the patient received after sustaining an injury and consisted of first aid and/or resuscitative measures. This phase of military medical care is referred to as *first echelon* (NATO, 1975). In Vietnam this care was usually initiated by paramedical personnel who were operating directly with combatant forces. These corpsmen were trained and equipped to provide first aid as well as more involved care including establishing and maintaining an airway, controlling hemorrhage, and instituting therapy for shock. They were usually able to evaluate the patient's immediate needs and initiate evacuation.

Initial transfer was to a facility staffed and equipped to provide a continued and/or upgraded level of therapy—*second echelon care*. This was often a field aid station or mobile medical unit staffed by physicians, dentists, and supporting personnel whose function was to provide emergency care including initial resuscitation and to determine the priority of the casualty for continued evacuation. These emergency stations were usually located adjacent to a transportation facility, either surface or helicopter, so that the wounded requiring hospitalization could be

quickly transported to hospitals having facilities to meet their immediate needs. The majority of these patients were transported by helicopter.

In some instances, early wound care was provided by medical or paramedical personnel in direct combat zone installations—*third echelon care*. Some minor abrasions, lacerations, or sprains were definitively treated while initial wound care and resuscitation was provided in other instances. The minor injuries usually did not require extensive care, were not severely handicapping, and could be easily followed up in the aid station at a more convenient time. Other patients whose injuries were more severe were evacuated to a rear echelon facility after initial care had been provided.

### Definitive Care

Patients whose injuries were more than extremely minor or would materially interfere with the normal performance of duties were transported to evacuation hospitals—*fourth echelon care*. Because of the rapid evacuation made possible by almost immediate triage and availability of transportation at advanced facilities, resuscitative measures and initial shock management were often still being carried out on arrival at the evacuation hospitals. In general, early care hospital facilities that provided definitive care had personnel, supplies, and equipment to begin wound care once the patient's vital signs stabilized.

For some maxillofacial injury patients it was possible to render early care sufficiently definitive in nature to obviate secondary reconstructive surgical procedures. In one series of 110 casualties treated during the earlier phase of the Vietnam conflict (1965–66) 41% of the patients received early definitive surgical care that permitted them to be returned directly to active duty in Vietnam within 60 days after convalescence at the early care facility (Terry, 1969). These patients were obviously those that had not sustained substantial loss of bone or soft tissue and did not have complicating postsurgery problems. They were also among those who were rapidly evacuated from the battle zone and were able to receive definitive surgical care within several hours following injury. The number of patients for whom initial definitive maxillofacial care was sufficient was probably higher since some patients who would undoub-



tedly not have required secondary maxillofacial care had to be evacuated because of concomitant injuries and were not included in the 41%.

*As the number of casualties increased the availability of beds for convalescence at early care facilities was sharply reduced and virtually all patients were evacuated following their early treatment.*

Regardless of the logistics involved in patient management, surgeons rendering definitive care attempted to follow certain basic principles that were directed toward providing uncomplicated hard and soft tissue wound care. These principles will be elucidated in the early care chapter.

## INTERMEDIATE CARE

### LOGISTICS

Following early care all patients who could not be returned to full duty were prepared for evacuation to the intermediate care facilities throughout the Pacific theater (PACOM) where their treatment was continued. Occasionally, patients were flown from Vietnam directly to military hospitals in the Continental United States (CONUS) (see Figure 43). The evacuation decisions were based on the medical condition of the patient as well as casualty flow numbers, patient load, and other considerations related to transportation that influenced the evacuation plan. The mean interval of transfer from early to intermediate facilities was 1.64 days (Table 2).

### PATIENT CARE

Intermediate care encompassed the period from arrival at the designated intermediate hospital until evacuation to CONUS. The mean period of intermediate hospitalization for MFCS patients was 17.42 days with a range of from 2 to

209 days (Table 2). During this hospitalization a variety of treatment was afforded including general supportive care, management of postsurgical complications such as infection or dehiscence, revision of fixation devices, additional debridement as indicated, and in some instances definitive fracture reduction or wound closures.

In this phase it was particularly important to establish positive rapport with the patient to enhance his mental attitude regarding his injury and the projected treatment outcome. Experience in dealing with the psychologic aspects of war injuries on the part of the surgeon proved invaluable in building healthy psychologic attitudes in these patients. Early recognition of potentially serious psychiatric abnormalities was, of course, highly desirable though such conditions were seldom manifested during this period. Immense psychologic uplifting was provided by concerned nursing personnel and others including chaplains and their assistants. It was noted that the overall morale of patients was better if those having similar injuries could be grouped together in the same ward or hospital area.

## LATE CARE (RECONSTRUCTION-REHABILITATION)

The late care interval began approximately 3 weeks following injury. For the patients in the MFCS the mean interval from date of injury to the admission at the late care facility was 24.55 days (Table 2). Although the range for this interval was from 1 to 216 days, it was rare that patients arrived at a CONUS facility in less than 4 or 5 days or in more than 30 days.

The late care facility was generally the military

hospital closest to the patient's home with staff and facilities necessary to manage his injuries and their complications until final military disposition. *On arrival at this hospital the casualty was again thoroughly examined and evaluated.* All accompanying records including transfer summaries, laboratory findings, radiographs, operation reports, and oftentimes handwritten notes from previous surgeons were carefully reviewed.

Routine, as well as special, laboratory and radiographic studies were obtained. If the maxillofacial injury was the only or most severe problem, the patient was usually admitted to the service that was best able to manage the principal maxillofacial condition. When the maxillofacial injury was not the most serious problem, or when patients had multiple injuries, the maxillofacial surgeons usually functioned in a consultative role. The majority of jaw-injured patients were eventually transferred to the Dental Service since their total masticatory reconstruction and rehabilitation required the longest period of treatment.

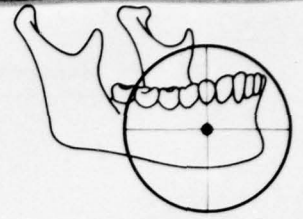
During late care specific attention was directed to the general goals of *reestablishment and maintenance of masticatory and communicative abilities as well as acceptable cosmetics*. Frequently this only required general supportive care during the healing of hard and soft tissues followed by minimal physiotherapy to assist in reestablishing normal function. Other patients required vestibuloplasties, scar revision, and prostheses of varying complexity. Still others required extensive reconstructive surgical procedures including bone grafting, soft and special tissue procedures, and complicated prosthetic treatment.

Surgeons performing late care were faced with many diagnostic and therapeutic challenges and called upon other specialists in solving these complex problems. *Late management ideally became a team effort* because no one individual was prepared to satisfactorily resolve all the varied problems presented by these patients. Every effort was made to formulate treatment plans that would eventually satisfy the identified treatment goals. These treatment plans, which often would require months or even years to complete, were frequently reviewed and altered as needed to fit the overall goals. The patients were kept informed of their progress and were encouraged to become a cooperative part of the total team effort. Most MFCS patients underwent prolonged treatment at the late care facilities. The mean period of CONUS hospitalization was 268.96 days, thus the mean period of hospitalization from date of injury to discharge from the CONUS military facility was 289.26 days (Table 2). In addition, many of these patients require continued follow-up that will extend the rest of their lives. The remainder of the text will concern specific problems of management during these complicated and prolonged treatment intervals.

## BIBLIOGRAPHY

- Department of Defense, OASD (Comptroller). Directorate for Information Operations. March 14, 1973 and December 7, 1973. NATO Handbook. *Emergency War Surgery* (US Revision). Washington, D.C., US Govt Print Off, 1975, pp 2-3.
- Maughon, J. S.: An inquiry into the nature of wounds resulting in killed in action in Vietnam. *Milit Med* 135:8, 1970.
- Terry, B. C.: Facial injuries in military combat: Definitive care. *J Oral Surg* 27:551, 1969.

- Tinder, L. E., Osbon, D. B., Lilly, G. E., Salem, J. E., and Cutcher, J. L.: Maxillofacial injuries sustained in the Vietnam conflict. *Milit Med* 134:668, 1969.
- White, M. S.: Medical aspects of air evacuation of casualties from Southeast Asia. *Aerosp Med* 39:1338, 1968.
- White, M. S., Chubb, R. M., Rossing, R. G., and Murphy, J. E.: Results of early aeromedical evacuation of Vietnam casualties. *Aerosp Med* 42:780, 1971.



## CHAPTER III

# *Anatomic Illustrations*

---

Regardless of when or where a human being is injured the common denominator of the surgical care he receives will be anatomy. Nowhere is this more evident than in the oral and maxillofacial area where there exists an extremely complex morphologic, functional, and esthetic milieu.

Perhaps the finest graphic illustrations of human anatomy have been prepared by Frank J. Netter, M.D., under the auspices of the CIBA Foundation. Rather than developing illustrations of maxillofacial anatomy for the numerous conditions discussed in this text, we have elected to reproduce selected Netter illustrations that, in our opinion, clearly and accurately represent the

anatomy that is considered. These illustrations (Figures 8-15) have been printed through the courtesy of Dr. Netter and the CIBA Foundation. We will not refer to them frequently but rather will rely on individual readers to determine at what point in the text they require an anatomic reference to better appreciate the narrative. In addition, it is the hope of the authors that inclusion of this section will provide a completeness to the publication that will enhance it as a practical single-source document for those surgeons who are called on in the future to manage the care of maxillofacial casualties.



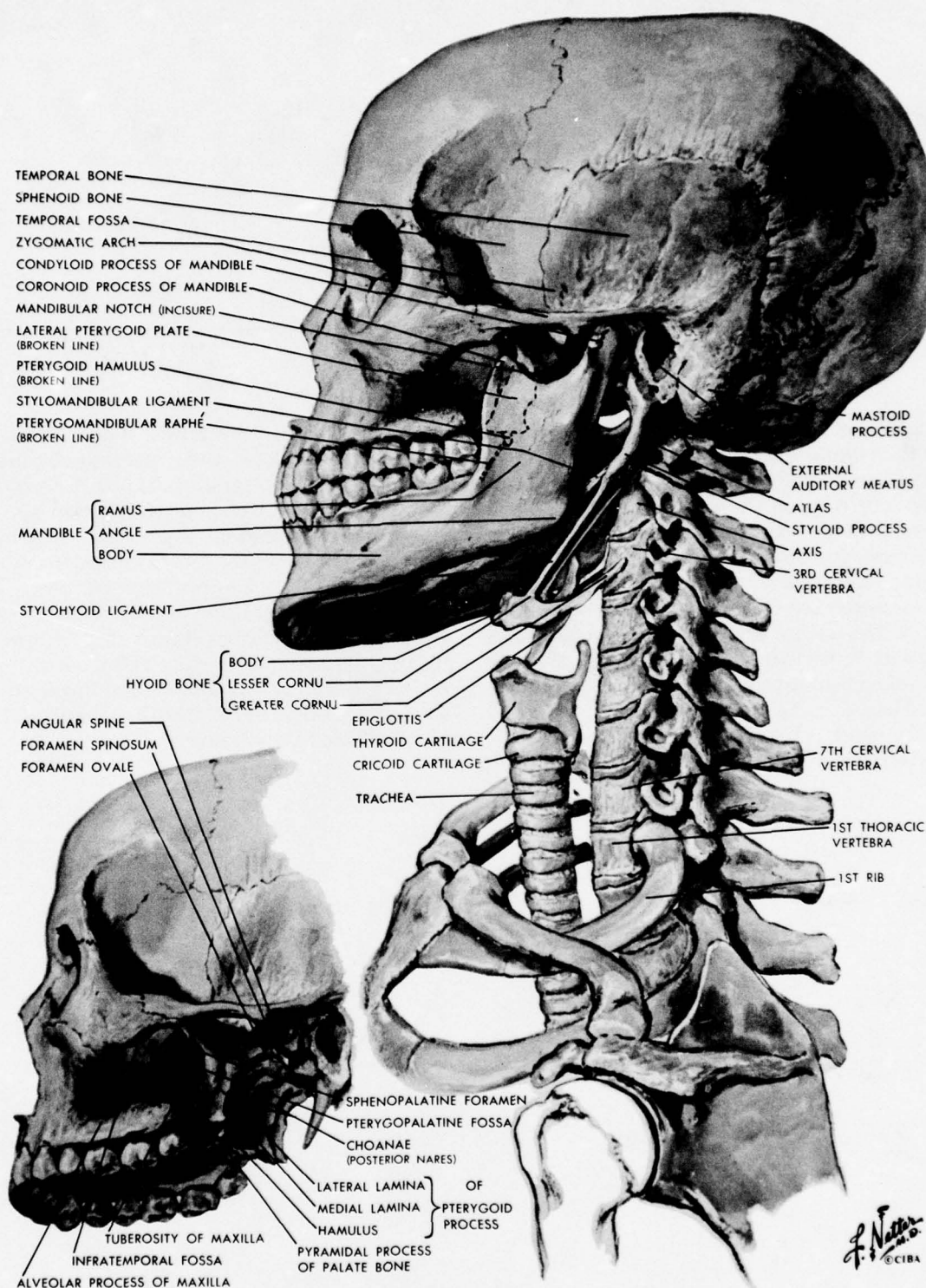


Figure 8.—Osteology

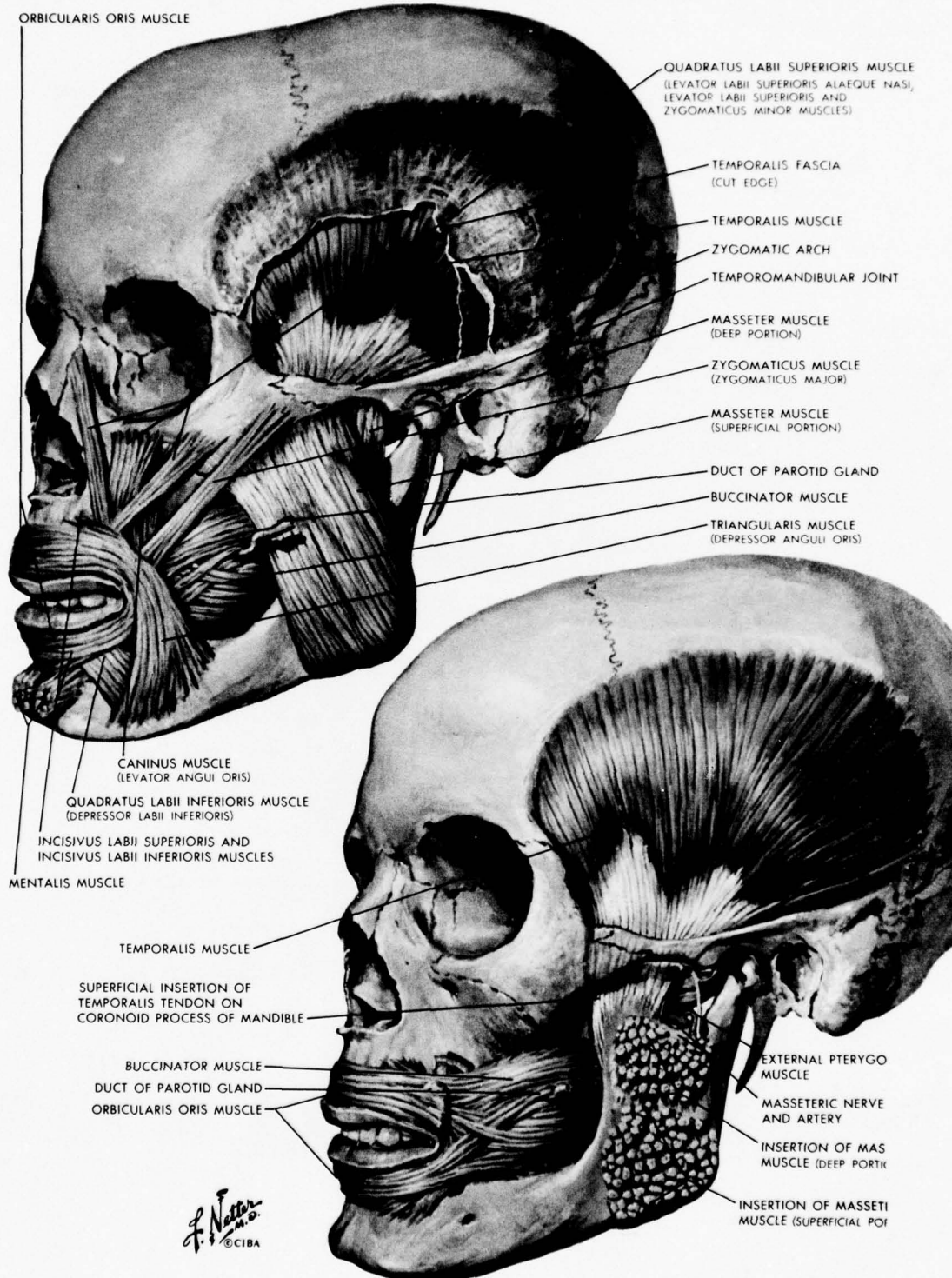


Figure 9.—Muscles of Mastication (I)

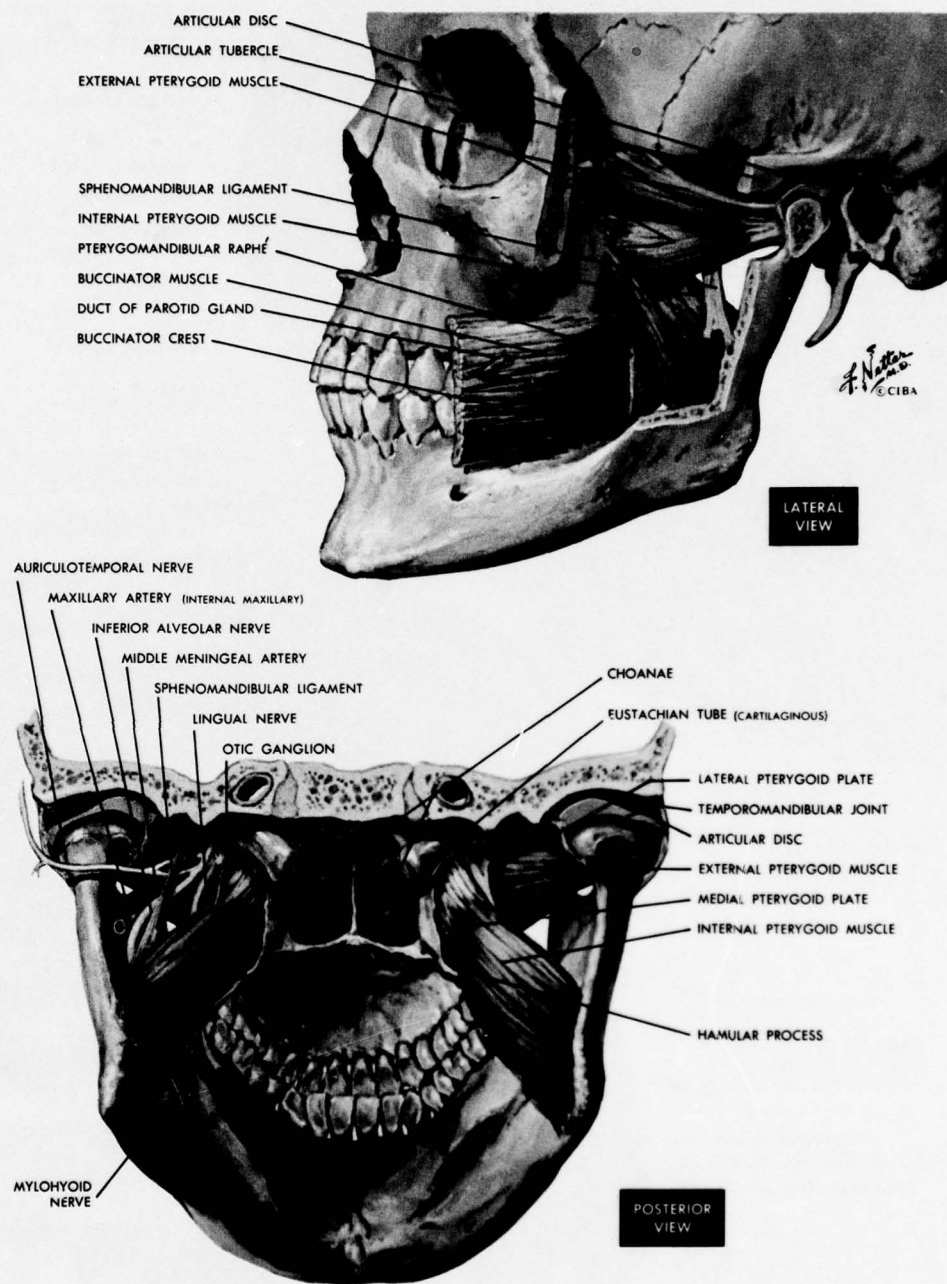


Figure 10.—Muscles of Mastication (II)



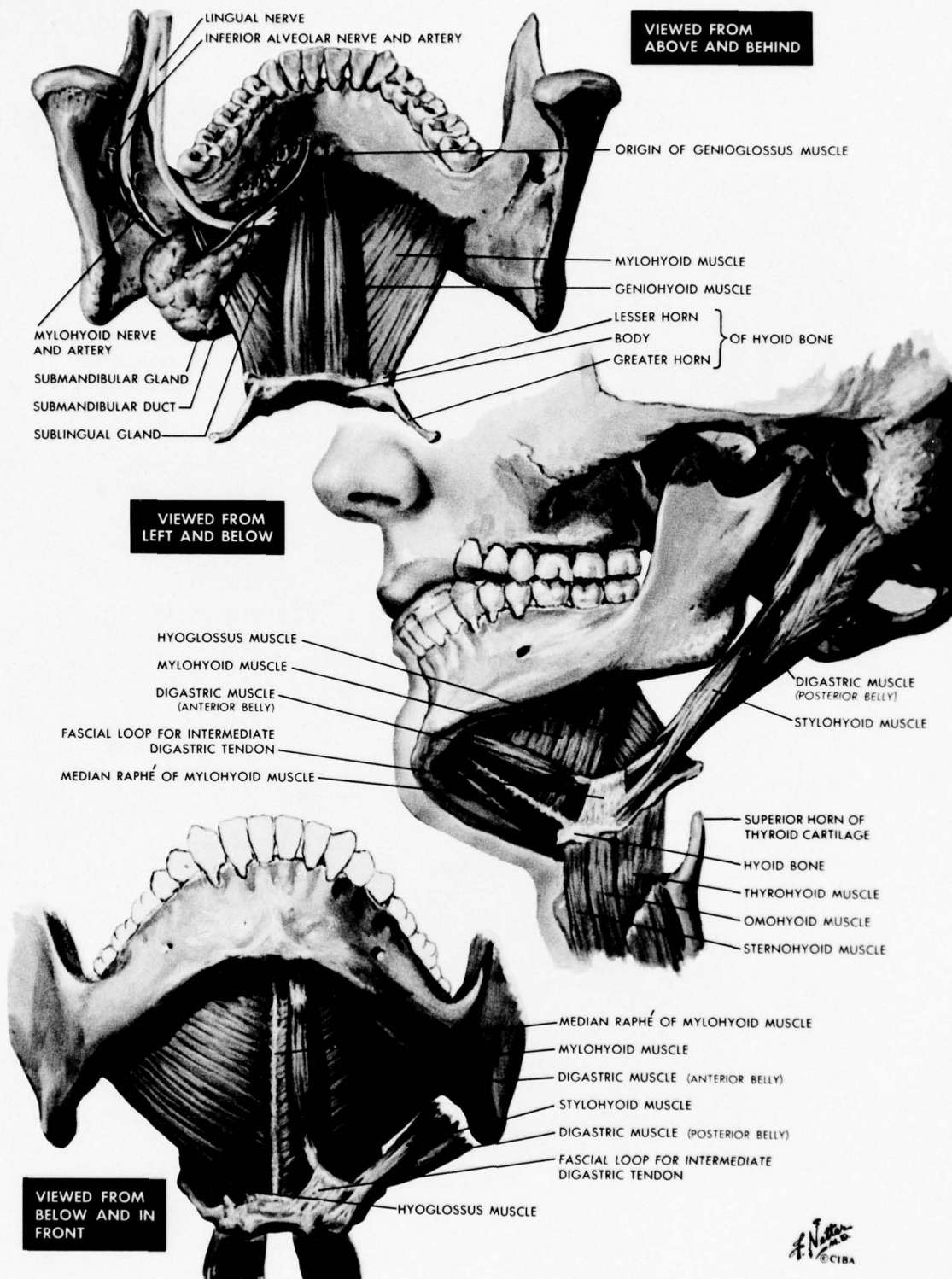


Figure 11.—Muscles of floor of mouth

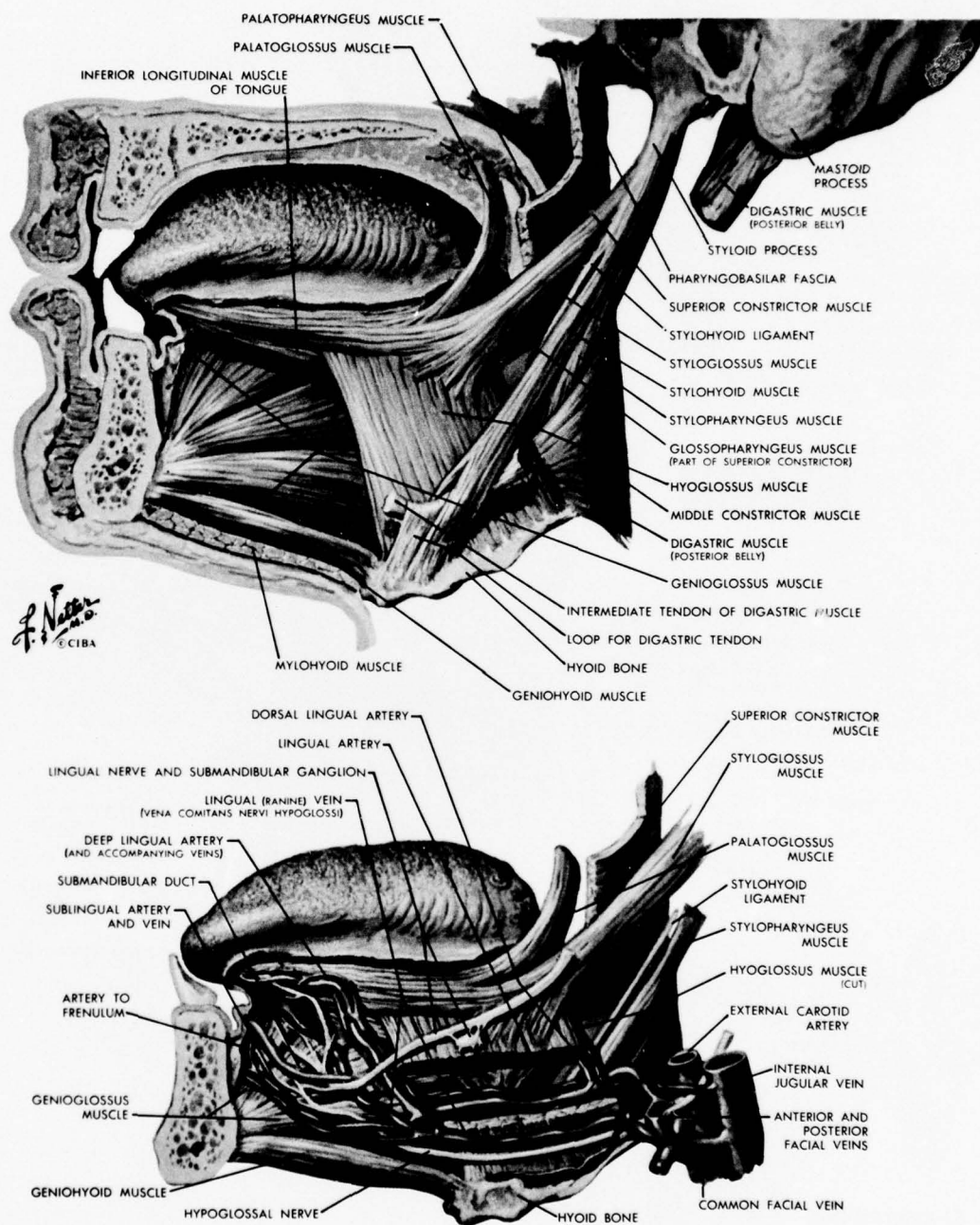


Figure 12.—Muscles of tongue and floor of mouth with neurovascular relations

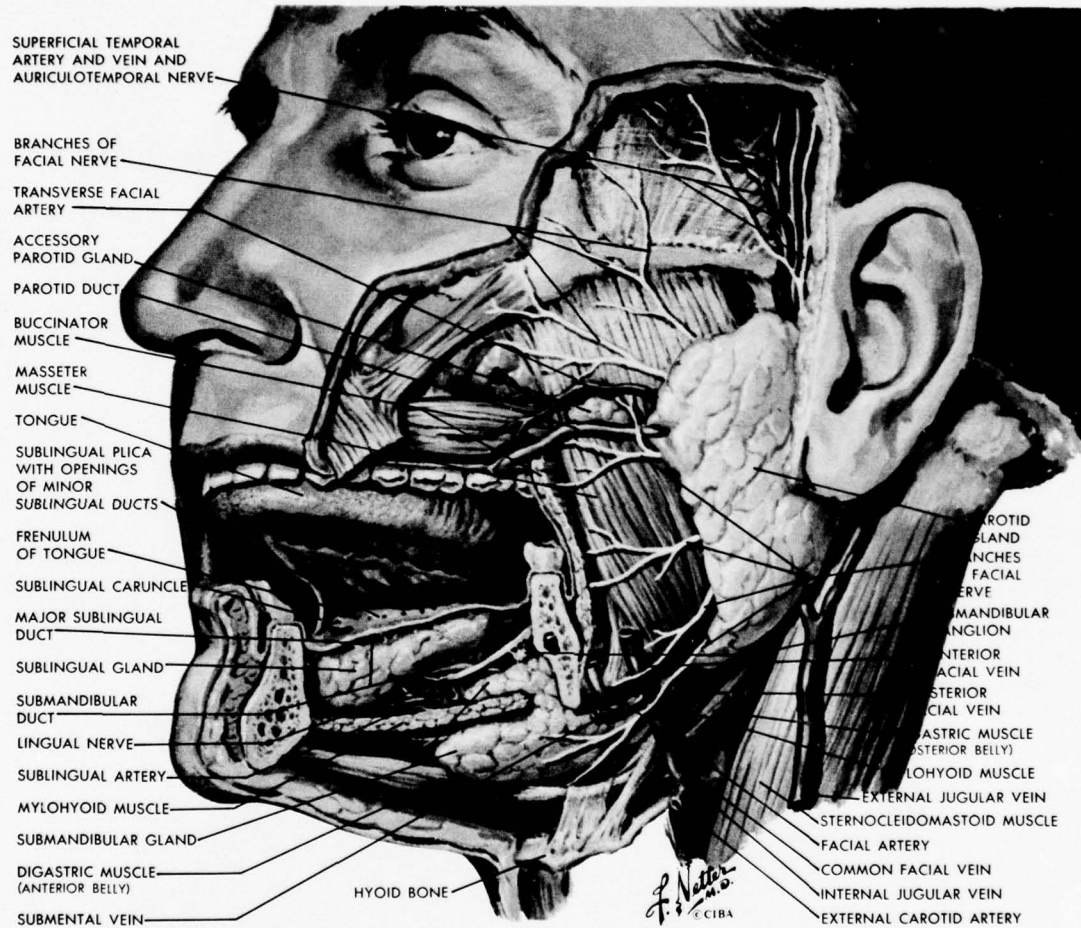


Figure 13.—Lateral face with neurovascular and muscular relations



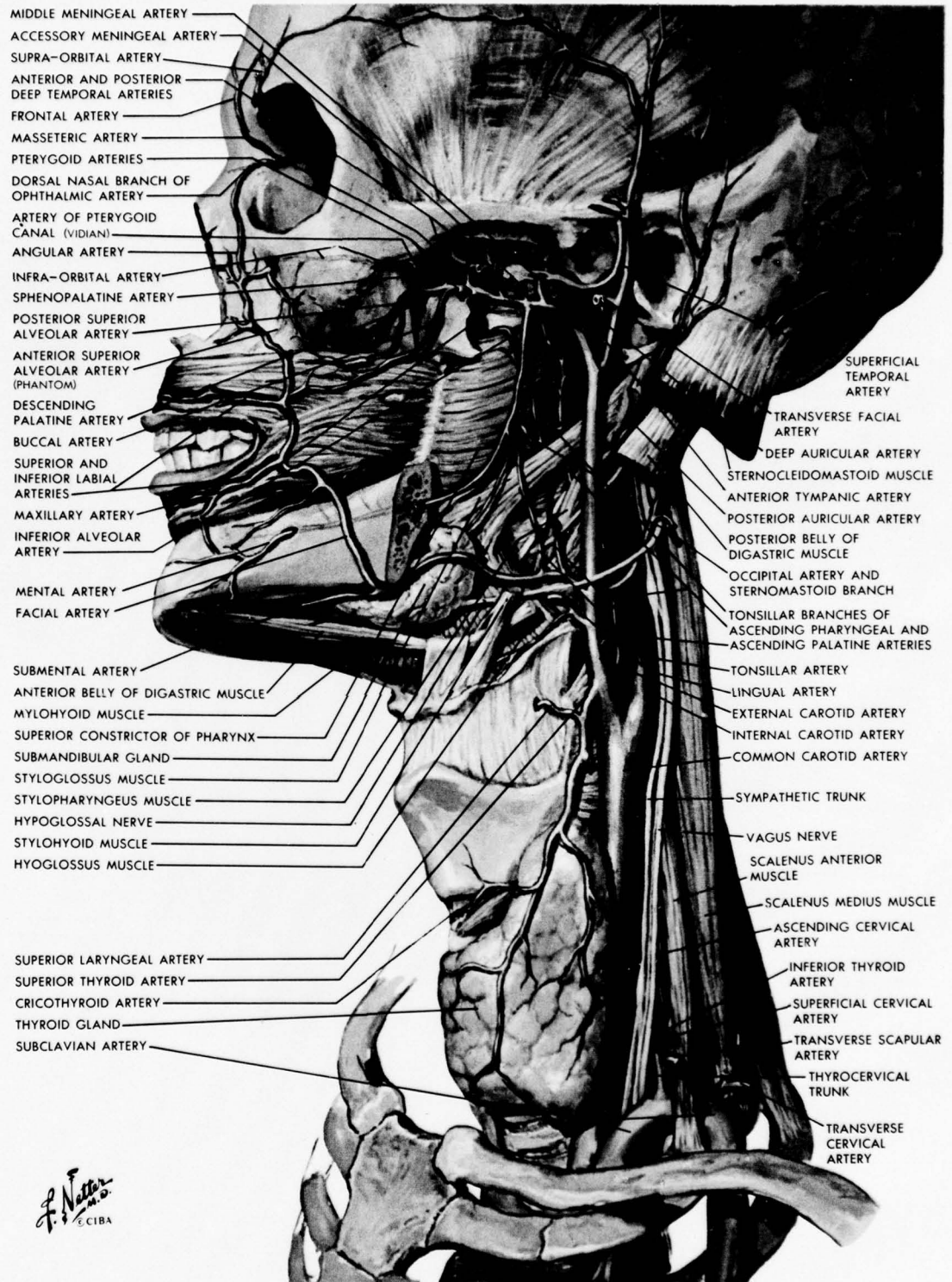


Figure 14.—Arterial supply to orofacial region (1)

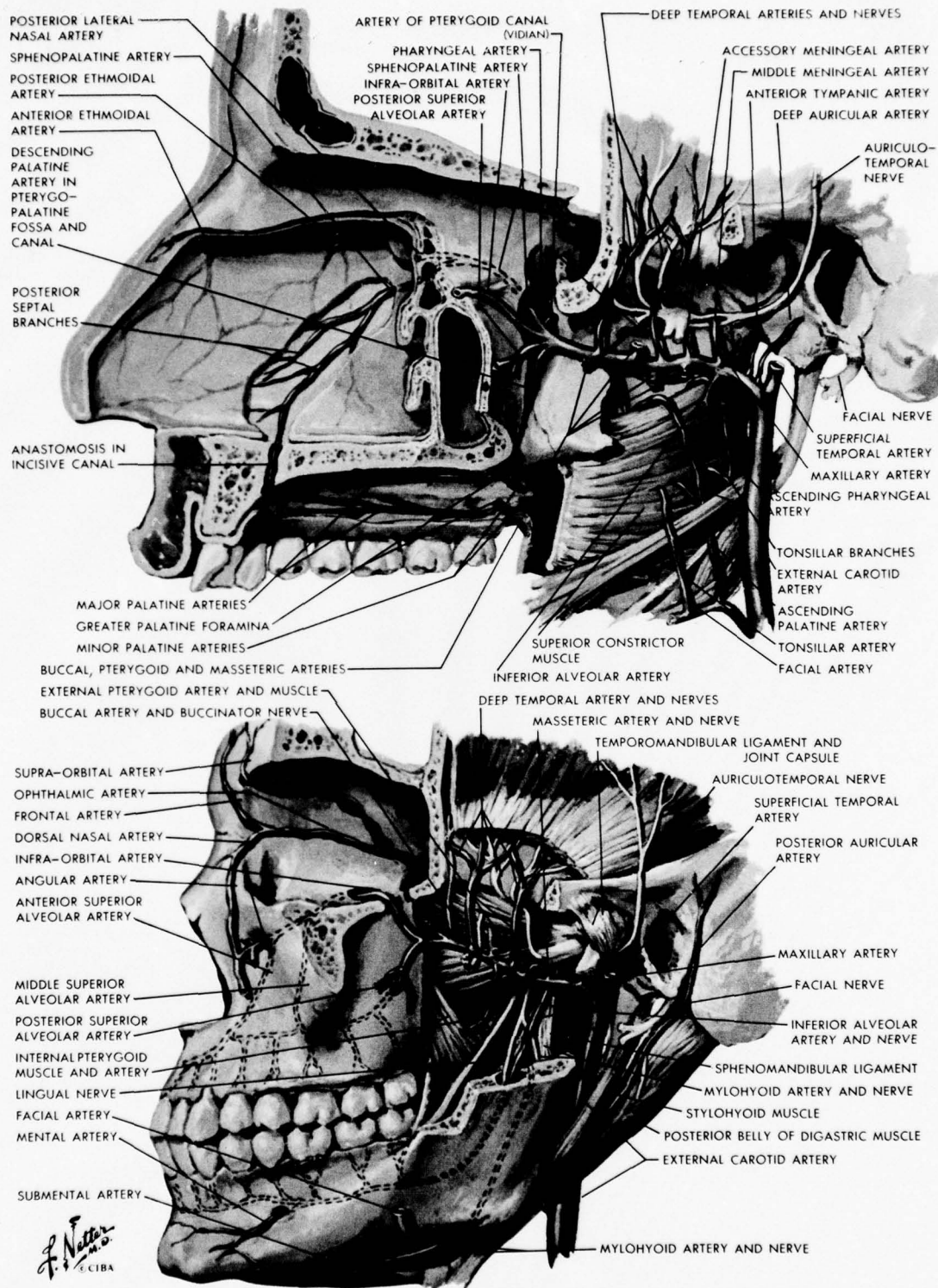
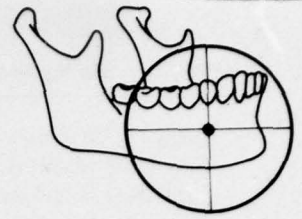


Figure 15.—Arterial supply to orofacial region (II)



## CHAPTER IV

# Early Care

By ELGENE G. MAINOUS  
HENRY J. SAZIMA  
THOMAS E. STUMP  
JAMES F. KELLY

## INTRODUCTION

The early care phase represented the most critical stage of overall patient management. This was true because of the relatively high potential mortality rate of this period, which depended on the nature and extent of injuries as well as the adequacy and speed of emergency care. Also, this period was highly important because the adequacy of early treatment rendered significantly influenced the prognosis and course of intermediate and late treatment required. Obviously, the optimal preservation of soft and hard tissues, judicious debridement, and anatomic reduction at the time of early management permitted a more ideal end result with fewer complications and less need for reconstructive efforts in later management periods. By definition the early phase began at the instant of injury and encompassed all early management including: the initial first-aid measures instituted on the field of battle, early definitive surgical treatment, postsurgical management, and transfer to the next echelon of treatment.

The management of all casualties generally followed a similar procedural sequence. This narrative will be presented in a format consistent with that sequence in order to attempt simulation of the clinician's perspective. Although a general pattern of casualty care was evident, complete consistency was seldom achieved. Numerous factors modified the management of individual patients, which required a flexible approach by the surgeon.

## FACTORS INFLUENCING TREATMENT

Three groups of factors that significantly influenced the treatment of persons who sustained bodily trauma are worthy of discussion.

Group I: *The wounding agent, type of wound, and intrinsic response to bodily trauma.* These factors were not modifiable by the surgeon. Military combatants were essentially in good health and therefore could be expected to exhibit an optimal response to wounding, consistent with the extent and nature of injury.

Group II: *Access to and availability of treatment.* These factors depended on transportation opportunities and proximity of appropriate surgical personnel, i.e., the logistics of the military operation.

Group III: *The skill and experience of the surgical treatment team.* Optimal care depended on early, vigorous treatment provided by competent surgeons in adequate surroundings. These factors relied on the ability of the military organization to provide satisfactory operating facilities and to staff such facilities with well-trained surgeons who were screened and briefed for combat support duty.

## DESIRABLE CHARACTERISTICS OF THE COMBAT SURGEON

Certain traits were desirable in an individual who was to be held responsible for the early surgical management of injuries in a combat environ-



ment. Obviously the best combat surgeon was one best trained, but it should not be assumed that all trained surgeons possessed characteristics suitable for managing battle casualties.

Numerous factors should influence the selection of surgeons for early treatment of casualties. There was generally, and rather continuously, a tremendous amount of stress on the military combat surgeon. It was important that he be capable of coping with the multitude of devastating permanent injuries and deaths constantly confronted in the theater of war. Periods of endless boredom were contrasted with sheer exhaustion from long hours of overwork without rest. The surgical clinician required a strong constitution and positive self-motivation to endure these pressures. He needed to be continually able to exercise good judgment and make intelligent critical decisions while performing with dexterity and skill. He had to remain in a favorable and sober state of mind with willingness to be fully cooperative with his colleagues. The surgeon had to respond rapidly, be highly innovative in his response to unique circumstances, be flexible, and be adaptable to sudden changes. These human characteristics, while desirable in all individuals charged with care of the wounded, were particularly important in the surgeon since he had the primary responsibility for definitive treatment of combat injuries.

### COORDINATION OF EVACUATION

In the early phase *priority of casualty transport* to the initial treatment facility was a triage or sorting consideration, which usually depended on the number of casualties present at the battle scene and the availability of adequate transportation resources. Additional triage considerations again came into play at the treatment facility in determining relative priority of care among the incoming patients from various locations.

Whenever possible, efforts were made to coordinate the medical evacuation of wounded patients to that regional facility best equipped to handle the number and types of injuries present. Transport of an intracranial injury patient, for example, bypassed the closest hospital facility, if it had no neurosurgeon, in favor of a more distant hospital with a neurosurgeon on the staff. In the same manner, patients with orofacial injuries, when possible, were selectively evacuated to those

facilities having a maxillofacial capability. This highly effective rapid system, which was initially implemented in Korea, depended on the accurate diagnostic assessment by the initial medic, physician, or dentist, and also on skilled helicopter evacuation coordinated by alert and intelligent radio communication. As a result, the opportunity of survival for the patient in Vietnam was better than in any previous war. During World War II, 29.3% of the wounded died as compared to 26.3% in Korea and 19% in Vietnam (Neel, 1968, 1975).

Once patients arrived at a hospital facility, all surgical specialists were expected to assist in or manage surgical problems not ordinarily within the scope of their practice. For example, if the primary injury of a patient involved the orofacial area, he was triaged to the maxillofacial specialist for definitive care. The maxillofacial specialist consulted freely, as required, but was normally expected to also care for accompanying minor injuries involving other areas. This was the accepted *modus operandi* in Vietnam. Specialists were also expected to be available for inclusion in extemporaneous surgical teams for joint management of patients with multiple system injuries. This type of patient was seen frequently and as a result *the mixed surgical team, conjointly rendering operating room care, was very common*. Depending on presenting injuries and their distribution, the surgical specialists assisted one another in the same general injury site, or they worked concurrently upon injuries in different anatomic sites. Cooperation and coordination were essential to success.

### TREATMENT FACILITIES

Four basic types of treatment facilities were available in Vietnam in support of the combatant forces. Their capability differed depending on proximity to the actual combat area. The *Minimal Facility* was temporary and mobile and was used primarily to assess the adequacy of initial or first-aid care and to supplement this care as required. Stability of the patient's condition was ascertained and he was prepared for further evacuation. Combatants with minor wounds were treated and returned to duty directly from these installations. Staffing usually included a general medical officer and hospital corpsmen—there was no maxillofacial capability. The *Mobile Limited Facil-*

ity was a surface vessel configured and staffed to handle casualties. It was either a troop transport capable of handling rotary winged aircraft and landing craft or a small aircraft carrier. Once the troops were disembarked for combat, the berthing spaces were prepared for use as casualty care areas. These vessels were positioned along the coast in locations that were as near the combat area as militarily practical. The medical staff included a general surgeon, orthopedic surgeon, anesthesiologist, and support paramedics. These facilities were not routinely staffed by a maxillofacial surgeon. The use of *Mobile Complete Facilities* or hospital ship depends on the presence of a large navigable body of water near the area of combat. Obviously, their use was ideally suited to the logistics of the Vietnam conflict. These ships, the *U.S.S. Repose* and *U.S.S. Sanctuary*, were outfitted as hospitals and were fully staffed with medical personnel capable of providing the most sophisticated diagnostic and therapeutic care. The staff included personnel trained in maxillofacial surgery. *Fixed Complete Facilities* were the equivalent of a major civilian hospital and in a military sense provided the same capability as the hospital ships. They were constructed as permanent facilities in strategic locations that would ordinarily be well back from the actual combat area. In the circumstances of the Vietnam conflict, however, with battle lines obscure and insurgent

enemy infiltration frequent, these hospitals were occasionally close enough to combat zones to be subject to periodic enemy rocket attack. These facilities were also staffed with a full complement of medical personnel including at least two maxillofacial specialists.

At the fixed and mobile complete facilities, patients were provided *optimal early definitive care*, and then evacuated to intermediate facilities or directly to the Continental United States (CONUS). When early care was considered definitive, patients were retained for up to 30 days and when well were returned directly to duty. It was necessary at all times to maintain an adequate number of beds for reception of anticipated fresh casualties; therefore, only a limited number of patients could be retained at these facilities in Vietnam for prolonged convalescence.

The American hospital system also provided complete care for South Vietnamese troops and other allied military personnel serving in this area. Injured enemy soldiers were, of course, also provided appropriate care, according to established American policy of humanitarian care of all wounded persons in need of help. The greatest number of non-American patients to receive care were the Vietnamese civilians of both sexes and all ages (Byerly and Pendse, 1971; Stump, 1971).

## WOUNDING AGENTS AND WOUNDS

### BALLISTICS

In any treatise on war wounds, a review of the physical principles of ballistics is necessary to afford the reader a better appreciation of the nature and mechanism of action of wounding agents common to the conflict being discussed. Of great importance, particularly in the maxillofacial area, is an understanding of how the flight path and speed of a projectile are altered by sudden resistance, as for example, from human hard and soft tissue structures. Equally significant is knowledge of the amount and dispersal of impact kinetic energy from the projectile that is dissipated to impacted structures, and the effects of this transposed energy on these tissues.

Ballistics can be defined as the scientific study

of the motion of projectiles in flight (Dorland, 1974). The severity of a missile wound is directly related to the shape and size of the missile and to its contained kinetic energy. Those factors most important in determining the type and extent of a missile wound included: 1) kinetic energy of the missile, 2) mass, composition, and contour of the missile, and 3) relative density and bulk of tissue into which the missile impacts or through which it passes (Figure 16) (Shelton and Albright, 1967; Schmidt et al., 1969).

The *impact kinetic energy* of a missile is a function of its mass and velocity. The amount of impact kinetic energy is equivalent to one half the product of the missile mass times the square of the missile velocity, divided by the constant of gravitational deceleration. This relationship is ex-



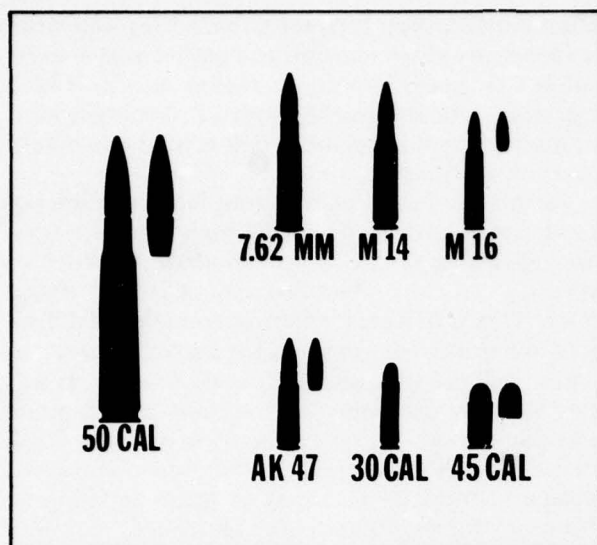


Figure 16.—The comparative shape and size of various bullets (cartridges, rounds) and their projectiles or missiles (wounding agents). 50 Cal = 50 caliber machine gun bullet; 7.62 mm = NATO Automatic Rifle bullet; M-14 = U.S. Automatic Rifle bullet; M-16 = U.S. Automatic Rifle bullet; AK-47 = Russian Automatic Rifle bullet; 30 Cal = pistol bullet; 45 Cal = pistol bullet.

pressed by the equation  $E = Mv^2/2g$ . Since the impact kinetic energy relates to the square of the missile velocity, it becomes clear that this value is a most significant factor in determining resultant wounding effect. The standard allied weapon, the *M-16 automatic rifle*, was designed to fire ammunition that produces a very high muzzle velocity of 3,250 feet per second. In addition to contributing most significantly to the impact kinetic energy, the high velocity improves the accuracy of the missile and permits an increased effective range. To attain such a high muzzle velocity, it is necessary to reduce the weight or mass of the bullet to avoid a prohibitive recoil. A fairly light 55-grain bullet measuring 5.56 mm in diameter was thus utilized in the M-16 weapon (Dimond, and Rich, 1967). The impact kinetic energy of the M-16 missile is derived as follows:

- 1) Conversion of bullet weight in grains to pounds:

$$\frac{55 \text{ grains}}{5760 \text{ grain/lb.}} = .00955 \text{ lbs.}$$

- 2) Calculation of impact kinetic energy:

$$E = \frac{Mv^2}{2g} = \frac{(.00955 \text{ lbs.}) (3,250 \text{ ft./sec.})^2}{2 (32 \text{ ft./sec./sec.})} = 1576 \text{ ft./lbs. (muzzle value)}$$

At increased ranges the missile velocity and consequently impact kinetic energy show a progressive decline from the initial muzzle value.

The 45-caliber pistol by comparison usually takes a heavy 220-grain bullet, but produces a muzzle velocity of only 850 feet per second which results in an impact kinetic energy of 431 foot-pounds or about 27% that of the M-16.

In Vietnam, opposing forces were most commonly armed with the AK-47 rifle. The bullet mass for this weapon is 122 grains, the muzzle velocity is 2,330 feet per second, and the resultant impact kinetic energy is 1,798 foot-pounds. Although the impact kinetic energies or wounding forces of the AK-47 and the M-16 are roughly comparable, the AK-47 derives more of its impact effect from the larger missile mass, whereas the M-16 relies on its greater velocity (Figure 16). The maximum range of the AK-47 is 2,500 yards and that of the M-16, 3,000 yards (Kjellgren, 1970).

## TYPES AND PATTERNS OF INJURY

The types of tissue injury encountered in war casualties included the following: soft tissue—lacerations, avulsions, and burns; hard tissue—noncomminuted fractures of bone and teeth, comminuted fractures of bone, and avulsions of bone and teeth. As a result of the violently destructive force of high velocity missiles, isolated injuries of a single type were less common than combinations of injuries. The nature and extent of the wounds depended on the type of missile and the pattern of injury produced.

The pattern of injury in missile wounds depended on the manner in which the missile traversed the tissues. When a high velocity missile impacted and traveled through soft tissue, a cone-shaped shock wave was produced which created a transient cavitation space in the wake of the bullet that could expand up to 30 times the diameter of the bullet (Dziemian and Herget, 1950) (Figure 17).



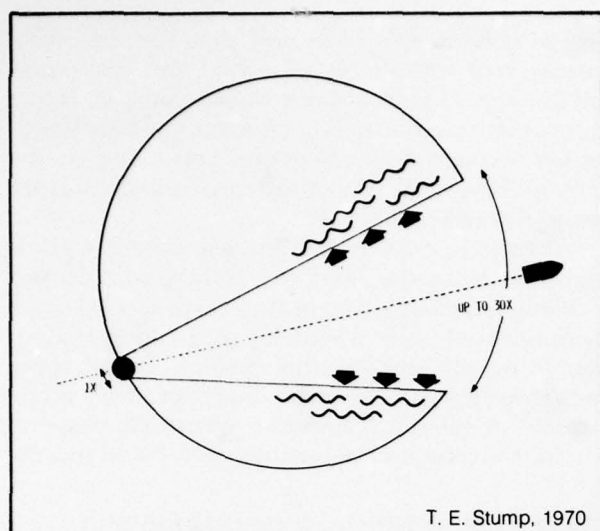


Figure 17.—Diagrammatic illustration of transient cavitation space that is produced in the tissues by the shock wave generated with passage of a high velocity missile (HVM). Tissue injuries generally conform to the location and configuration of the cavitation space which can extend up to 30 times the diameter of the missile.

This transient cavitation persisted for about 5–10 milliseconds before collapsing to leave the permanent bullet tract. That tract and the extent of wounding were highly dependent on the composition of the soft and hard tissues struck, as well as on the size, shape, and impacting energy of the missile. Generally, however, the injuries conform directly to the location and configuration of the cavitation space along the missile tract. If the missile completely perforated the body part, the characteristic pattern of wounding was a *small entrance and much larger exit wound* (Figure 18) (Case report 01).

Although foreign matter was not always evident, it was usually present because it was carried into the wound in front of the moving missile or drawn retrograde into the vacuum of the transient cavitation space. Additionally, contamination from clothing fragments, dirt, or other debris

occurred via the exit site of the missile. As a result all high velocity missile wounds were considered to be contaminated.



Figure 18.—Upper) Photograph of patient who sustained a high velocity missile wound to the face and jaws. The relatively smaller wound of entrance (En) is seen on the left cheek just lateral and superior to the lip commissure. The missile trajectory was directed posteroinferiorly and the large exit wound (Ex) is seen on the right cheek overlying the body and ramus of the mandible. Middle) Extent of underlying osseous damage along the missile tract as visualized on a posteroanterior radiograph of casualty seen in upper figure. Lower) Example of small entrance wound (area of nasolabial fold) and much larger exit wound (cheek and preauricular area) on the left face in another patient.

### CLASSIFICATION OF MISSILE WOUNDS

A simple and useful classification of high velocity missile wounds includes: 1) *penetrating*, 2) *perforating*, and 3) *avulsive* (Rowe and Killey, 1970 [a]). These categories generally reflect increasing amounts of velocity and impact kinetic energy of the missile, but not necessarily increased wounding effect (Figure 19).

#### Penetrating

The penetrating wound (Figure 19) was one in which the wounding agent (missile) had been retained within the injured tissues. According to

physical laws, this indicated that the wounded tissues had completely absorbed and dissipated all the impact kinetic energy of the missile. It was convenient to subdivide penetrating wounds into *superficial and deep* categories according to the impact kinetic energy of the missile and its tissue penetration (Figure 20).

After penetrating the skin, the missile was capable of lacerating and macerating soft tissues, causing burns of surrounding tissues, producing comminuted bone fractures, transecting vessels, and entering organs and cavities. In all these penetrating-type wounds, however, the single missile or missile fragments eventually came to rest within the injured tissues, and could usually

Figure 19.—Diagrammatic representation of the three types of high velocity missile wounds. A description of each type is presented in the text.

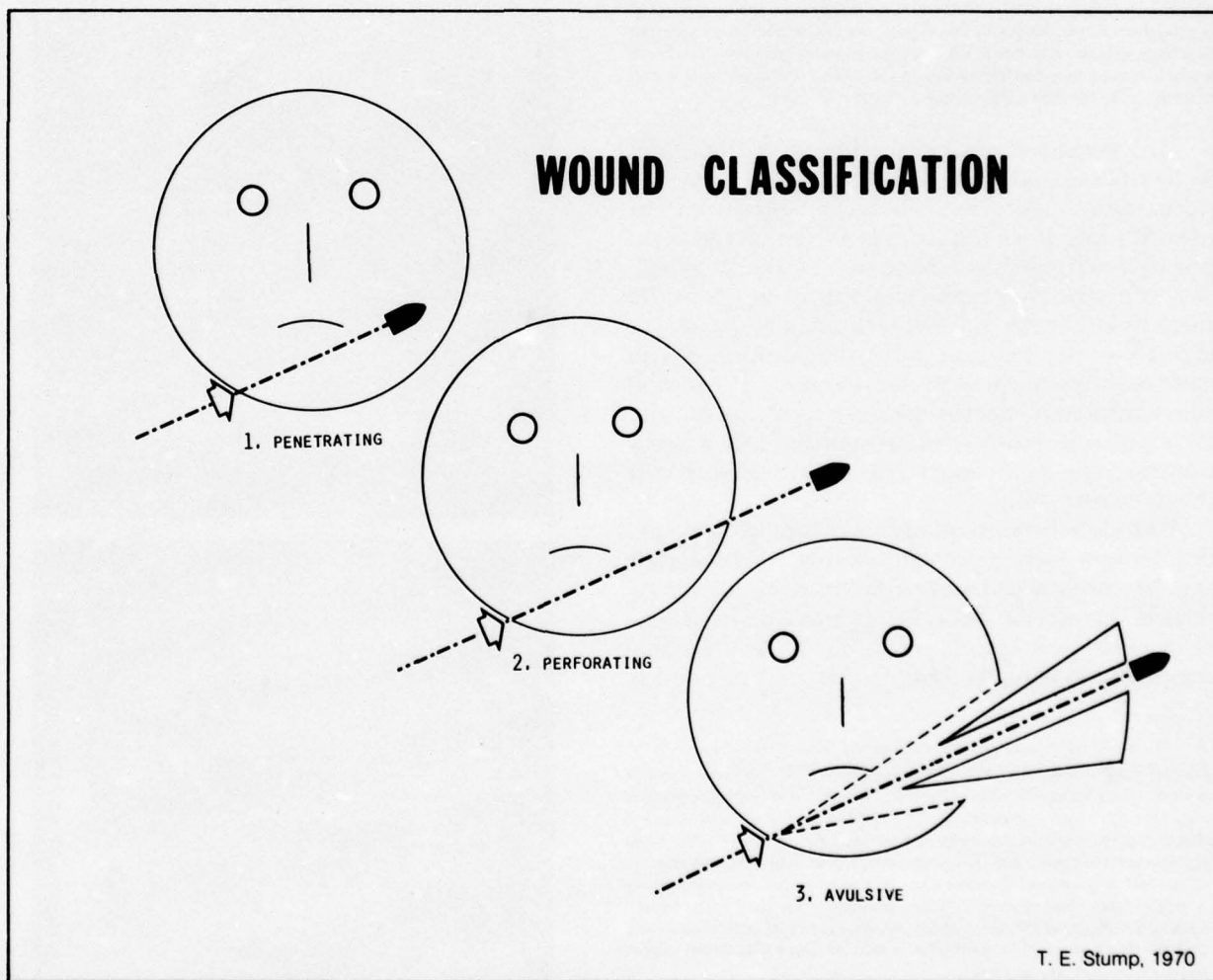




Figure 20.—Upper left) Appearance of a 25-year-old casualty who sustained a blast injury to the face that resulted in *superficial penetrating wounds*. Upper right) Immediately post treatment. The wound had been thoroughly debrided and scrubbed to eliminate foreign debris and reduce the potential for the development of scar tattoo. Lower left) Twelve months post injury. Lower right) Sixty-one months post injury.

be demonstrated on radiographs (Figure 21).

The *extent of severely damaged tissues* extended well beyond the limits of the observable wound tract. This resulted from the effects of radiating injury associated with the compression shock wave generated at missile impact. From the point of view of military effectiveness as a wounding agent, the penetrating missile was highly efficient in completely utilizing all its available energy in the wounding process. Occasionally, however, the penetrating-type wound was caused by missiles with relatively low residual velocity, such as

almost spent bullets. In these cases, the effective impact kinetic energy was considerably reduced as was, of course, the resultant wounding effect (Figure 22).

Although penetration wounds resulted from single missiles, they were also caused more frequently by *fragmentation devices* such as mortar rounds, grenades, bombs, booby traps, or rockets that created multiple small low velocity missiles (Table 3). The missiles emanating from these fragmentation devices were usually rough and irregular, resulting from the exploding shell



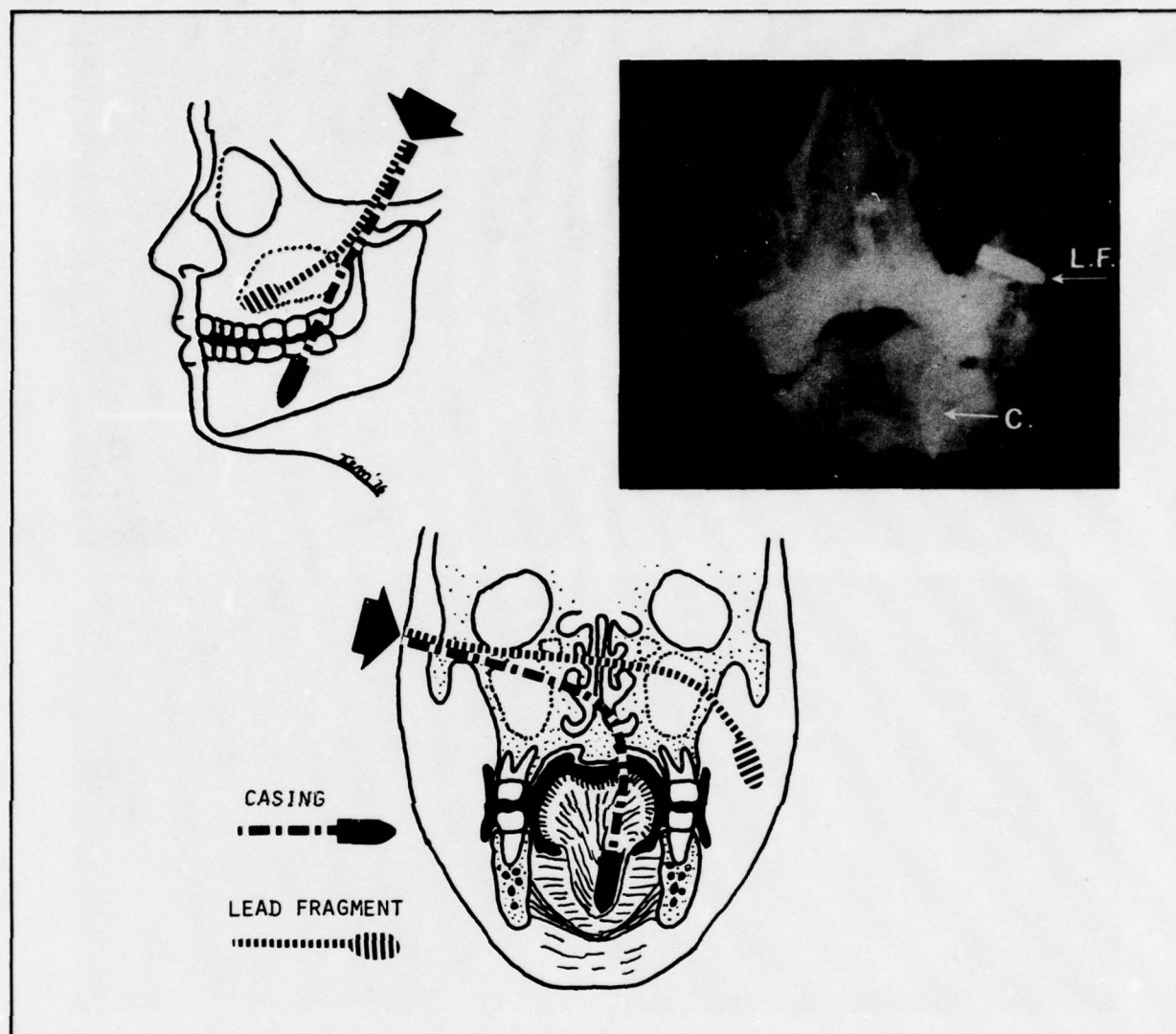


Figure 21.—Upper left and lower) Diagrammatic example of a deep penetrating wound. The missile components (lead fragment and casing) of an AK-47 missile separated after entering the cheek, traversed the maxillofacial region individually, and came to rest within the tissues after expending their residual energy. Upper right) Posteroanterior radiograph of patient who sustained the missile wound described above. The lead fragment (L.F.) and casing (C) are seen lying in the tissues where they came to rest.

casing itself, or they were also from specially designed multiple mini projectiles contained within the casing. In the past the fragments were commonly referred to as "shrapnel" after Henry Shrapnel, a British artillery officer who was the designer of the first known missile device that contained secondary projectiles. Shrapnel's device, which was described in 1842, consisted of a projectile that carried a case provided with a powder charge and a large number of small lead

balls that would be explosively dispersed in flight when the contained powder charge was detonated. It is descriptively more accurate not to use the term "shrapnel" for fragments from modern high explosive devices (Rich and Johnson, 1967). The wounding effect of missiles from fragmentation devices, because of their frequently large size, irregular shape, and relatively low velocity, customarily resulted in multiple penetrating wounds.

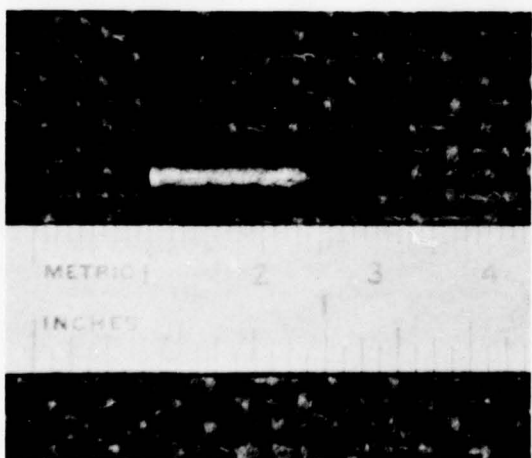
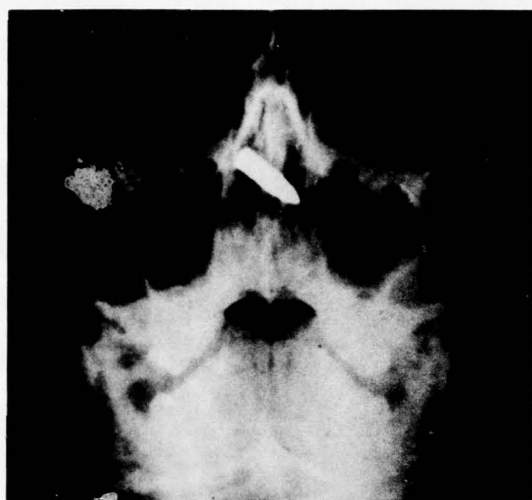


TABLE 3.—*Type of Weapons That Produced Fragmentation Wounds in a Series of War-Injured Patients Studied by Rich and Johnson (1967)\**

Missile	Number of patients	Percent
Artillery and mortar	133	50.6
Grenades	73	27.8
Antipersonnel mines	20	7.6
Unknown	34	12.9
Rockets	3	1.1
Total	263	100.0

\*Reprinted with the permission of the *Journal of the American Medical Association*.

Byerly and Pendse (1971) reported on 1,381 patients who sustained missile injuries—70% were fragmentation type and 30% gunshot wounds. In a reported series of Vietnam maxillofacial cases, penetrating missiles accounted for 80% of injuries, and of these, 38% were caused by bullets and 62% by fragments from mortars, mines, booby traps, and miscellaneous explosive devices (Terry, 1969).

Table 4 describes the manner in which the MFCS patients were selectively divided into groups to facilitate analysis of the data concerning wounding and treatment. This grouping will be used throughout the text.

Data concerning suspected wounding agents for the injuries sustained by patients included in the MFCS are listed in Table 5. The most common wounding agent for all groups was fragmentation devices (51.30%). In those patients in whom massive tissue avulsion occurred and bone grafting was required (group I), high velocity missiles (45.98% and fragmentation devices (47.13%) were implicated equally as etiologic agents. In 65.22% of the comminuted fractures (group III) and 56.25% of the simple fractures (group IV), fragmentation missiles were the wounding agents.

Although both gunshot and fragmentation wounds were often grouped together under a common heading of high velocity missile wounds, the structure, number, ballistics, and wounding

Figure 22.—(Upper) Posteroanterior radiograph of facial skeleton showing spent missile that came to rest in the nasal cavity after perforating the axillary area and then penetrating the face just lateral to the lip commissure. The missile had expended most of its energy before entering the face and, as a result of its low velocity, penetrated but did not perforate the facial area. (Middle) Path of the missile. (Lower) Missile after its removal.

TABLE 4.—*Grouping of Maxillofacial Casualty Study (MFCS) Cases by the Type of Mandibular Injury*

Group I	Osseous avulsion with bone graft
Group II	Osseous avulsion without bone graft
Group III	Osseous fracture with comminution
Group IV	Osseous fracture, simple-linear
Group V	Minimal or no osseous damage

potential of the wounding agents differed significantly. In its normal effective range, the singular smooth gunshot missile was unquestionably a *high* velocity missile with a great potential for tissue damage. By comparison, irregular shrapnel fragments were usually of a relatively lower velocity and individually have a lessened wounding effect than singular gunshot missiles. However, these fragments, or "frags" as they were called, usually struck the patient as a group of missiles and as such were highly destructive, gaining their wounding advantage from the multiplicity of their action.

### Perforating

Although fragmentation-type wounds were

nearly always multiple, and often involved widely dispersed locations in an individual victim, the gunshot wounds by contrast were usually singular and, typically, were perforating in nature.

The perforating type of war wound (Figure 19) was one in which the wounding missile had completely passed through and exited from the wounded tissue. Thus, by definition, there was always an entrance and exit wound. The tissues absorbed only a portion of the impact kinetic energy of the missile. The balance of the unneutralized energy was expended in producing a continued trajectory at a diminished velocity after the missile had exited the tissues. Radiographically there was a picture of tissue destruction but no metallic evidence of the major missile mass. Occasionally, however, the tissues retained some minor fragmented metallic debris residual from the departed missile. Perforating wounds were caused by either high or low velocity missiles. Typically, however, the perforating wound was the result of a high velocity gunshot projectile and there was a small, discrete entrance wound and a large, destructive exit wound (Figure 18). The entrance wound was related to the size, shape, and entry position of the missile and usually had a narrow peripheral border of

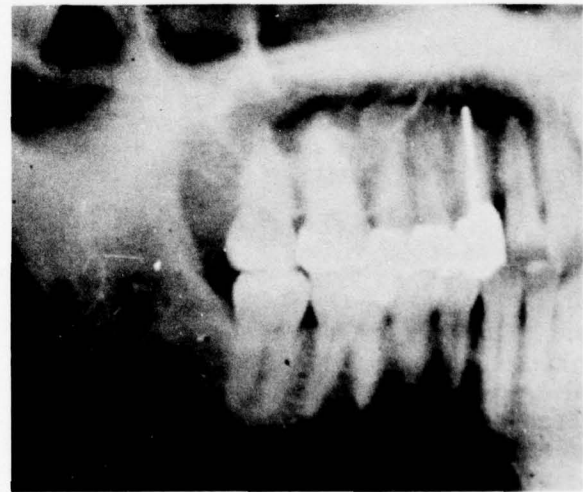
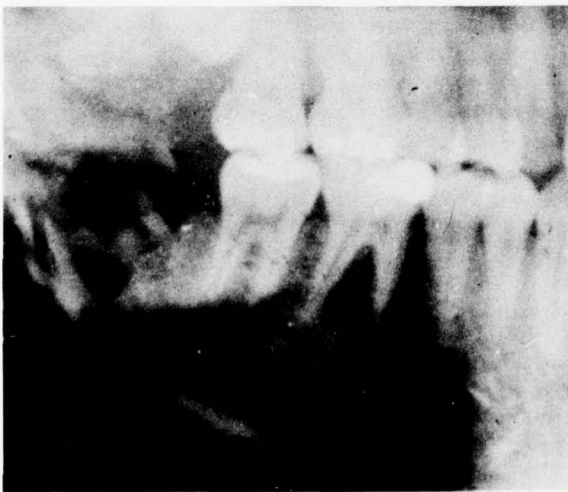
TABLE 5.—*Suspected Etiology of Injury for the Five Groups of Patients Included in the MFCS*

Group	High velocity missile	Fragmentation	Small arms	Other
I (N= 87)	40 [45.98]*	41 [47.13]	6 [ 6.90]	0 [00.00]
II (N= 44)	23 [52.27]	19 [43.18]	0 [00.00]	2 [ 4.55]
III (N= 23)	7 [30.43]	15 [65.22]	0 [00.00]	1 [ 4.35]
IV (N= 32)	6 [18.75]	18 [56.25]	0 [00.00]	8 [25.00]
V (N= 7)	1 [14.29]	6 [85.71]	0 [00.00]	0 [00.00]
Total (N=193)	77 [39.90]	99 [51.30]	6 [ 3.11]	11 [ 5.70]

\*Figures in brackets equal percentage of N.

Figure 23.—*Upper left*) Large exit wound of right face and neck resulting from a high velocity missile that entered the cheek just inside the right corner of the mouth. The size of the exit wound was accentuated by secondary osseous missiles created as the primary gunshot missile fragmented the bone during its course through the maxillofacial region. *Upper middle*) The patient prepared for surgical treatment of the wound which had been copiously irrigated and scrubbed with an antiseptic soap solution. Only those bone fragments not attached to soft tissue that could be irrigated from the wound were removed. *Upper right*) Wound following closure. Contused wound margins were sharply excised and local tissue flaps undermined, advanced, and closed without undue tension. The wound was drained through its posterior corner. Primary closure was successfully accomplished because of the application of correct wound closure principles and the fact that the extent of soft tissue avulsion was more *apparent than real*. *Middle*) Appearance of patient 63 months post injury. Only slight weakness of the marginal mandibular branch of the 7th cranial nerve was evident. The wound and open reduction scars were well healed and presented an esthetic appearance. Occlusion was within normal limits. *Lower left*) Panoramic radiograph of the right mandibular ramus 3 months post injury showing the extent of osseous comminution. No direct wire reduction had been performed. *Lower right*) Panoramic radiograph of right mandible 62 months post injury. The major portion of the ramus had consolidated but had been augmented with an autogenous iliac bone graft 21 months following injury.





burned tissue in the circumference of the skin. The nature and size of the exit wound were more variable and depended on the impact kinetic energy of the missile as well as the number of secondary missiles created by fragmentation of hard structures such as bone, teeth, or dentures. These secondary missile fragments, which were created and put into motion from the primary missile, acted independently with their own trajectories and paths of destruction. Often these lower velocity secondary missiles were penetrating in nature rather than perforating. The maxillofacial area was particularly prone to secondary missile damage because of the relatively high proportion of hard structures located there (Figure 23).

### **Avulsive**

Avulsive wounds (Figure 19) were caused by either high velocity missiles or missile fragments that perforated the tissues, produced multiple secondary missiles, and carried large segments of hard and soft tissues out a very large exit site. As with the nonavulsive perforating wounds, there

was usually minimal radiographic evidence of residual missile within the tissues. There was, however, ample evidence radiographically and clinically of the major extent of the avulsive injury (Figures 24 and 25). Because of the massive destruction and loss of tissue along the missile path, this type of wound was usually the most severe and management of all stages presented the greatest challenge to the surgeon.

Many wounds that on first inspection appeared to be avulsive in nature, subsequently could be shown to have little or no actual tissue loss. The injured tissues were simply displaced to a significant degree, and after debridement and exploration, it was possible to reconstruct them and perform primary closure. In essence there was apparent versus real tissue loss (Figures 23 and 26).

The wounding pattern was highly variable in avulsive injuries, and underlying skeletal avulsion was common. Discontinuity defects of the mandible occurred frequently—their management will be discussed in subsequent sections of the text. Such wounds most often resulted from high velocity rifle missiles (Table 5).

## **INITIAL CARE**

### **INTRODUCTION**

Treatment at the site of injury or during initial medical transit in the combat zone was usually minimal and expeditious. This was predicated on ready availability of rapid, early evacuation to more definitive treatment facilities and initial care was most often provided by fellow combatants or paramedical personnel.

### **AIRWAY MANAGEMENT**

#### **Assessment of the Airway**

The airway was frequently compromised and of primary concern. Initially the airway was assessed to determine partial or complete obstruction. This assessment included inspection and gross debridement of blood, teeth, and foreign material. Clearing the mouth and oropharynx of debris usually obviated upper airway or supraglottic

obstruction. When available, suction was used in conjunction with inspection and debridement. If the patient was conscious and in possession of reflexes, he was usually able to maintain his own airway if placed in either a lateral, semi-Fowler's, or lateral prone position. Patients with severe maxillofacial injury and potential airway compromise were never allowed to remain on their back, since in the supine position they were most susceptible to the aspiration hazard of blood, emesis, oral secretions, and foreign materials such as teeth, dental appliances, and wounding missile fragments.

#### **Artificial Airway Assistance**

When airway patency and adequate respiration could not be established and maintained by inspection and debridement of the upper airway, some type of artificial airway assistance was employed. The first method of assistance was in

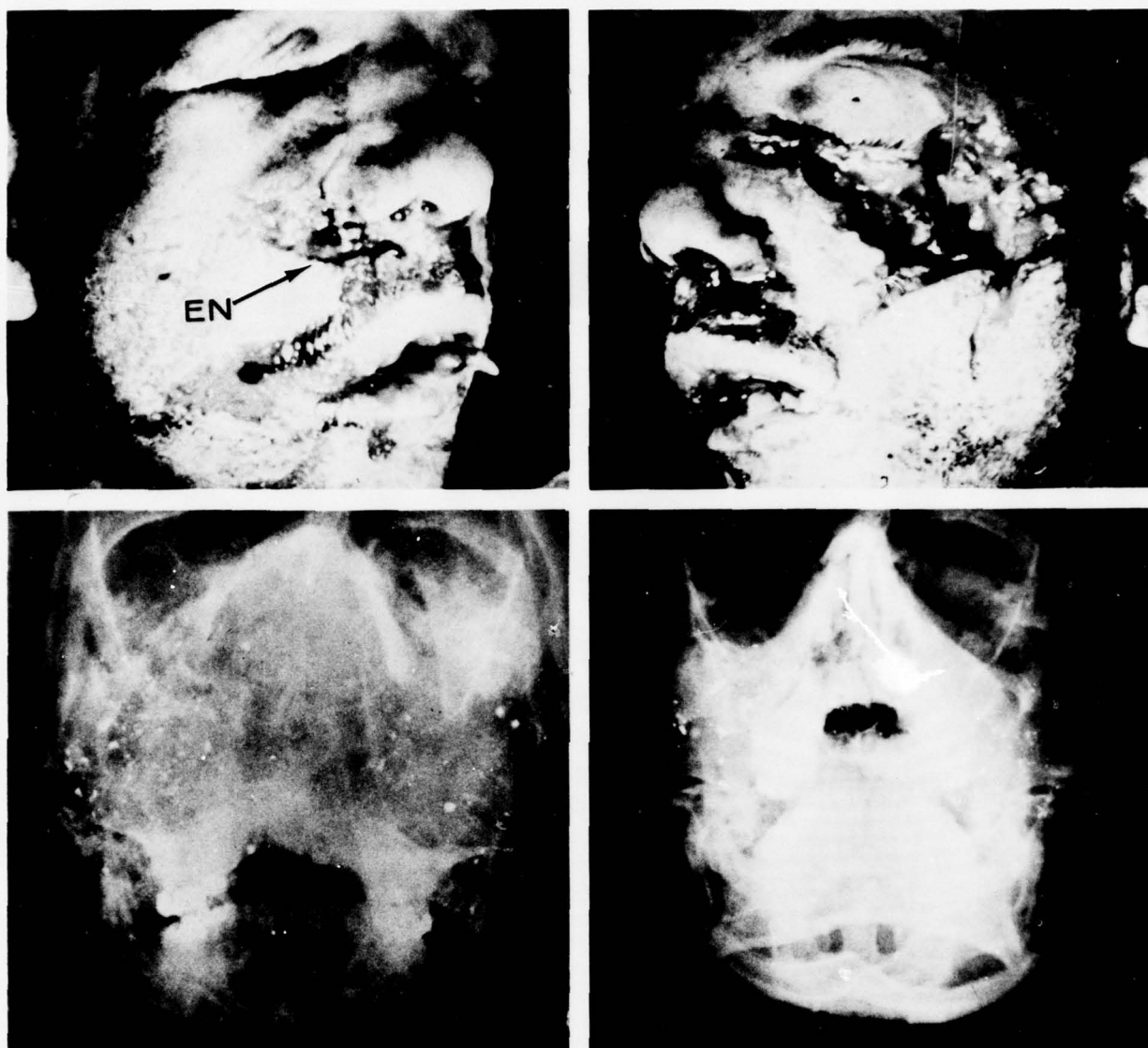


Figure 24.—Upper left) Wound of entrance (En) for a high velocity missile in the right cheek of a 22-year-old casualty. Upper right) Wound of exit in left cheek. Lower left) Anteroposterior radiograph showing the extreme comminution and avulsion that occurred in the midfacial skeleton as a result of the missile injury. The major extent of damage was above the level of the apices of the maxillary teeth and below the orbit. Although a portion of the left orbital floor was avulsed, damage to the eye was not severe enough to warrant enucleation. The face was noticeably elongated. Lower right) Posteroanterior Waters projection radiograph 49 months following injury showing the healing that had occurred in the midfacial area. Following consolidation of the midfacial skeleton, a bone graft was placed in the orbital floor-zygomatic area to support the globe and restore contour.



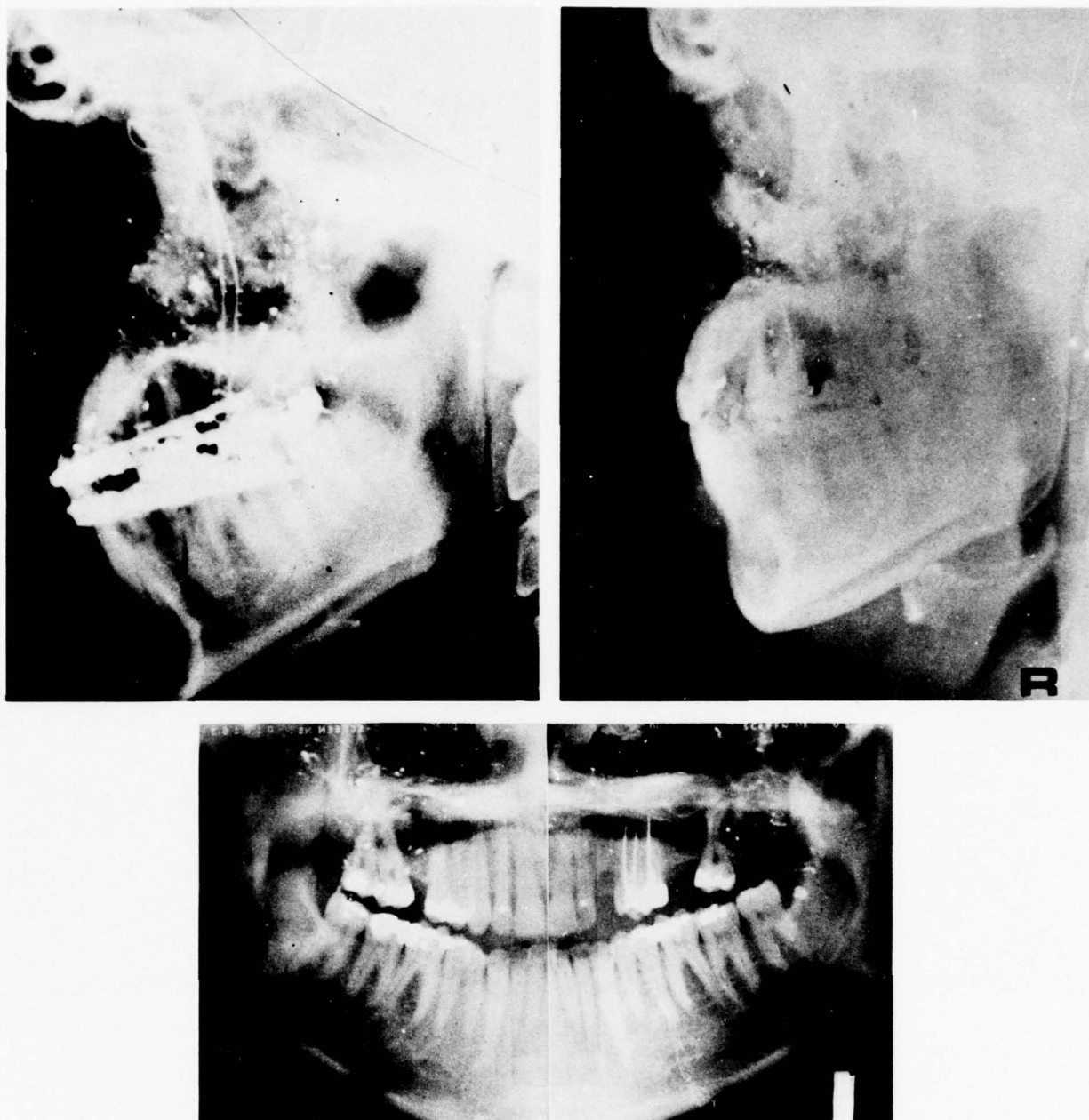


Figure 25.—*Upper left*) Lateral cephalometric radiograph of casualty shown in Figure 24 four months after injury showing intermaxillary fixation and internal suspension wiring that were providing fixation and stabilization to the facial skeleton. The pterygoid plates were intact and it was possible to restore the vertical dimension of the face with this means of stabilization during healing. *Upper right*) Lateral cephalometric radiograph 49 months following injury showing normal vertical dimension of the facial skeleton as well as a normal maxillary-mandibular relationship. *Lower*) Panoramic radiograph 49 months following injury showing the well-healed midfacial area and the normal relationship of the maxilla to the mandible. Numerous small missile fragments are still present in the tissues. There has been rehabilitation of the remaining dentition.



Figure 26.—Upper and Middle) Injury produced by a high velocity missile in the left cheek. There had been soft tissue avulsion although in this instance the extent of tissue loss was more *apparent than real*. Lower) Satisfactory wound closure that was possible only because of a limited, real loss of tissue.

the form of a supraglottic airway that was usually of the oral type. These were adequate for short periods prior to definitive treatment but were usually not well tolerated by fully conscious patients and were more appropriate for the unconscious patient as a temporizing measure.

If upper airway obstruction could not be cleared by mechanical measures or by insertion of an artificial airway, consideration was given to opening the airway beneath the level of the vocal cords by a cricothyroid membrane penetration.

Cricothyrotomy was fast and simple and could be safely performed by trained paraprofessionals. This procedure was temporarily lifesaving in acutely obstructed patients.

In those instances where paraprofessionals were trained in endotracheal intubation this method of airway maintenance was employed (Salem, 1967). Either of these procedures was safer and less complicated than tracheostomy and allowed further transportation under observation to a location where definitive care could be accomplished. *Tracheostomy* was not attempted by personnel without surgical training and when performed was accomplished only when there were adequate operating facilities including lighting, suction instrumentation, and trained surgical assistants (Lehr, 1972).

### Altered Consciousness

In the conscious patient obstruction was usually quite evident since patients exercised protective reflexes in an attempt to clear air passages thus suggesting the presence of obstructive material. On the other hand, *unconscious or semiconscious patients* with diminished protective reflexes experienced varying degrees of obstruction with no gross evidence of airway compromise. For this reason the maxillofacial patient with altered consciousness required extremely careful airway observation until he came under continuous medical supervision.

### Respiratory Diagnosis

Although diagnosis of respiratory lesions below the upper airway in patients with maxillofacial injury is not within the purview of this text, a comment concerning the respiratory system as a whole is necessary. The airway is a component of the respiratory system and compromise of respir-

ation may result not only from *supraglottic obstruction but also from infraglottic obstruction, pulmonary pathology, or central nervous system depression or damage*. Efforts to sustain respiration will fail if the upper airway alone is maintained while other serious respiratory lesions are neglected. As an example, clearing the upper airway will assist resolution of, but not correct, a ventilatory deficiency resulting from the sequelae of severe pulmonary trauma. The main objective of airway management in the initial care period was to establish and maintain the upper airway and provide ventilatory assistance as required until definitive diagnosis and treatment could be provided for other suspected respiratory problems.

### Effect of Facial Fractures on the Airway

Patients with *loss of mandibular continuity* had significant potential for airway jeopardy depending on the severity of the injury. The mandible provides support to the tongue and floor of mouth (Figures 11 and 12, Chapter III) and when this support was lost these structures collapsed into the airway producing partial obstruction; swallowing became difficult and the effects of edema, increased secretions, and debris on the patency of the upper airway were magnified. These patients required careful management to prevent avoidable respiratory obstruction and death. By careful observation, patient positioning, manual support, and retraction with clamps, sutures, or dressings, the mandible and tongue were maintained in a forward position to provide for a maximal airway opening. These casualties were placed in the lateral prone position since this allowed gravity to assist rather than worsen the airway situation. Intubation or tracheostomy was accomplished as soon as possible in these circumstances.

The deleterious effects of maxillary/midfacial fracture result from the tendency of these structures to become inferiorly and posteriorly positioned in the presence of fracture disruption. This skeletal and soft tissue repositioning, in conjunction with edema and a tendency for profuse bleeding from the maxillary area, also produced compromise of the airway and the attendant measures were appropriate to prevent asphyxia. The most satisfactory position for midfacial injury, especially with a relatively intact mandible, was either semi-Fowler's or upright,

providing such a position could be adequately tolerated by the cardiovascular status and/or other injuries.

### OTHER ADJUNCTIVE INITIAL CARE

Only the most obvious and gross debridement and cleansing of wounds were indicated at this interval. Bleeding was controlled by pressure dressings and attempts were made to tie off bleeding vessels only if they were large, readily visible, and a judgment could be made that they would continue to bleed profusely even if covered with pressure dressings. Orthopedic splinting of maxillofacial fractures is not possible though simple dressings, such as the barrel or modified Barton bandage, were occasionally used for temporary support of the unstable mandible (Rowe and Killey, 1970 [b]). If applied, such bandages were placed to provide essentially vertical support and thus avoid accentuating the tendency of the unsupported jaw and associated muscles to collapse backward and downward into the airway (Figure 27).

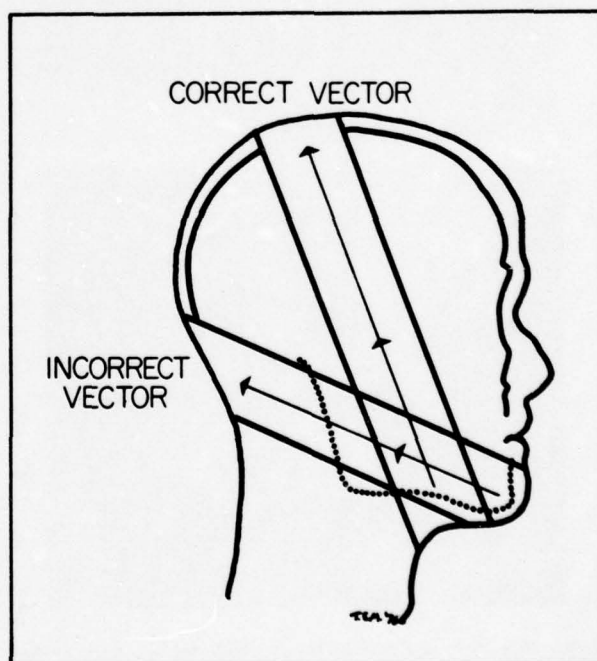


Figure 27.—Diagram illustrating the correct and incorrect vector of application for bandages applied for temporary support of a fractured, unstable mandible.



Supportive therapy was desirable but depended on the skill of the attendant personnel and available medical supplies. Whenever possible, an intravenous line was established very early to prepare for medically directed infusion of appropriate resuscitative fluids and medications. At this stage, pain medication was usually best administered by the intramuscular route.

It is evident from the foregoing that the major

effort of initial care by nonprofessionals or paraprofessionals was directed toward maintenance of the airway because this is the most life-threatening complication of maxillofacial injuries. Treatment beyond the temporizing measures described was reserved for those subsequent facilities that were staffed and equipped to medically manage casualties.

## TRIAGE AND PATIENT EVALUATION

### TRIAGE CONCEPTS

Triage is essential in all phases of casualty care. It can be defined as the sorting out and classification of the wounded who have been brought to a treatment facility. The requirement for triage exists when there is a discrepancy between the volume of patients presenting for treatment and the available treatment resources. Triage was not confined to major medical facilities but in fact began shortly after injury when patients were first seen in casualty clearing areas or minimal facilities. Priorities for early care were based on the establishment of categories of patients according to urgency so that patients were cared for in a time frame consistent with their injuries. At the initial triage point the *objective of triage was to sort patients on the basis of their medical condition for:* 1) immediate transfer to large facilities after assessing stability of their airway, bleeding, and circulation or 2) temporary retention to provide immediate lifesaving emergency surgery (i.e., tracheostomy, thoracotomy, etc.) in preparation for later transfer, or 3) retention for minor medical or surgical procedures in preparation for return to duty. Triage from the advanced battle facility was coordinated with the evacuation system, and patients were routed to more sophisticated facilities depending on the location of these facilities, the nature of the patient's injuries, and the availability of patient beds and specialized professional personnel required for treatment (i.e., neurosurgeon, ophthalmologist).

The fully implemented concept of triage was accomplished at the major complete facilities where staffing and equipment permitted optimal management of casualties. The triage officer was ideally the general surgeon most experienced in

combat trauma treatment. He worked in a triage area staffed by paraprofessionals well trained in emergency resuscitation. This area was designed to be simple and efficient and permit rapid turnover of patients. Most patients were transported on a litter, and at many facilities, movable wooden supports were used for litter holders rather than fixed tables. This arrangement eliminated the necessity for transfer of patients from one table to another and permitted greater flexibility of movement within the triage area. The triage officer directed patient resuscitation and established priorities for presurgical workup. Surgical specialists were called by the triage officer as required to assist with specialty diagnoses and to accept responsibility for supervision of the treatment workup after the triage officer had established the priority of management.

In the triage process patients were generally sorted into *three broad categories*: 1) Those casualties with relatively minor wounds, 2) casualties with major wounds that were potentially life-threatening, and 3) mortally wounded casualties whose injuries appeared likely to be fatal. The guiding principle was to do the best for the most persons with what was available by way of supplies and personnel. To most effectively utilize available personnel, it was thought to be more important to devote the maximum time and energy to those who could certainly be salvaged rather than to those who might survive only with enormous expenditure of man-hours and resources (Wilson, 1970).

Management varied according to the location and facilities of the treating hospital and also according to the immediate combat situation. The majority of the injured who were evacuated to the complete hospital facilities were retained until all

requisite treatment had been completed. The minimally injured or category 1 patients, under normal circumstances, were not assigned high priority for care since they were better able to await treatment without developing serious complications. Category 2 patients usually ranked top priority for earliest care. Mortally wounded category 3 patients received at least humanitarian pain-obtunding medications as indicated. As professional personnel became available, all appropriate lifesaving surgical and/or medical procedures were carried out on these morially injured patients regardless of the prognosis.

## PATIENT MANAGEMENT IN THE TRIAGE AREA

### Primary Procedures

The triage area permitted ease of movement and provided ready access to supplies, laboratory, and radiography spaces. General and specialty surgeons and medical technicians had their triage responsibilities clearly defined and regimen of treatment standardized.

Initially vital signs were obtained and compared to any previously recorded notations and then recorded at appropriate intervals depending upon the condition of the patient. One or more *intravenous routes* were established with indwelling intravenous cannulas, and blood was drawn for typing and cross-matching (Knight, 1973). The earliest possible *typing and cross-matching* were required to permit the laboratory blood bank time for preparation of compatible donor blood. More *constant* and reliable laboratory results were obtained when this initial blood typing preceded transfusion of volume-expanding solutions such as dextran, which complicated the cross-matching procedure.

*Intubation* under direct vision and without adjunctive anesthesia or medications was the customarily indicated emergency procedure when the airway was seriously compromised (Salem, 1967). A narcotic, if not contraindicated by neurologic injury or respiratory compromise, assisted tolerance to the nasotracheal or orotracheal intubation. Tracheostomy was deferred until the patient was brought to surgery.

To accomplish the necessary examinations all

clothes were removed from the patients, care being taken not to disrupt splints or protective bandages that might be acting as pressure stops to bleeding. Removal of clothes was often facilitated by cutting them off. Care was taken to detect undetonated ordinance remaining in combat clothing. To minimize further injury, it was prudent to avoid excessive manipulation of the head, neck, or other potentially injured parts. Although physical examination was one of the most important procedures to be accomplished on these patients, in the triage area it was necessarily condensed, and the definitive preoperative physical examination was deferred until the surgical specialist who would be performing the treatment accepted responsibility for the patient.

*Control of pain was not a serious problem* and few patients required analgesics before surgery (Knight, 1972, 1973).

### Sequence of Management

Priority of treatment was established and those injuries requiring earliest repair were identified. The sequence of patient management was altered depending on the priority of treatment established for the various injuries and combinations of injuries. Figure 28 diagrammatically illustrates the potential routes utilized in bringing patients to the operating room for definitive care.

The most common route was:

Triage → Radiology → Surgical Staging → Operating Room.

Variations in this routing were usually predicated on the acute needs of the patients, particularly their requirement for immediate treatment of extensive vascular injuries. The surgical staging area was a buffer between triage-radiology and the operating room. More definitive preoperative diagnostic assessment of the casualty was accomplished in this area by the surgical specialist(s) responsible for treatment. Direct routing to the operating room from triage occurred only for eminently life-threatening conditions. Radiographs were not obtained when the need for rapid surgical intervention outweighed the value of the information that could be derived from the films. It is obvious that expediency was far more prevalent in these conditions than in the ordinary clinical environment although it should *not* be inferred that treatment was less than optimal. Incorporation of patients into the medical



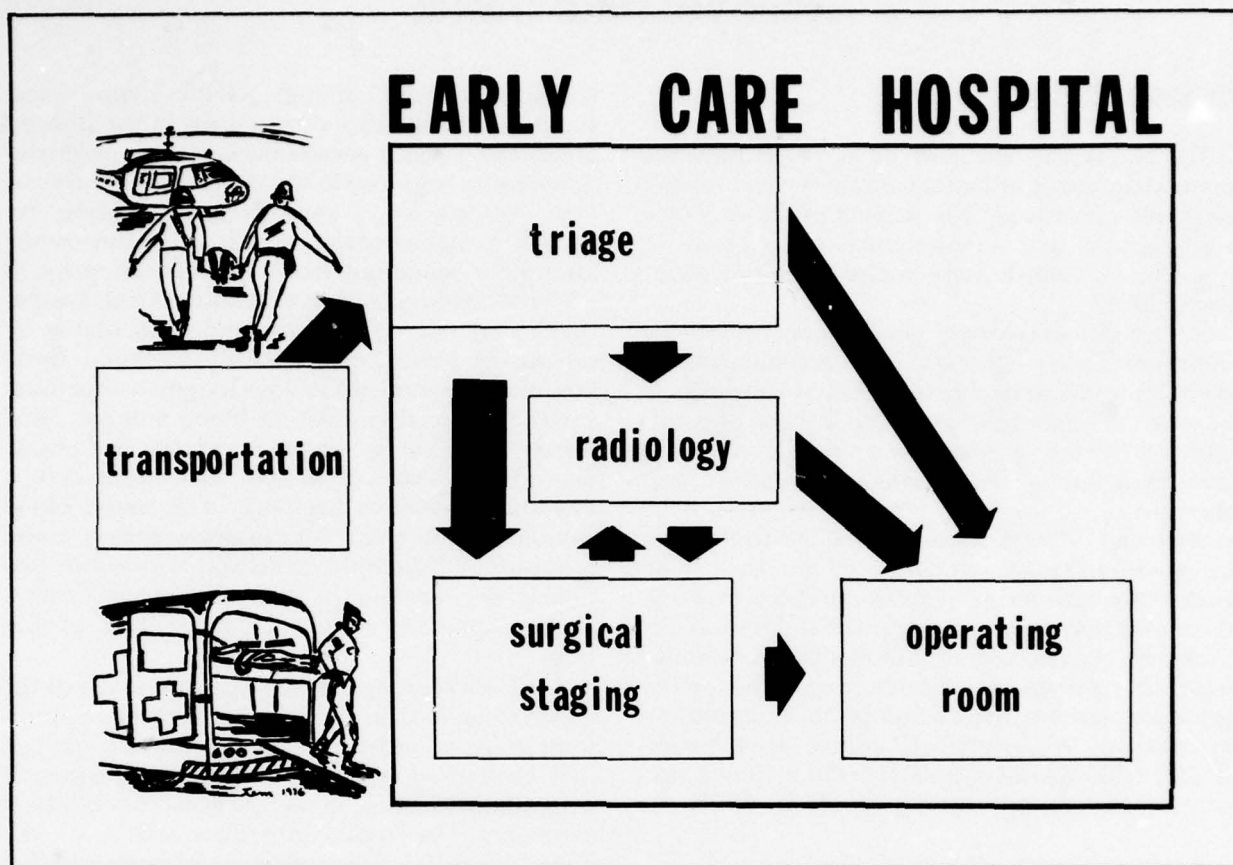


Figure 28.—Diagrammatic illustration of the potential course that casualties followed en route to the operating room at the Early Care Hospital Facilities where they were to undergo definitive treatment of their wounds.

system was highly dynamic, and flexibility of management was essential.

#### Priority of Treatment

If all resources were available, the following *types of injury in order of priority* required the most urgent treatment: 1) major vascular or burns, 2) major thoracic, 3) major abdominal, 4) major urologic, 5) major brain and spinal cord, 6) orthopedic (extremities), and 7) oral and maxillofacial.

*Numerous factors influenced the priority of treatment*

and these included the following: 1) stability of vital signs, 2) number of anatomic areas injured, 3) number of patients injured, 4) availability of surgical facilities, 5) availability of general anesthesia, and 6) availability of surgeons.

*Treatment of maxillofacial injuries* could normally be deferred once the vital signs were stable, airway established, fluid and electrolyte replacement initiated, hemorrhage controlled, and pain medication administered. However, in the case of the multiply injured patient, maxillofacial injuries were treated simultaneously with other injuries whenever possible.



## HYPOVOLEMIC SHOCK

### CLASSIFICATION

It was necessary for all surgeons responsible for the management of battle casualties to be knowledgeable concerning the subject of shock, since resuscitation and maintenance of patients in hypovolemic shock were major components of early care.

Although controversy persists concerning the definition, type, etiology, and mechanisms of shock, it is still desirable to briefly review what is known and generally accepted concerning this entity in order to establish a suitable frame of reference for a discussion of diagnosis and therapy.

Blalock (1930) classically described four major categories of shock, which served as a basis from which our knowledge of this subject has evolved. A *contemporary classification of shock* and its etiology includes: 1) hypovolemic (blood, plasma, or water loss), 2) cardiogenic (infarct, arrhythmia, tamponade, late hypovolemia, epidural, or general anesthesia), 3) peripheral pooling (spinal anesthesia, endotoxemia), and 4) cellular deficit (decreased oxygen utilization) (McClean, 1971).

### MECHANISMS AND PHYSIOLOGIC MANIFESTATIONS

Shock results from failure of the pump (heart), the pumped fluid (blood), the arterial resistance of vessels (arterial tone), the integrity of the capillary bed, the capacity of the venous bed (venous tone), or combinations of these (Shires, 1966 [a]). In essence, regardless of the cause, the shock state implies *inadequate tissue perfusion*. A low perfusion rate of blood to the tissues is the most common reason for irreversible damage to the cells (Gelin and Border, 1970). The major type of shock encountered with war injuries, including maxillofacial wounds, was hypovolemic, therefore further discussion will be limited to this particular entity.

Hypovolemic shock is caused by a significant *depletion in the circulating blood volume*. This volume deficiency may be from the loss of whole blood (hemorrhage from lacerations), plasma (burns and crush injuries), or extracellular fluid in extravascular spaces (water loss or deprivation). In war-wounded patients hemorrhage was

the predominant etiology. Acute hypovolemic shock, apart from local responses in the injured area, brings about *generalized increase in peripheral resistance* in response to the reduction in intravascular volume. This compensatory vascular response to hemorrhage, which is a homeostatic attempt to maintain hemodynamic integrity, is effected through reflex activation of the sympathetic and adrenal systems and is mediated by release of serum catecholamines. When these adaptive mechanisms can no longer compensate for the reduced circulating blood volume, *blood pressure falls, cardiac output is reduced, and venous return to the heart is diminished*, as evidenced by a low central venous pressure. The initial blood pressure change is a fall in systolic pressure and narrowing of the pulse pressure. With continued deficit, the diastolic pressure falls progressively and compensatory tachycardia becomes prominent.

*Biochemical changes* also occur with onset of the shock state. Because of the low perfusion conditions there is a reduction in the amount of oxygen delivered to organs and tissues, and consequently a mandatory change in metabolism from *aerobic to anaerobic*. The most immediate effect of the anaerobic shift is the production of lactic acid that replaces carbon dioxide as the end product of metabolism. A progressive metabolic acidosis results as lactic acid accumulates and there is depletion of available buffer bases.

In severe hypovolemic conditions *reflex shunting mechanisms* come into play to selectively divert most of the available blood to essential organs, particularly the brain and heart. This shunting is at the expense of other organ system perfusion, particularly the kidney which is the first to demonstrate functional impairment. The biochemical aberrations which have been described are magnified by the compromise of renal function.

### CLINICAL MANIFESTATIONS

Presenting signs and symptoms of hypovolemic shock included hypotension, increased pulse rate, increased rate and depth of respiration, cool-ashen to cyanotic skin, thirst, early restlessness progressing to apathy or coma, and frequently nausea and vomiting. "Clammy skin" was

not normally a feature. A rapid pulse is considered to be a manifestation of early hypovolemic shock, but some patients failed to develop a tachycardia especially if blood loss had been very sudden and the patient kept in a reclined position. Tachycardia was stimulated if the patient was brought to an upright position (Knight, 1973). These patients often presented a *deceptive appearance* since they manifested little or no distress and complained only of chills and thirst. If the shock condition was advanced and therapy inadequate or absent, the apathetic state proceeded to coma. When cerebral perfusion was compromised to the extent that unconsciousness ensued, the prognosis became very poor. Lesser degrees of shock were more common and the signs and symptoms were similar but of reduced magnitude.

## MANAGEMENT

Management of the patient in hypovolemic shock first required a prompt and accurate diagnostic assessment followed by *rapid, aggressive, and appropriate care*. Selected laboratory data were obtained on venous and arterial samples to establish a biochemical profile for the patient and serve as a base line for subsequent studies. Collins et al. (1970) reported the following findings in 450 seriously injured combat casualties when first admitted to the hospital. As the blood pressure lowered, arterial hydrogen ion concentration, lactate concentration, and pulse rate increased and arterial pH, blood buffer base, carbon dioxide tension, and hematocrit decreased. Individual variations were great especially in the hypotensive patients; acid-base status could not be accurately predicted on clinical grounds.

The *major therapy* for hypovolemic shock was adequate replacement of depleted blood volume by crystalloid solutions and properly cross-matched, type-specific whole blood (Lowery, et al., 1971; Moss, 1972). The amount of fluid that could be passed into the hypovolemic circulation depended on the reactivity of the recipient veins, the size of the hollow tube used for administration, and the rheologic properties of the substance given. Spasm was overcome by use of large veins proximal to the knee or elbow. Only the largest size cannulas were recommended for use, and needles were avoided since they could become dislodged at critical times. Cold blood is

slow and sticky whereas crystalloid solutions are fast and free. Thus, it was common practice to accomplish rapid massive replacement of volume deficits with crystalloid solutions and await the availability of whole blood if required (Dudley, 1973).

The crystalloid solutions were administered at a rapid initial rate of 1 to 2 liters within the first hour. This was useful, not only to restore circulatory fluid but also helped to restore depleted extracellular fluid reserves, which were commonly seen in the tropical climate of Vietnam (Thompson, 1967; Knight, 1973).

Blood was indicated if the initial fluid replacement with crystalloid was unsuccessful in restoring and stabilizing vital signs to a satisfactory range or there was a need to reestablish oxygen-carrying capacity at physiologically acceptable levels. Whenever possible, only type-specific, cross-matched blood was transfused, but it was occasionally necessary to use "O" negative blood with low anti-A titer for the initial emergency treatment of critical patients with life-threatening hypovolemia.

Crystalloid electrolyte solutions were sometimes followed or supplemented with colloid solutions such as plasma, albumin, or dextran. Most popular of these was human plasma. Although readily available and effective, its main disadvantage was the risk of viral hepatitis, especially if the plasma was from a pooled source. It also had no significant oxygen-carrying capacity and therefore was not considered a definitive whole-blood substitute. Low molecular weight dextran was occasionally used as a plasma expander solution. Although it remained intravascular for longer periods than crystalloid solutions, it again had no oxygen-carrying capacity and occasionally caused allergic reactions. Dextran also produced defects in the clotting mechanisms, an obvious detriment in a patient with hemorrhage problems.

The *adequacy of fluid replacement* was usually monitored by the response of the arterial pressure, urine output, temperature and color of the skin, level of consciousness, and central venous pressure (Carey et al., 1971). A depressed or normal central venous pressure that did not rise significantly with rapid administration of a crystalloid solution was thought to reflect reduced venous return or capacitance and thus hypovolemia. Conversely, an elevation of the central venous pressure after fluid administra-



tion was considered indicative of impairment of the pump mechanism in the right heart as a result of fluid overload. At present, more sophisticated methods of evaluating cardiovascular hemodynamics in critically ill patients are available. These involve the measurement of the filling pressures of the right and left ventricles as well as cardiac output by balloon flotation catheterization techniques (Swan, 1975; Swan and Ganz, 1975).

*A horizontal position of the body with the head and knees slightly elevated was usually advocated for the patient with hypovolemic shock. Some redistribution of pooled blood was effected by this elevation of the head and legs. The Trendelenburg head-down position was not recommended, especially for the patient with maxillofacial hemorrhage since this position stimulated hemorrhage and also interfered with respiratory exchange.*

Oxygen support was administered via nasal mask or carefully placed nasal oxygen catheters into the nasopharynx. In these patients an airtight oronasal anesthesia mask was frequently contraindicated because of the severity of orofacial injuries.

Placement of an indwelling urinary catheter, which was accomplished in all patients with major injuries (Knight, 1973), permitted recovery of urine for laboratory evaluation and allowed subsequent monitoring of urine output as an indicator of the adequacy of renal perfusion. Satisfactory renal perfusion was in turn indicative of a stabilizing hemodynamic status.

*Pain was not normally a significant problem with the maxillofacial patient in hypovolemic shock. As care and general medical support became apparent to the conscious patient, his anxiety was reduced, and accordingly his need for analgesics was less. If, however, pain medications were required, it was probably best to administer them in the form of narcotics in small readily effective intravenous doses because these did not contribute significantly to the potentiation of the shock syndrome.*

The use of steroid therapy or digitalis in the patient with hypovolemic shock was not ordinarily indicated (Shires, 1966 [b]). Vasopressors were used selectively and sparingly in the management of hypovolemic shock because the major physiologic imbalance was inadequate tissue per-

fusion, and increasing peripheral vasoconstriction tended to further aggravate this condition.

The *ultimate evaluation* for adequacy of therapy was a response of the patient to resuscitative measures such that anesthesia could be administered and surgical repair of wounds initiated. Success was best reflected in stabilization of vital signs, restoration of cerebration, and resumed organ perfusion as exemplified by adequate urinary output.

A succinct, reasonable discussion of what constitutes an acceptable physiologic status for resuscitated battle casualties prior to surgical wound care has been presented by Dudley (1973). He stated:

The only overriding major contraindication to the administration of an anaesthetic is a fall of available oxygen (Richards, 1944; Nunn and Freeman, 1964) to levels at or close to oxygen needs. This matter can easily be represented on a two-dimensional graph [see Figure 29]. Available oxygen is the product of cardiac output, haemoglobin and oxygen carrying capacity; at any moment it is possible for the body to operate within a triangle bounded at the lower limit by threshold oxygen consumption, at the upper limit by optimal cardiac output, and to the right by the normal level of haemoglobin. From Figure [29] it is clear that, provided cardiac output is maintained, haemodilution down to 8G% is tolerated without transgressing a level of available oxygen 1.5 times the basal oxygen requirement—a fact long known to and exploited by cardiac surgeons who use dilutional perfusion for cardiac bypass. It follows that resuscitation with crystalloid or haemoglobin free colloid to maintain cardiac output is acceptable within the critical triangle and such rapid restoration of cardiac output by volume replacement raises available oxygen to levels which will permit anaesthesia. For this purpose it is the speed at which replacement exceeds loss that will count, and very fast infusion, even if composed of substances that will soon dissipate themselves from the circulation, are effective in making the patient ready for surgery. The efficacy of Ringer-lactate in this regard rests on its ability to flow rapidly through infusion equipment and provided it is used in large amount (1.5–2.00 liters/10 minutes) it will restore circulating volume and available oxygen, thus allowing an operation to begin. It has consequently been the practice of most teams in Vietnam to use rapid massive replacement of circulating volume with Ringer's solution, recognizing that the effect will be shortlived, but that by the time escape into extravascular spaces has occurred, haemorrhage will have been controlled and blood become available (Figure 29).



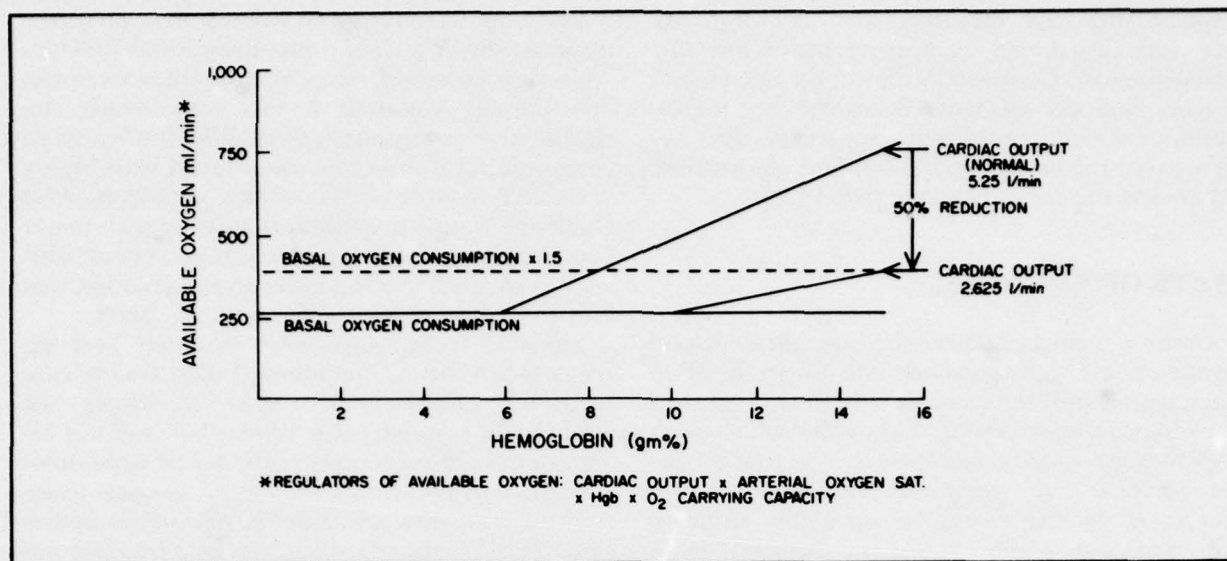


Figure 29.—“The relationship between available oxygen, haemoglobin, and cardiac output. Full saturation (95%) and normal oxygen-carrying capacity (1.34 ml/g Hb) has been assumed. The theoretical available oxygen has been multiplied by 0.7 which is the maximum extraction ratio. It is seen that if cardiac output can be maintained—and this in oligæmia is a function of blood volume—haemodilution down to approximately 6G% is compatible with actual available oxygen which will meet basal requirements. A level of 8G% provides a reserve equal to  $1.5 \times$  basal requirements—[a safe level]. By contrast even with a normal haemoglobin a reduction of cardiac output by [50%] puts available oxygen into the danger area. This diagram treats the body as a whole. Normal extraction ratios vary for different tissues. Thus the heart may be more sensitive to reductions in flow because its extraction ratio is usually high.” [Reprinted with permission from Dudley, H. A. F. *Some Aspects of Modern Battle Surgery*. J Royal Coll Surg (Edin) 18:20, 1973.]

## PRESURGICAL CONSIDERATIONS

### INTRODUCTION

Individual circumstances frequently dictated modifications of treatment and therefore a “standard” approach to these complex injuries was neither possible nor desirable. However, it was advantageous to follow certain general principles which were used as guides to management in the formulation of individualized treatment regimens. Some of these principles are well known and widely accepted, but others are more empirical and controversial with less scientific validity. One purpose of this text is to review and analyze the results of various modalities of management and hopefully to establish a reasonably valid, long-term scientific perspective for them. Following is a description of some of the immediate presurgical considerations that were found effective

in managing oral and maxillofacial injuries during the early care period.

The principle of “team management” was of paramount importance in the handling of severe and multiply traumatized patients. Although a single team member was clearly the leader, the composition of the team was highly variable, being dependent on the nature of presenting injuries. *The team leader was ideally the member best qualified in the area of principal injury.* Frequently more than one surgical team concurrently evaluated and treated injuries on the same patient to expedite care and minimize operating room time. Team leaders or members occasionally shifted roles. For example, in the management of multiple head injuries the maxillofacial surgeon was occasionally an assistant member of the neurosurgical team, after which he accepted

responsibility for directing the maxillofacial care with assistance as appropriate from the neurosurgeon. Cooperation and mutual respect of well-qualified specialists were the key ingredients to the successful team approach, thus assuring that the best of each discipline was utilized to provide the most effective patient care.

### STATE OF READINESS

In the war theater where the hospital workload requirements were sporadic and unpredictable, the hospital staff emphasized a high state of preparedness (Knight, 1972). This included *thorough preplanning for sudden mass casualties* so that available physical and personnel resources of the treatment facility could be optimally utilized. All types of combinations of injuries were envisioned and contingency plans formulated for their management. Necessary medications, equipment, and supplies were adequately stocked well in advance of their projected need. Members of the surgical staff became familiar with the total available armamentarium. Periodic supply problems developed even though the supply system, particularly in relation to medical supplies, was remarkably efficient. Many obstacles were overcome in efficiently maintaining these very long and complex supply lines. It was necessary to intelligently estimate future medical supply requirements and assure that necessary supplies were ordered well in advance so that adequate inventories could be maintained for periods of heavy usage. It should be emphasized that the surgeon did not completely delegate this important responsibility as he was the one required to utilize these supplies, and therefore, ideally, was closely involved in the planning for timely acquisition. In general, the maxillofacial war surgeon developed his early care treatment plans predicated on a relatively simple or uncomplicated surgical armamentarium with a necessity for limited prosthetic support (Fleet, 1975).

It was found desirable to study and if possible practice in advance special procedures or techniques not commonly employed. As a result of such advanced mock preparation, when clinical application was required it was done expeditiously since there were no operating room delays for familiarization with these special procedures.

Surgeons were required to keep an open fertile mind in dealing with nonconventional injuries. Although accepted surgical principles were not intentionally violated, it was occasionally desirable or even necessary to modify, innovatively, conventional techniques when faced with highly variable and unusually complex problems. This challenge was most evident in dealing with major avulsive injuries resulting from high velocity missiles in which there was extensive mutilation that left distorted and unstable anatomic parts.

Surgical technicians were essential and extremely important members of the casualty care team. It was mandatory for these individuals to be adequately trained prior to combat medical assignment because of the frequency of rotation of paramedical personnel within the surgical team, treatment facility, and theater of combat operation. This advanced combat medical training was regularly reinforced and enhanced at the treatment facility to ensure a continued high level of competence in triage and operating room procedures.

### INITIAL OVERALL MANAGEMENT

#### Total Patient Assessment

It was the responsibility of the specialist to maintain a state of awareness concerning the general status of the patient during preparation for surgical treatment. Despite any previous assessment, it was important for the maxillofacial surgeon to perform his own examination of the patient to determine the integrity of all organ systems.

#### Airway

The airway, as always, was the first priority of evaluation and care. The principles of airway management discussed under initial care and triage management were applicable in this definitive care setting, with the exception that the proper environment for performing tracheostomy was now readily available. In many instances artificial maintenance of the airway had already been initiated by this time. However, if the patient's airway problems had become acute, immediate insertion of an oral endotracheal tube was still the procedure of choice, since this obvi-



ated immediate tracheostomy, permitting it to be delayed for performance under more favorable circumstances in the operating room. Awake intubation was considered the safest technique because it minimized aspiration complications (Salem, 1967).

### Control of Hemorrhage

The next matter for consideration was control of hemorrhage. The vascular supply to the maxillofacial area is generous, and although hypovolemic complications are not ordinarily associated with blunt trauma to this region, bleeding from missile wounds was profuse and hemorrhage control was often necessary during presurgical care.

The patients presented with both dressed and undressed wounds, depending upon the logistics of their postinjury transfer and the extent of their initial care. If no dressing was present, the wounds were inspected and obvious bleeding was controlled. If a dressing was present, it was removed to allow presurgical assessment of the wounds. *Aggressive investigation of wounds to detect potential bleeding sites during the presurgical preparation of the patient was not recommended* because it could lead to the development of profuse bleeding that could not be adequately controlled without surgical anesthesia. Detailed wound inspection was therefore delayed until the patient was under general anesthesia and prepared for surgery. This was especially true where there had been a history of persistent or recurrent bleeding from the dressed wound or significant wound instability. If bleeding occurred during inspection it was controlled by appropriate measures such as direct pressure on the bleeding part or local arterial pressure points, hemostatic clamps, vascular ties, or occlusive dressings.

As a result of the rich blood supply, intraoral and intranasal bleeding was often brisk and control was complicated by poor access, limited visibility, and compromise of airway. The most expeditious method was the use of gauze pressure dressings that were applied with careful consideration for airway adequacy. It should be emphasized that these temporizing measures were considered a prelude to the definitive management of vascular injury as a component of overall wound treatment, which was best accomplished

later in the operating room.

### Vital Signs

While completing a rapid initial total-body evaluation, and managing airway and significant hemorrhage, attention of personnel was also directed to *acquisition, recording, and evaluation of vital sign data*. Whenever possible this information was obtained by paramedical personnel, thus freeing the primary clinician for performance of definitive surgical evaluation and care. Minimum data acquired included: measurement of blood pressure, pulse rate, respiratory rate, and determination of level of consciousness. Monitoring of vital signs during the presurgical period was continued at appropriate intervals dependent on the status of the patient.

### Intravenous Infusion

Intravenous routes had been inserted during initial care or triage, but their adequacy had to be determined and additional routes added as necessary in anticipation of more rapid sustained fluid replacement during the operative period. Since many of these patients required prolonged intravenous sustenance, indwelling cannulas were recommended rather than needles. Large lumen, proximal veins were used in preference to smaller distal veins such as those in the hand. Simple venipuncture was sometimes quite difficult in the "bled-out" patient with low peripheral venous pressure, and it was often easier to cannulate a vein if the skin was anesthetized with local anesthesia before trying to insert the cannula (Knight, 1973). The most common presurgical replacement fluid was a crystalloid solution such as lactated Ringer's, the amount and rate dependent on the clinical assessment of the surgeon in charge of the patient.

### Laboratory Studies

When the intravenous infusion was initiated, a sample of blood was drawn for laboratory examination. Routine blood tests included hemoglobin, hematocrit, electrolytes, complete blood count, and differential leukocyte count. If not already performed, typing and cross-matching were also



ordered as a preliminary to procurement of compatible whole blood for transfusion. Additionally, a heparinized refrigerated arterial blood sample was frequently obtained to determine base line values of  $pO_2$ ,  $pCO_2$ , and pH in patients with compromised cardiopulmonary function, as for example, hypovolemic shock or partial airway obstruction.

A urine specimen was obtained for standard laboratory analysis. If the patient was unable to void or had major injuries, a urethral catheter was placed (Knight, 1973).

### PRESURGICAL EVALUATION

Once the initial assessment had been accomplished and necessary lifesaving resuscitation measures performed, attention was directed to a more *definitive evaluation* of the patient in preparation for the surgical treatment of wounds. Byerly and Pendse (1971) reviewed the management of patients over an 11-month period at a surgical hospital designed, staffed, and equipped to handle battle casualties. They found that, although there were no specific time limits set, it required approximately 60 minutes (range 40–360) to resuscitate and evaluate the patient, obtain radiographs, and prepare him for surgery.

### History

Conscious and alert patients were usually apprehensive; therefore, during the period of evaluation, it was desirable not only to acquire necessary medical information but also to provide reassurance. Because of the need to expeditiously accomplish treatment, only *pertinent* historical data were obtained such as allergies, current medications, special problems, and time and content of last feeding. Few patients were expected to have a remarkable medical history because of the rigid medical screening required of all military personnel prior to combat deployment. However, all newly admitted hospital patients including trauma victims were carefully evaluated for the presence of diseases indigenous to the combat area. Malaria, dysentery, intestinal parasites, and fungal infections were among the incidental diagnoses observed. Concomitant medical disease was seen most frequently during the late care period (see Table 18, Chapter V) (Gilbert, 1968).

In the noncommunicative patient available in-

formation was obtained from uniform, wallet, and dog tags. Frequently, stretcher bearers or other personnel accompanying the injured patient provided accounts of useful historical information concerning the patient that had been related to them during the period of transfer.

On a humanitarian basis Vietnamese patients, both military and civilians, were frequently seen and managed in American Early Care Hospital facilities. These patients presented many special problems, the most frustrating of which was the language barrier that made communication more difficult (Stump 1971). Even when interpreters were available, an uncommon circumstance, customary oral communication was significantly compromised. Consequently, highly verbal procedures such as obtaining meaningful historical data were most inadequate, and a crude form of sign language became the only available communication link for obtaining information or providing instruction. Despite these hardships, the Vietnamese were generally highly cooperative and grateful patients. Professional, specialized maxillofacial surgical care through domestic Vietnamese civilian or military facilities for these patients was limited.

### Physical Examination

Effective definitive surgical care was predicated upon an adequate presurgical examination protocol that included intelligent assessment of the extent of injury and all organ systems followed by formulation of a logical treatment plan. A competent physical examination to properly access the amount, extent, and nature of injuries was the most important of all preoperative procedures.

The examination was thorough yet expeditiously performed. Although it was not always possible to record findings at the time of evaluation, it was necessary to complete the patient chart at the earliest interval consistent with the pressing demands of casualty care. Paraprofessional personnel were of great assistance in performing some of these clerical duties. If an earlier examination had been performed and recorded at another facility, such records were reviewed prior to initiation of examination. Special attention was directed to those anatomic areas and systems that had sustained *apparent* injury or to those symptomatic areas without overt evidence of

damage. Clothing had usually been removed in the triage area, but if this had not been completed it was necessary to finish disrobement to permit examination of the entire body. Bandages and dressings previously placed by personnel in earlier treatment facilities were carefully removed if appropriate and required for preoperative inspection of the underlying wound. If definitive surgical care was to be delayed, the wound was redressed. Frequently, some of the definitive portions of the examination were best deferred until after the patient was under general anesthesia and initial debridement had been effected.

In those patients where the maxillofacial injury appeared to be the only injury, the physical examination included an assessment of all systems and was not limited to the apparent site of damage. Concomitant injuries, especially those from fragmentation weapons, were common. Extremity injuries (53.77%), and head and neck injuries (37.69%), other than those directly associated with the maxillofacial injury, were seen most commonly in the MFCS patients. The severity of the maxillofacial injury was not related to the incidence of the various concomitant injuries because the frequency of these injuries was found to be similar for all the maxillofacial casualty study (MFCS) groups (Table 6).

The concomitant injuries were not always obvious and even in the asymptomatic patient it was necessary to be alert to their possibility, particularly undetected cranial or cervical injuries. Appropriate evaluation of these structures was accomplished prior to further evaluation and/or treatment of maxillofacial injuries. Neurologic findings were recorded as the base line to be used as a frame of reference for interpretation of subsequent findings.

Examination of the neck was accomplished

with the understanding that *it was desirable to surgically explore all penetrating missile wounds* (Fitchett et al., 1969). Laryngeal injury was associated with visible or palpable evidence of wounding such as swelling, airway obstruction with stridor, retraction and cyanosis, hoarseness or aphonia, emphysema and crepitation, and inability to swallow secretions. Surgical management of neck wounds was initiated by the appropriate specialist when positive findings of injury were noted.

It should be emphasized that patient evaluation included not only initial physical examination but also *continuing assessment of the condition of the patient* during the preoperative period. Since this text deals with oral and maxillofacial injuries, further comments concerning examination will concentrate on this area.

**Examination of the Facial Skeleton:** Numerous descriptions of the examination for patients with facial fractures are in the literature (Guralnick, 1968; Kruger, 1968 [a]; Thoma, 1969; Rowe and Killey, 1970 [c]; Waite, 1972; Converse, 1974 [a]; Osbon, 1974; Archer, 1975); therefore, in this section we will highlight only those aspects of the oral and maxillofacial examination that are considered most pertinent to casualty care.

The examination procedure for the facial skeleton was organized into *upper, middle, and lower thirds*. In the battle-injured patient it was more convenient to include the oral, nasal, and sinus cavities with the lower face. The examination included a visual survey of the superficial tissues and palpation of underlying osseous structures to determine the morphologic integrity and stability of the facial skeleton. Radiographic examination was accomplished after completion of the clinical examination and was used to confirm physical findings rather than as a primary source of diagnostic information.

TABLE 6.—*Listing of the Incidence of Concomitant Injuries by General Anatomic Region for the Five Groups of Patients Included in the MFCS*

Group		Head and Neck	Thorax	Abdomen	Extremity
I	(N= 93)	29 [31.18]*	18 [19.35]	9 [9.68]	52 [55.91]
II	(N= 45)	20 [44.44]	2 [ 4.44]	6[13.33]	20 [44.44]
III	(N= 22)	7 [31.82]	5 [22.73]	4 [18.18]	12 [54.55]
IV	(N= 32)	18 [56.25]	8 [25.00]	7 [21.88]	19 [59.38]
V	(N= 7)	1 [14.29]	0 [00.00]	2 [28.57]	4 [57.14]
Total	(N=199)	75 [37.69]	33 [16.58]	28 [14.07]	107 [53.77]

\*Figures in brackets equal percentage of N.



*Upper Third of the Face.* In the absence of a primary head injury, the upper third of the face was carefully scrutinized in conjunction with examination of the rest of the cranial vault. Scalp lacerations are known to bleed profusely; therefore, care was exercised when temporary dressings were removed from the craniofacial area. Lacerations, contusions, and abrasions were carefully examined to detect the presence of underlying skull fracture and/or the presence of missile fragments or other foreign bodies. In hirsute areas all hair was removed by scissors and shaving before the patient was examined, with the exception that the eyebrows were never shaved. Neurosurgical opinion was solicited in those cases where there was confirmation or reasonable suspicion concerning the presence of skull fracture. Damage to the frontal sinus area was evaluated with the understanding that underlying osseous fractures could involve both the outer and inner table of the sinus and thus produce an open injury to the brain.

*Middle Third of the Face.* It was possible to evaluate injury to the midfacial region by review of damage to the following anatomic units: orbital area, zygomaticomaxillary cheek area, naso-orbital area, and the areas described by the Le Fort fracture patterns. Because of the extensive nature of these wounds, isolated injuries to a single unit were the exception rather than the rule.

*Orbital injuries* involved bone, soft tissue, and specialized tissue of sight. It was ordinarily the function of the maxillofacial specialist initially to assess the skeletal and nonocular soft tissue damage and determine the functional integrity of the eye. Visual acuity was determined and efforts were made to save every eye in which there was at least light perception. Lacerations of the lids and associated soft tissues including the globe were noted, with the understanding that repair by an ophthalmologist was desirable. Subconjunctival hemorrhage was a common finding in orbital fractures but did not in itself signify ocular injury of any consequence. Hyphema, on the other hand was particularly dangerous and ophthalmologic evaluation and treatment were essential in managing such injuries to assure that secondary glaucoma was correctly treated. In any patient who sustained direct trauma to the eye the presence of corneal abrasion was suspected (CINC PAC, 1971 [a] and NATO, 1975 [a]).

Continuity and contour of the orbital rims were determined by palpation, with the knowledge that the most common fracture locations, other than from direct missile damage, would be at the infraorbital rim and the zygomaticofrontal suture. Avulsion, displacement, or instability of the orbital rims caused malposition of the orbital contents and/or malfunction of the extraocular muscles, thus producing visual disturbances such as diplopia. Ophthalmologists were routinely involved in the management of orbital injuries and, regardless of the extent of injury, it was desirable whenever possible to have patients sustaining orbital trauma undergo ophthalmologic examination. A more detailed description of bony orbital injury will be presented in the section on surgical considerations.

*Zygomaticomaxillary cheek injuries* involved soft tissues, fracture, and avulsion. Missiles traversing the lateral facial area frequently damaged the facial nerve and parotid gland (Figure 13, Chapter III). It was desirable to ascertain the degree of functional compromise at this time to determine the nature and extent of surgical repair that would be required. In addition to avulsion and comminution at the site of the missile tract, there was also fracture of the zygomaticomaxillary complex that occurred in the usual patterns (Knight and North, 1961).

*Naso-orbital fractures* ordinarily are produced by crushing injury to the central portion of the upper midfacial area; they may be isolated or more commonly are associated with Le Fort II or III fractures. Although these injuries were rare in Vietnam, the naso-orbital area was occasionally involved in missile injuries to the midface and it was necessary to diagnose the complex of naso-orbital injury to obviate the development of late adverse sequelae. The classic picture of fractures in the naso-orbital area is a backward displacement of the nasal skeleton and the medial wall of the orbit into the interorbital space. This produces a characteristic depression over the upper portion of the bridge of the nose as well as deformity of the canthal area resulting from lateral displacement of the attachment of the medial canthal ligaments (Converse, 1974 [b]). If the cribriform plate and roof of the ethmoid were fractured, thus producing open injury in the anterior cranial fossa and cerebrospinal fluid leakage, neurosurgical consultation was required.

*The patterns of facial fracture* were originally de-



scribed by Le Fort (Tilson et al., 1972) and in a general sense remain valid today. Although different combinations of the various *Le Fort fractures (I, II, and III)* were occasionally seen in Vietnam, this was not the typical injury pattern from war wounds. High velocity missiles more commonly created wounds, with severe comminution or avulsion in the direct missile tract. When present, however, as primary or secondary injuries, Le Fort fractures were treated in a conventional manner without violation of basic treatment principles. The common denominator of these fractures was disruption of the occlusion by fracture through the midfacial skeleton at a level somewhere between the maxillary dentition and the base of the anterior cranial fossa. Treatment involved stabilization at the most superior uninjured point on the facial skeleton. *Therefore, the essential objective of the examination was to determine the superior level of fracture since the inferior level was established by the maxillary teeth or edentulous alveolar ridge.*

In *Le Fort I* injury only the maxilla was unstable—the line of fracture was in a horizontal plane just above the apices of the teeth. Clinical findings included ecchymosis, swelling of the maxillary vestibular mucous membranes, facial edema, nasal bleeding, and malocclusion.

In *Le Fort II* or pyramidal fractures, the superior level of the fracture lines extended superomedially from the malar buttresses across the maxilla to the midportion of the infraorbital rim and then continued superomedially to join in the midline at about the level of the nasal bones. In addition to the *Le Fort I* findings, there was paresthesia of the infraorbital nerves and noticeable elongation of the middle third of the face in conjunction with periorbital swelling and ecchymosis. Visual disturbances were seen if the floor of the orbit or the extraocular muscles were involved in the fracture line. These fractures were often seen as combinations of *Le Fort II* and *Le Fort III*.

*Le Fort III* injuries, the so-called craniofacial disjunctions, are the most severe midfacial injuries other than gross avulsion. The upper level of fracture extended across the superior portion of the midfacial skeleton, running from the zygomaticofrontal suture on each side medially through the walls of the orbits and joining in the midline at or just below the level of the cribriform plate of the ethmoid bone. The findings of *Le*

*Fort I* and *II* injuries were present as well as any or all of the following: marked periorbital swelling and ecchymosis, subconjunctival hemorrhage, ocular impairment, visual disturbances secondary to extraocular muscle imbalance and/or damage to the orbital floor, and canthal-nasal deformities such as those described previously for naso-orbital injuries. When cerebrospinal fluid was escaping into the naso-oral cavities via fracture of the cribriform plate, neurosurgical consultation was indicated. The incidence of cerebrospinal rhinorrhea in nonmissile injuries is reported as approximately 25% (Lewin, 1954; Rowe and Killey, 1970 [d]). The incidence in missile injuries is not known although it relates to the path of the missile as well as the extent of secondary craniofacial fracture. In these extensive fractures the entire midface was elongated and often displaced posteriorly as a result of the action of the internal and external pterygoid muscles acting on the pterygoid plates of the sphenoid bone just posterior to the maxilla (Figure 10, Chapter III).

In all these fractures it was possible to grasp the maxilla and demonstrate movement of the midfacial skeleton below the level of fracture. Most of the midfacial war injuries were secondary to direct or concussion effects of missiles and included severe comminution and avulsion in addition to the usual *Le Fort* patterns of skeletal fracture. Combinations of injury were common. In some instances missiles traversed the entire midface and produced instability of the osseous skeleton by frank avulsion and fracture comminution (Figure 24). It was essential that the maxillofacial surgeon have a thorough knowledge of the anatomy and function of all structures in the midfacial area to assure thorough diagnostic assessment of the damage imparted by the wounding agents. It was often necessary to involve an ophthalmologist and neurosurgeon as well as the maxillofacial specialists in the management in order to establish a definitive diagnosis concerning the extent of injury.

*Lower third of the face.* During examination of the lower one-third of the face, the basic consideration was to determine whether the injury had produced disruption of mandibular continuity by either fracture or avulsion. *The foundation of the facial skeleton was an intact mandible capable of stable dental occlusion.*

Mandibular stability, range of motion, and the

status of the occlusion were determined, even though it was recognized that in cases of severe damage inadequacies were grossly evident. Patterns of injury were variable and included all regions of the mandible though the body and symphysis areas were more commonly damaged. The *classical clinical findings in jaw fractures*, as described by Rowe and Killey (1970 [e]), include: history of injury, pain, functional interference, abnormal mobility, malocclusion, deformity, swelling, ecchymosis, crepitus, and absence of transmitted movement.

In those situations where comminution and avulsion had occurred, no attempt was made to

determine the potential viability of residual osseous fragments since it was found by experience that such decisions were best delayed until the time of definitive surgical debridement when all areas of the wound could be meticulously investigated.

**Examination of Soft Tissues.** Severe disruption of the oral sphincter occurred as a result of missile wounds to the anterior portion of the lower and midface. Retraction of the orbicularis and other muscles of facial expression (*see* Figure 9, Chapter III) often caused injuries to appear more extensive than they actually were. Careful assessment of the missile damage including pre-



Figure 30.—*Upper left*) Fragmentation wound to the lower face involving the lips. *Upper right*) Assessment of the amount and type of tissue available for closure. *Lower left*) Closure immediately following surgery. The vermilion border of the lip was used as a guide in the approximation of displaced tissues. The oral commissure was not directly violated although care was taken that it not be distracted during wound closure to prevent lip dysfunction at the corner of the mouth. *Lower right*) Appearance of patient 18 months after injury. Lip competence is evident and the scars are maturing satisfactorily.



*Figure 31.—Upper*) High velocity missile produced extensive injury to the orofacial region including damage to the tongue, floor of mouth, and mandible that effected loss of muscular support to the tongue and floor of mouth. Initial airway maintenance was followed by tracheostomy thus obviating upper airway compromise. *Lower*) Lateral radiograph illustrating the inferior and posterior collapse of the anterior mandible that was associated with the injury.

liminary repositioning of tissue flaps was desirable to assist in determination of the approximate amount and type of tissue that would be available for closure—the vermilion border of the lip was the key landmark in these situations (Figure 30; Case report 02). It was recognized that it was not possible to definitely assess the adequacy of soft

tissues available for closure until the underlying skeletal structures had been repaired.

A very significant consideration was the extensiveness of the injury to the tongue and its stability. The tongue was affected by either direct wounding, which produced hemorrhage and edema, and/or by loss of its anterior muscular support (Figures 11 and 12, Chapter III) due to fracture avulsion of the mandible, which produced posterior collapse (Figure 31; and Case reports 03, 04, 05, 06). Both conditions were potential hazards to the upper airway, and continuous monitoring of ventilatory exchange was required if tracheostomy or intubation had not been accomplished before the presurgical examination.

The floor of the mouth, palate, pharynx, and nasal and sinus cavities were examined to determine the extent to which their anatomic integrity had been disrupted. Hemorrhage and edema that could possibly compromise the airway were consistent features of injury to these structures.

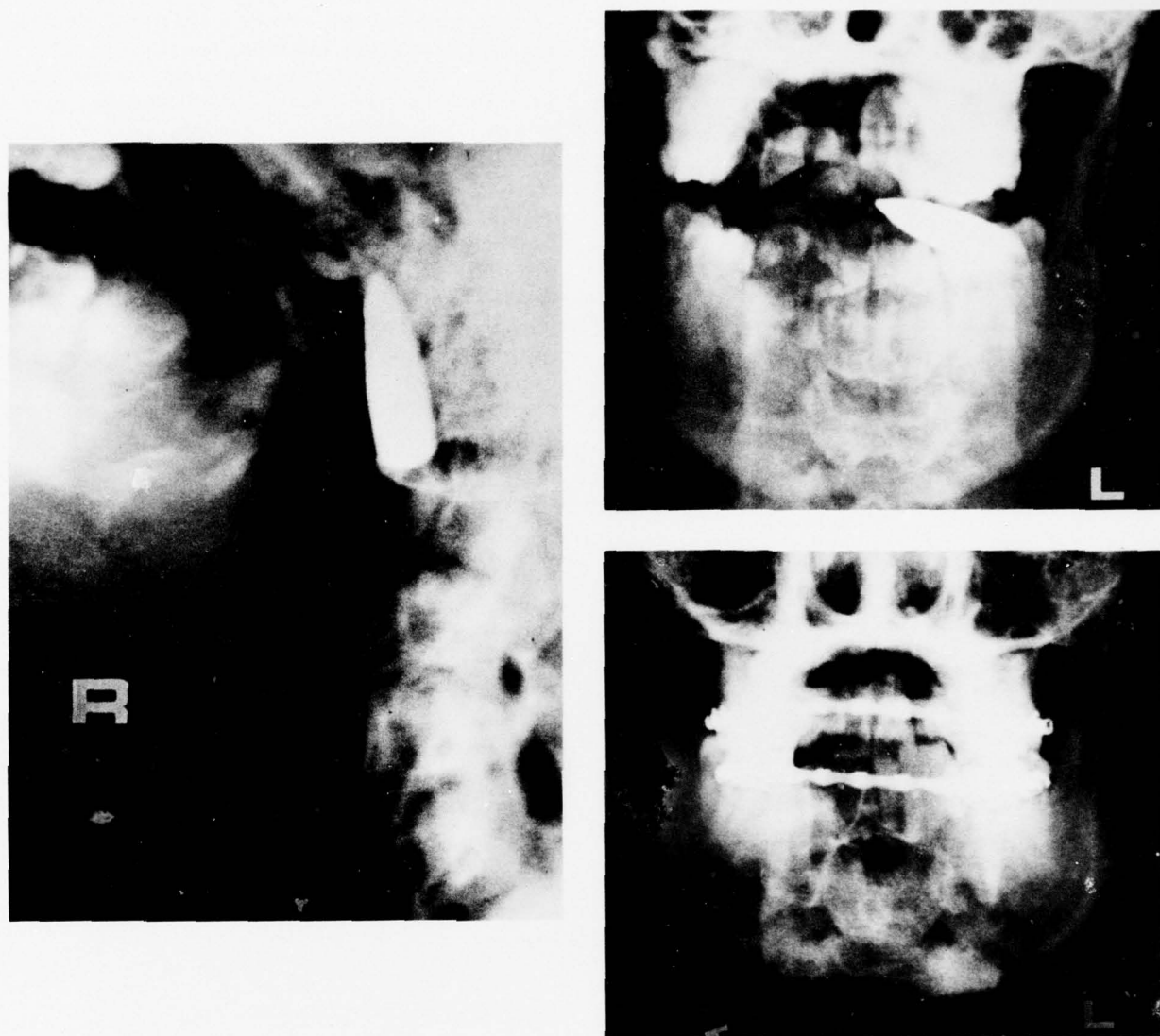
At this time it was necessary to examine for overt and suspected evidence of communication between oral and neck wounds such as avulsive missile tracks or mucosal lacerations suggestive of missile penetration (Figure 32).

Because the oral-pharyngeal-nasal area is extremely vascular (Figures 12, 14, and 15, Chapter III), produces copious secretions, and provides difficult access, visual examination was difficult. These examinations were best accomplished with additional light, suction, and assistance.

### Radiographic Examination

Preoperative radiographic studies were important diagnostic aids to help determine or confirm such matters as: osseous fracture sites, retained missile fragments and foreign bodies, subcutaneous emphysema (particularly in neck injuries) and the pulmonary status in anticipation of general anesthesia. Such radiographically determined information was helpful in planning subsequent surgical procedures, particularly if the surgeon took an active part in ordering, obtaining, and interpreting the films. Generally, the patient was not sent to the radiology department until his condition and vital signs were reasonably stable. Because of the continuous threat to the airway the maxillofacial patient was carefully at-





*Figure 32.—Left and Upper right) Lateral and posteroanterior radiograph of the maxillofacial-neck region showing the presence of a high velocity missile (AK-47). The missile was almost spent when it struck the patient's chin as it had penetrated the thigh of a fellow combatant. It passed through the symphysis and floor of mouth and came to rest within the posterior wall of the pharynx just anterior to the spinal cord. After careful examination of the wounds, the missile was located and removed without incident. The wound was drained through the floor of the mouth and out the edentulous space that had been created in the symphysis area of the mandible. Neck exploration was not considered necessary in this case. Lower right) Posteroanterior radiograph of mandible following treatment showing the normal relationship of the mandible and maxilla that has been established by closed fracture reduction with intermaxillary fixation. No direct wire fixation of the fractures was accomplished.*

tended at all times.

Although the capability existed for comprehensive radiographic evaluation (i.e., laminography, arteriography), such studies were rarely ordered preoperatively and only the most essential views were obtained to expedite prep-

aration of the patient for surgery by avoidance of logistic delays in the radiology department. The number of radiographic views was reduced in comparison to nonbattle circumstances, but there appeared to be little compromise in the diagnostic and therapeutic capability of the maxillofacial

surgeon. Occasionally the radiology department was bypassed entirely if immediate surgical intervention was critical to the patient's survival (Figure 28).

All patients requiring general anesthesia had a posteroanterior (PA) chest radiograph and maxillofacial patients were additionally evaluated with a series of extraoral facial films which commonly included just *five views*: Water's PA projection, PA and lateral skull, and right and left oblique lateral projections of the mandible. The PA and lateral skull radiographs were taken with large films in order to facilitate positioning and provide for inclusion of neck structures in the study. Supplemental views were occasionally ordered if there was a distinct need for additional radiographic information and if the condition of the patient permitted. These additional views included: Townes, submento-vertex, paranasal sinuses, and floor of the mouth-occlusal.

Radiographic survey of the cervical spine was indicated mainly for determining the presence and location of foreign bodies or demonstration of emphysema rather than for detection of cervical spine fracture or dislocation, which is more commonly associated with blunt, nonmissile trauma. If there was any possibility of cervical spine injury, manipulation of the head for radiographic purposes was accomplished with extreme caution.

The quality of the radiographs in these necessarily expedient circumstances was frequently compromised as a result of the following problems: large, bulky facial dressings that prevented visualization of anatomic references by the radiology technician; traumatic alteration of

normal anatomy; extensive soft tissue swelling; oral secretions and bleeding; painful head positioning; and obtunded, uncooperative patients. In addition, poor quality films were occasionally produced because of expeditious positioning, exposure, or processing that occurred while the radiology staff was attempting to meet the demands associated with an exceedingly heavy input of casualties.

*Whereas radiographs were of great value as diagnostic aids in maxillofacial trauma, they were never a substitute for astute clinical evaluation.* Some types of fractures, such as maxillary or alveolar, were often much easier to determine clinically than radiographically; indeed, it was sometimes impossible to demonstrate an apparent clinical fracture on poor radiographs. When such diagnostic conflicts arose, primary reliance was placed on the clinical evaluation.

#### Documentation of Examination Findings

If time permitted, photographs were obtained and diagrams of the pattern of damage were prepared since they were valuable for subsequent reappraisal of the injury, particularly at the time definitive plans for reconstruction and rehabilitation were being formulated in the late or reconstructive phase of management. This later phase of patient management occurred at a different facility and by a different team of surgeons that had no means of convenient communication other than initially provided written records and photographic documentation of findings. *A standardized form* for oral and maxillofacial injuries was not available but is considered to be a neces-

TABLE 7.—Incidence of Osseous Injury for Various Anatomic Sites in the Maxillofacial Region for the Five Groups of Patients Included in the MFCS

Group	Mandible					Midface				
	Symphysis	Body	Angle	Ramus	Condyle	Maxillary segmental	Le Fort type	Zygoma	Naso-ethmoid	Orbit
I (N=91)	55[60.44]*	84[92.31]	44[48.35]	31[34.00]	2[2.20]	20[21.98]	8[8.79]	7[7.69]	3[3.30]	7[7.69]
II (N=44)	19[43.18]	17[38.64]	8[18.18]	9[20.45]	4[9.09]	4[9.09]	11[25.00]	14[31.82]	7[15.91]	12[27.27]
III (N=25)	5[21.74]	16[69.57]	9[39.13]	6[26.09]	4[17.39]	6[26.09]	0[00.00]	4[17.39]	3[13.04]	3[13.04]
IV (N=32)	11[34.38]	14[43.75]	8[25.00]	4[12.50]	4[12.50]	8[25.00]	4[12.50]	5[15.63]	3[9.38]	5[15.63]
V (N=7)	1[14.29]	2[28.57]	0[00.00]	0[00.00]	0[00.00]	1[14.29]	1[14.29]	1[14.29]	0[00.00]	0[00.00]
Total (N=199)	91[66.19]	133[67.34]	69[35.03]	50[25.38]	14[7.11]	39[19.80]	23[11.68]	31[15.74]	16[8.12]	27[13.71]

sary future requirement to assist this type of supplementary documentation and treatment planning.

### ANALYSIS OF EXAMINATION FINDINGS IN MAXILLOFACIAL CASUALTY STUDY PATIENTS

Cases included in the MFCS were reviewed to determine the type and site of oral and maxillofacial injury. The patients were divided into 5 groups (Table 4), which were determined by the nature of mandibular injury since these injuries were most common in the maxillofacial area (Tinder et al., 1969).

The most common site of osseous injury in the mandible was the body (67.51%), followed by the symphysis (46.19%), angle (35.03%), ramus (25.38%), and condyle (7.11%) (Table 7).

These data contrast with civilian-type mandible fractures (blunt trauma). Hagan and Huelke (1961) concluded that the location of such fractures was related to the cause, force, and location of injury, an observation that was confirmed by Salem et al. (1968) in their analysis of 423 mandibular fractures of *non-gunshot* etiology in patients treated at U.S. Army installations. Huelke et al. (1962) found that the association of fractures between location, site of impact, etc., was not haphazard and could be statistically confirmed. Although this may be true for blunt-type civilian trauma, the matter is far more complicated for combat injuries because they are almost all due to randomly directed, highly destructive missiles and as such are more severe and complex and do not follow common patterns.

In the midfacial area, 19.80% of the MFCS patients sustained maxillary segmental fractures and 11.68% some type of Le Fort fracture. Other midfacial osseous injuries seen in these patients were zygomatic (15.74%), naso-ethmoidal (8.12%), and orbital (13.7%). The highest incidence of midfacial bony injuries was seen in those patients with avulsive osseous injuries of the mandible that did not require bone grafting (group II), reflecting the multiplicity and severity of their maxillofacial injuries.

The distribution of maxillofacial injuries in Federal Services treatment facilities was studied by Lilly and Kelly (unpublished data) in an analysis of 3,104 facial bone fractures. They found the following distribution of fractures:

mandible 64%, maxilla 13%, zygoma 14%, and orbital floor 8%. These fractures were from all types of causes though only 0.5% were gunshot wounds.

Other sites and types of injuries in MFCS patients are listed in Tables 8 and 9. Teeth were fractured in 62.44%, avulsed in 42.64%, and required extraction in 62.94% of all patients. As would be expected, the highest incidence of dental damage was in group I patients in whom osseous tissue was avulsed to the extent that bone grafting was required.

Intraoral soft tissue injuries were most common in group I patients in which the following incidence was noted: tongue (47.25%), floor of mouth (62.64%), palate (13.19%), and pharynx (13.19%). For all groups the tongue (31.98%) and floor of mouth (40.10%) were injured in the largest percentage of patients.

For all groups extraoral soft tissue injuries were most common in the cheek (57.78%)—75.82% of the group I patients sustained cheek injuries. The sub- and infra-mandibular area (32.99%) and the lower lip (32.49%) were the next most common sites of injury. Salivary gland injuries were seen infrequently in these groups of patients; they occurred in only 8.12% of all cases for submaxillary and 2.54% for parotid.

### ADDITIONAL PREOPERATIVE CONSIDERATIONS

Once the essential diagnostic information had been accumulated it was possible to proceed with definite plans for operative treatment. Formulation of these plans was dependent on continued observation of the clinical and physiologic status of the patient as well as the presurgical logistics in the casualty care area. The treatment category and priority assigned in the triage area (p. 49) were important in determining the timing of surgical intervention. This priority was reappraised in light of any dramatic changes that had occurred in the condition of the patient.

### Preliminary Wound Care

In some instances it was elected to superficially debride wounds during the staging period prior to operation (Figure 28). Such preliminary wound preparation was desirable, but it was done only if long delays were definite and it was im-



TABLE 8.—Incidence of Orofacial Injury to the Teeth, Alveolus, Tongue, Floor of Mouth, Palate, and Pharynx for all Groups of Patients Included in the MFCS

Group	Teeth			Alveolus		Tongue	Floor of mouth	Palate	Pharynx
	Fracture	Avulsion	Extraction	Maxilla	Mandible				
I (N=91)	70[76.92]*	54[59.34]	68[74.73]	38[41.76]	66[72.53]	43[47.25]	57[62.64]	12[13.19]	112[13.19]
II (N=44)	23[52.27]	15[34.09]	19[43.18]	5[11.36]	3[6.82]	12[27.27]	12[27.27]	7[14.29]	3[6.82]
III (N=23)	8[34.78]	5[21.74]	15[65.22]	1[4.35]	1[4.35]	2[8.70]	4[4.35]	3[13.04]	0[00.00]
IV (N=31)	17[54.84]	8[25.81]	17[54.84]	2[6.45]	2[6.45]	4[12.90]	4[12.90]	2[6.45]	0[00.00]
V (N=8)	5[62.50]	2[25.00]	5[62.50]	1[12.50]	2[25.00]	2[25.00]	2[25.00]	2[25.00]	0[00.00]
Total (N=197)	123[62.44]	84[42.64]	124[62.94]	47[23.86]	74[37.56]	63[31.98]	79[40.10]	26[13.20]	15[7.61]

\*Figures in brackets equal percentage of N.

possible to take the patient directly to surgery. Serious bleeding must have been controlled by hemostats or temporary ligatures before initiation of the procedure. This preliminary superficial debridement in advance of preparation in the operating room was accomplished by vigorous fluid irrigation. A method of wound debridement referred to as *hydrodynamic* was described by Peacock (1971[a]); this is essentially what was accomplished in these contaminated war wounds. By forceful irrigation onto the wound surface of a large volume of irrigating solution (saline), contaminants could be flushed away and the number of bacteria presumably reduced, which helped assure primary wound repair after closure. Substantiating these efforts are reports that a recently developed pulsating jet lavage, which is in effect a hydrodynamic flushing device, has reduced the number of bacteria and debris as well as the incidence of infection in wounds experimentally contaminated (Gross et al., 1971, 1972; Stewart et al., 1971; Green et al., 1971).

If the maxillofacial injury was obviously so severe that a high priority of treatment was established and wound care was imminent, it was advisable to defer any type of wound debridement and, in fact, even wound examination until the patient was resuscitated and in the operating room.

During the delay in the staging area, other simple procedures could be performed that improved the patient's status during the interim and also expedited the subsequent operating room procedure. *Temporary immobilization of unstable mandibular fractures*, for example, could be accomplished by simple measures such as tying adjacent and/or opposing teeth together with a ligature (dental floss, suture, wire, etc.) to stabilize the fragments thus minimizing associated pain. Occasionally, time and circumstances permitted the application of dental fixation devices under local anesthesia. This was done in the staging area or, in some instances, patients were temporarily transported to a clinic area where more ideal

TABLE 9.—Incidence of Orofacial Injury to the Lips, Cheek, Sub- and Infra-Mandibular Area, and Salivary Glands for all Groups of Patients Included in the MFCS

Group	Lips		Cheek	Sub and infra-mandible	Salivary glands	
	Upper	Lower			Parotid	Submaxillary
I (N=91)	9[9.89]*	43[47.25]	69[75.82]	60[65.93]	4[4.40]	14[15.38]
II (N=44)	4[9.09]	9[20.45]	16[36.36]	4[9.09]	0[00.00]	0[00.00]
III (N=23)	1[4.35]	3[13.04]	11[47.83]	0[00.00]	1[4.35]	1[4.35]
IV (N=32)	8[25.00]	6[18.75]	13[40.63]	1[3.13]	0[00.00]	1[3.13]
V (N=7)	2[28.57]	3[42.86]	5[71.43]	0[00.00]	0[00.00]	0[00.00]
Total (N=197)	24[12.18]	64[32.49]	114[57.87]	65[32.99]	5[2.54]	16[8.12]

\*Figures in brackets equal percentage of N.

facilities, such as better lighting, were available. Soft tissue measures included not only superficial wound debridement as a preliminary to definitive care but also placement of temporary tacking sutures or dressings to cover gaping wounds.

When *occlusive dressings* were used for temporary wound coverage, they were moistened with either Betadine® (povidone-iodine solution)\* for external application or saline for intraoral placement. Although moist dressings are known to contaminate clean wounds, it was thought that in these instances of temporary open packing of contaminated wounds the antiinfective nature of povidone-iodine would reduce rather than exaggerate contamination and also maintain a moist wound surface, thus lessening cellular injury secondary to desiccation. The moisture prevented surface coagulation and promoted drainage, which lessened the drying of a viscous exudate on the surface. To assure identification and retrieval, intraoral dressings were tagged with long heavy-gauge suture material (0 or 00) that was brought out of the mouth and secured to a stable portion of the craniofacial skeleton. These patients were under careful observation while awaiting surgery, and personnel in attendance were instructed to make sure that oral dressings did not become dislodged and compromise the airway.

All these measures were accomplished in anticipation of primary closure of the orofacial lacerations which, because of the excellent blood supply, could be closed *primarily even after a delay of up to 24 hours*. Delayed primary closure of maxillofacial wounds was seldom performed in Vietnam though it has been successfully accomplished, in other conflicts where military logistics did not permit routine primary wound treatment (Chipps et al, 1953; Awty and Banks, 1971).

Facial fractures normally constituted no "acute" emergency in relation to such injuries as those requiring major vascular repair though it was highly desirable to reduce and fix them as early as possible. Reduction was sometimes delayed for up to 10 days as a result of associated wound complications. However, in those instances where orofacial soft tissue wounds were closed and underlying skeletal fractures not reduced, the wound closures were invariably disrupted when definitive fracture reduction pro-

cedures were later performed.

## Anesthetic Management

**Presurgical Planning.** During the immediate preoperative period it was necessary to consult with the *anesthesiologist* that was to be responsible for the patient during surgery. Fortunately, the maxillofacial surgeons were familiar with the problems that might complicate anesthetic management and preoperative consultation between surgeon and anesthesiologist proved valuable in cases of maxillofacial injury. During this session understanding and agreement was sought concerning the following significant management issues: 1) intended intraoperative surgical treatment plan, 2) requirements expected of the anesthesiologist, 3) estimated length of the operative procedure, 4) timing and type of intermaxillary fixation, 5) use of oral or nasoendotracheal tube, 6) necessity and duration of postsurgical endotracheal tube retention, 7) necessity, timing, and technique of tracheostomy, 8) estimated intraoperative surgical blood loss and transfusion requirements, 9) type, dosage, and route of administration for anticipated preoperative and intraoperative medications.

**Intubation.** Intubation of these patients was mandatory, and in most instances, a nasal as opposed to oral endotracheal tube was preferred to improve access for the surgeon and to permit intermaxillary fixation when required. Although nasoendotracheal intubation was difficult, it did facilitate surgical wound management. If it was not possible to place a nasal tube, oral intubation was performed though it was understood that intermaxillary fixation would be deferred until an appropriate time after removal of the tube.

**Tracheostomy.** If not already accomplished, tracheostomy was performed most commonly after intubation, with the patient anesthetized. The indications and techniques of tracheostomy have been described in the literature (Sicher, 1952; Rowe and Killey, 1970[f]; McKelvey, L. E., 1972; Converse, 1974[c]). There was ordinarily no need to vary from the standard techniques—most of the tracheostomies were performed through a horizontal incision and a layered approach to the trachea was followed. It was understood that in most instances the tubes would remain in place at least during the period of medical evacuation and frequently well into the late phase

\*Purdue Frederick Company, Yonkers, New York.



of treatment, as will be discussed in the intermediate care chapter.

The overall incidence of tracheostomy in the MFCS patients was 47.21% (Table 10). Group I patients (bone graft) had the highest incidence (64.84%) followed by group II (avulsive—non-graft) patients (45.45%). The combined incidence for these two groups was 58.52%. The combined incidence for groups III, IV, and V, the less severely injured, was 22.58%. The incidence for these three groups is more consistent with that for the heterogeneous maxillofacial casualty populations reported by Terry (1969) and Tinder et al. (1969) in which they found a tracheostomy incidence of 17% and 14%, respectively. The frequency with which tracheostomy was performed was related to the severity of the orofacial injury and it was in fact a routine procedure in the face of extensive tissue damage.

The fact that tracheostomy was performed far more frequently than in previous conflicts (p. 12, Chapter I) was perhaps related to the evolution of improved cardiopulmonary management procedures and the need to prepare patients for early long-range evacuation. However, *tracheostomy* was not an innocuous procedure and its potential complications will be discussed in the intermediate management chapter.

TABLE 10.—Incidence of Tracheostomy for the Five Groups of MFCS Patients

Group	Tracheostomy	Percent
I (N = 91)	59	64.84
II (N = 44)	20	45.45
III (N = 23)	6	26.09
IV (N = 32)	8	25.00
V (N = 7)	0	00.00
Total (N = 197)	93	47.21
I, II (N = 135)	79	58.52
III, IV, V (N = 62)	14	22.58

**Anesthetic Techniques.** Most patients were anesthetized with a thiopental-type induction and maintained with halothane, nitrous oxide, and oxygen. Halothane had definite advantages for use in a combat zone including ease of administration, nonexplosiveness, and wide applicability. In addition, rapid emergence from anesthesia and decreased incidence of nausea and emesis postoperatively reduced the requirements on personnel in the surgical intensive-care unit. Halothane was not recommended for marked hypotensive patients because it is a potent vasodilator and it was difficult to maintain and obtain blood pressure during induction (CINC PAC, 1971[b]).

## SURGICAL MANAGEMENT

### INTRODUCTION

A rigidly standardized approach to the surgical treatment of these complex injuries was neither possible nor desirable; however, it was advantageous to adhere to accepted principles regardless of the extent of wounding. The material discussed in this section is a correlation of basic surgical principles with results of an analysis of the U.S. Navy maxillofacial casualty study and the personal experience of the authors.

Since the proper healing of a wound was influenced by what was done at the operating table, several questions were considered prior to and during the surgical procedure—was the wound massively contaminated, had it been adequately irrigated and debrided, had effective hemostasis been achieved, and had provisions been made for adequate drainage. If these questions were prop-

erly considered the majority of wound-healing complications were avoided.

### WOUND PREPARATION

As evident from the previous sections of this chapter, missile wounds differed from elective surgical wounds in that there was almost universal contamination and greater damage to and loss of tissue. As a result, the preoperative wound preparation was principally directed to reducing the potential for postsurgical sepsis by adherence to aseptic technique and performance of meticulous debridement.

If hydrodynamic debridement (p. 67) of the wound had not been accomplished then it was employed at this time. Operating room time in combat situations was valuable and the prelimi-



nary preparation of the wound helped reduce the time of wound preparation in the operating room. Antibiotics were not added to the irrigation solutions since there was no conclusive evidence that they improved the effectiveness of the hydrodynamic debridement (Gross, 1972). It is unlikely that topically applied antibiotic irrigants permeate the tissues and free-floating bacteria were equally well washed away with a saline solution. Achieving a therapeutic level of antibiotics in the tissues by systemic administration is a sounder anti-infective approach to bacterial control (Robson et al., 1973).

The usual principles of presurgical wound preparation were employed including cleansing of tissues surrounding the wound with an antiseptic soap solution after the removal of all hair from the field of operation by shaving. Shaving of the patient was performed very carefully in conjunction with a disinfectant because, as known, razor trauma can provide an additional portal of entry for exogenous bacteria (Robson et al., 1973). The most commonly used antiseptic soap solution was Betadine®.

At the time of wound preparation, all dirt and debris that had been driven into the cutaneous aspect of the wound by the blast was removed by vigorous scrubbing with sponges or brush to prevent development of a permanent tattoo scar (Osbon, 1969; Terry, 1969) (Figure 20).

Although scrubbing of the skin and wound surface with a medicated soap solution was an important prelude to surgery, it was recognized that correct draping, guarding against the soaking of drapes with irrigation fluids intraoperatively, and completing the surgical procedure in an expeditious manner were equally important in reducing the extent of infection.

## CONTAMINATED WOUNDS AND ANTIBIOTIC THERAPY

### Factors Effecting Contamination

Every open war wound was considered to be contaminated at the time of initial surgical examination following injury.

Because these wounds were characterized by devitalization of tissue, extravasation of blood, disruption of local blood supply, introduction of foreign bodies, and contamination by various bacteria, severe infection resulted if proper precautions were not insti-

tuted. The devitalized tissue and extravasation of blood provided nutritional support for bacterial growth, whereas edema produced tension within the wound and exaggerated the hypoxic conditions resulting from diminished blood supply thus favoring the development of wound sepsis.

Early surgical intervention was probably the most important means of reducing the likelihood of wound infection. Cleanly incised, viable tissues with an adequate blood supply were best able to combat bacterial invasion. Although antibiotic therapy was also important in reducing infection, it was not viewed as the *primary therapeutic measure*. The success of antibiotics in ameliorating wound infection depended more upon the prompt institution of sound surgical principles.

### Contaminating Microorganisms

The type of bacteria present varied with the geographic location and terrain, the type of debris soiling the wound, the bacteria residing on the skin and clothing at the time of injury, and the time between wounding and treatment (NATO, 1975[b]).

Seasonal variations in the incidence of microorganisms in wounds were well documented. For example, *Staphylococcus epidermidis* was the most common microorganism isolated in January, *Escherichia coli* and *Pseudomonas aeruginosa* in the summer months of June and July, and *Aerobacter aerogenes* was prevalent in March and April. Despite seasonal variations, however, *S. aureus* and *P. aeruginosa* were the most common organisms isolated on a year-round basis whereas the group of enteric organisms, including *A. aerogenes*, *E. coli*, and *Proteus*, were the next most prominent. Mixed cultures were also found which contained various combinations of *S. aureus*, *P. aeruginosa*, and *E. coli*, but these constituted less than 5% of the initial positive cultures (Kovaric et al., 1968; Matsumoto et al., 1969). Enteric organisms were prevalent in Vietnam because of the relatively primitive waste disposal methods, use of human waste as fertilizer, and the continuous hot, humid climate.

### Antimicrobial Therapy

Initial antibiotic therapy, which included penicillin and streptomycin, was directed to combating both gram-positive and gram-negative or-

ganisms. However, streptomycin was usually administered for a short term (5 days or less) because of its potential toxicity and, as a result, there was a predisposition to secondary invasion by the ubiquitous gram-negative organisms (Kovaric et al., 1968). Therefore, although the patients were receiving antibiotics, it was necessary to be continuously alert for the development of infection.

Two conditions were essential for antibiotic control of bacterial proliferation in tissues.

1. The antibiotic must be capable of destroying or suppressing the etiologic organisms which in turn must be sensitive to the drug employed. Bactericidal agents were preferable to those with bacteriostatic properties.
2. A therapeutic concentration of the antibiotic must be established in the tissues that harbor the bacteria for a period sufficient to allow destruction of the invading microorganisms (NATO, 1975 [c]).

*In certain conditions, such as shock or abscess formation, the effectiveness of systemic antibiotics was restricted until the underlying physiologic abnormality was corrected. Patients in shock experienced compromised circulation and as a result the efficiency of systemically administered antibiotics was limited by poor distribution of the agent to the tissues. Large abscesses were associated with avascular, necrotic, or fibrotic barriers that reduced blood supply and prevented antibiotics from reaching the infecting organisms in the area of the abscess.*

Table 11 lists the suggested choice of antimicrobial agents for the majority of organisms that were implicated in contaminated or septic wounds. Table 13 gives the daily dosage and routes of administration of antimicrobial agents that were used against the pathogenic organisms.

### Control of Contamination

The following principles were found effective in managing septic or contaminated wounds.

1. Immediate surgical treatment.
2. Adequate wound excision and debridement.
3. Adequate hemostasis in the initial surgery to prevent subsequent hematoma formation.
4. Removal of foreign bodies within the wound if this could be performed without causing damage to vital structures.

5. Provisions for adequate drainage of the wound.
6. Closure of the wound without tension and with elimination of dead space.
7. Adequate immobilization of the fractured or injured jaws.
8. Maintenance of a dry dressing over the wounds.
9. Prevention of secondary contamination by medical personnel.
10. Prophylactic antimicrobial therapy (NATO, 1975[b]).

## GENERAL PRINCIPLES OF WOUND MANAGEMENT

### Inside-out—Bottom-up

The basic principle of treatment for these injuries was to start with repair of the skeletal damage and work upward from the mandible to the superior extent of bony injury, whereas to repair soft tissues one works outward to the skin, or as Small (1971) has stated, *approach the injury from the inside-out and bottom-up.*

The key to restoration of the form and function of the facial skeleton is interdigitation of the teeth in a position of occlusion that is considered acceptable for the patient. Thus alignment of the teeth and alveolar segments was accomplished first and the restored segments then brought together into occlusion. Following this, the remaining facial skeletal injuries were repaired and the soft tissues closed, proceeding outward from mucosa to skin. If this procedure was followed it was not necessary to disrupt previously repaired tissues by working back through them to correct underlying injury that remained untreated. A common error in reducing facial skeletal injuries of this magnitude was to start at the orbits and work downward. When this approach was used, fragments could easily be incorrectly positioned and malalignment was so magnified at the level of the dental occlusions that it was impossible to establish a functionally correct intermaxillary relationship.

### Recovery of Foreign Material

Some missiles shattered bone on contact and fragmented into smaller metallic particles. Pre-



TABLE 11 — Suggested Choices of Antimicrobial Agents\*

Infesting microorganism	Agent of first choice	Alternative agents
I. Aerobic bacteria		
A. Gram-positive cocci		
1. Staphylococci		
a. Non-penicillinase-producing	Penicillin	Cephalothin, vancomycin, erythromycin, lincomycin.
b. Penicillinase-producing	Penicillinase-resistant, penicillin (e.g., methicillin, oxacillin).	Cephalothin, vancomycin, erythromycin, lincomycin, gentamicin.
2. Streptococci		
a. Pyogenic-groups A, B, C	Penicillin	Erythromycin, cephalothin, ampicillin.
b. Viridans	Penicillin with or without streptomycin.	Ampicillin, vancomycin with or without streptomycin, cephalothin, erythromycin.
c. Enterococci (group D)	Penicillin G with or without streptomycin.	Ampicillin, chloramphenicol, tetracycline.
B. Gram-negative cocci		
1. <i>Neisseria catarrhalis</i>	Penicillin	Tetracycline.
2. <i>N. gonorrhoeae</i>	Penicillin	Tetracycline.
C. Gram-negative bacilli		
1. <i>Escherichia coli</i>	Ampicillin, cephalothin	Kanamycin, tetracycline, gentamicin, chloramphenicol.
2. <i>Aerobacter</i> (Enterobacter) aerogenes	Kanamycin	Tetracycline, with or without streptomycin, gentamicin.
3. <i>Klebsiella</i> species	Cephalothin	Kanamycin, polymyxin, chloramphenicol.
4. <i>Pseudomonas aeruginosa</i>	Gentamicin	Colistin, polymyxin, carbenicillin.
5. <i>Proteus</i>		
a. <i>P. mirabilis</i>	Ampicillin	Kanamycin, cephalothin, gentamicin.
b. Other <i>Proteus</i>	Kanamycin	Nalidixic acid, cephalothin, carbenicillin, gentamicin.
6. <i>Serratia</i> species	Gentamicin	Kanamycin, chloramphenicol.
7. <i>Alcaligenes faecalis</i>	Chloramphenicol or tetracycline	Penicillin G.
8. <i>Salmonella typhi</i>	Chloramphenicol	Ampicillin, cephalothin.
9. <i>Haemophilus</i> species		
a. <i>H. influenzae</i>	Ampicillin	Tetracycline, cephalothin.
b. <i>H. ducreyi</i>	Tetracycline	Sulfonamides, streptomycin.
II. Microaerophilic bacteria		
A. Gram-positive cocci		
1. Streptococci		
a. Hemolytic	Penicillin G	Ampicillin, tetracycline, chloramphenicol.
b. Nonhemolytic	Penicillin G	Ampicillin, tetracycline, chloramphenicol.
III. Anaerobic bacteria		
A. Gram-positive cocci		
1. Streptococcus species	Penicillin G	Ampicillin, tetracycline, chloramphenicol.

\*NATO Handbook, Emergency War Surgery: First United States Revision, Emergency War Surgery, 1975, pp. 128-131.



TABLE 11.—Suggested Choices of Antimicrobial Agents (Continued)

Infesting microorganism	Agent of first choice	Alternative agents
III. Anaerobic bacteria (Continued)		
B. Gram-positive bacilli		
1. <i>Clostridium</i> species		
a. <i>C. perfringens</i>	Penicillin G and tetracycline	Cephalothin, erythromycin.
b. <i>C. novyi</i>	Penicillin G	Tetracycline, cephalothin.
c. <i>C. histolyticum</i>	Penicillin G	Tetracycline, cephalothin.
d. <i>C. septicum</i>	Penicillin G	Tetracycline, cephalothin.
e. <i>C. sordelli</i>	Penicillin G	Tetracycline, cephalothin.
f. <i>F. sporogenes</i>	Penicillin G	Tetracycline, cephalothin.
g. <i>C. tetani</i>	Penicillin G	Tetracycline, cephalothin.
<i>C. Bacteroides</i> species	Tetracycline with sulfadiazine	Chloramphenicol, Vibramycin.
IV. Miscellaneous		
1. <i>Actinomyces bovis</i>	Penicillin G	Sulfadiazine.
2. <i>Nocardia</i> species	Sulfadiazine	Penicillin G.
3. <i>Fusobacterium fusiforme</i>	Penicillin	Tetracycline, erythromycin.
4. <i>Calymmatobacterium granulomatis</i>	Tetracycline	Streptomycin.

cise localization and surgical removal of these retained missiles or fragments were difficult and were ordinarily not recommended. Usually the retained fragments presented no significant impediment to resolution of infection, healing, or function. *Ill-advised surgical exploration for elusive embedded fragments in the maxillofacial area was non-productive, and caused unnecessary surgical insult while taking valuable operating room time.* Attention to the effects of the wounding agent and their repair was far more important than recovery of the spent missile. A dictum for these cases that has been passed down and remains valid is "a bullet ceases to cause damage when it ceases to move" (Shira, 1972).

### Neck Exploration

However, in those situations in which a missile had damaged the maxillofacial area and penetrated or come to rest in a region where vascular or other vital tissues were present, such as the cranium or neck, it was desirable that the region be surgically explored to assess and repair damage to vital structures and to prevent the development of later complications such as vascular malformations or neurologic deficits (Figures 33 and 34) (Jones et al., 1967; Fitchett et al., 1969; Ashworth et al., 1971; McInnis et al., 1975; Arpin and Downs, 1975; Rich, 1976). Surgical neck explora-

tion was performed in 8.85% of patients in the MFCS (Table 12). As would be expected, the highest incidence (12.79%) was in those patients with avulsive damage that subsequently required bone grafting (group I) since they had received the most severe and extensive injuries.

TABLE 12.—Incidence of Neck Exploration of MFCS Patients at Time of Early Wound Care

Group	Neck explored	Percent
I (N = 86)	11	12.79
II (N = 44)	3	6.82
III (N = 23)	1	4.35
IV (N = 32)	2	6.25
V (N = 7)	0	0.00
Total (N = 192)	17	8.85

### HARD TISSUE

#### Principles

In a word, the basic principle guiding the surgical care of hard tissues was conservation. Avulsed teeth were lifted from the wound surface, but teeth contained within comminuted bone fragments were given the opportunity to survive so they could be used for fixation or to preserve the integrity of major osseous fragments. Removal of root fragments from loose bone segments was not



Figure 33.—Upper and Middle) Penetrating high velocity missile wound of the right cheek in an 18-year-old casualty. There is extensive swelling of the neck and the tissues overlying the mandible. Lower) Appearance of patient 1 week post injury showing the healing incision line for neck exploration.

only difficult but harmful because in the attempt secondary fractures were often produced and it was also necessary to strip mucoperiosteal attachments thus depriving the fragments of their blood supply. It was best to retain and periodically evaluate these root fragments and, if necessary, remove them 4–6 weeks later after the bone had consolidated. At that time, because of periodontal membrane thickening and granulation tissue proliferation about the roots, the technical procedure was easier and jeopardy to the major fragments was reduced. The preserved alveolar bone was useful at a later date to support prosthetic appliances or as an underlying base for secondary soft tissue reconstructive procedures such as vestibuloplasty.

*The conservation of bone and soft tissue cannot be overemphasized.* If a tooth was to be removed, care was taken not to displace or fracture the bone fragments or tear the soft tissue. When suturing the gingiva and mucoperiosteal tissues, every attempt was made to ensure that all bone was covered with mucosa.

Loose and scattered bone particles, and especially those which were soiled or dirty, were removed although these fragments had usually been flushed from the wound at the time of hydrodynamic debridement. Osseous fragments with soft tissue attachment that were considered to have a chance for survival were retained and restored as near as possible to correct anatomic position.

### Mandibular Injuries

Mandibular injuries were addressed first, because in utilizing the principle of bottom-up repair for multiple facial skeletal injuries the mandible was the foundation. If closed comminuted fractures existed they were treated by closed methods of reduction. The fragments were molded into the best possible position by digital pressure and maintained by external pressure dressing and appropriate fixation (Case report 07). If the comminuted fractures were open as a result of soft tissue laceration or avulsion they were managed with very conservative direct reduction. Extensive open reduction of comminuted fractures by multiple direct wiring or plating resulted in devitalization of bone fragments as a result of soft tissue stripping that occurred during the placement of wires or

TABLE 13.—Daily Dosage and Routes of Administration of Antimicrobial Agents\*

Drug	Oral dose	Intramuscular dose	Intravenous dose	Adult or maximum dose per day
Cephalothin (Keflin)		40-80 mg/kg in 4 doses	40-80 mg/kg in 4-6 doses	12.0 g
Chloramphenicol (Chloromycetin succinate)	50-100 mg/kg in 4 doses		50-100 mg/kg in 3-4 doses (10% solution)	Child: 3.0 g Adult: 4.0 g
Colistin (Coly-Mycin)	6-8 mg/kg in 3 doses (5 mg/ml)	1.5-5.0 mg/kg in 2-4 doses		300 mg
Erythromycins (Erythrocin) (Ilotycin) (Pediamicin)	30-50 mg/kg in 4 doses	10-20 mg/kg in 3-4 doses	40-50 mg/kg in 4 doses	Oral: 2.0 g I.M.: 600 mg I.V.: 2.0-4.0 g
Gentamicin sulfate (Garamycin)		2-3 mg/kg in 3 doses (7 to 10 days)		5 mg/kg
Kanamycin (Kantrex)	50 mg/kg in 4 doses	15 mg/kg in 2-4 doses	15-30 mg/kg in 2-3 doses (2.5 mg/ml)	Oral: 4.0-6.0 g I.M.: 1.0-1.5 g I.V.: 1.0-1.5 g Aerosol: 1.0 g Peritoneum: 0.5 g
Lincomycin (Lincocin)	30-50 mg/kg in 3-4 doses	10-20 mg/kg in 2-3 doses	10-20 mg/kg in 2-3 doses	Oral: 2.0 g I.M.: 1.2-1.8 g I.V.: 1.2-1.8 g
Penicillin G Potassium or sodium	0.1-2.0 million units in 4-6 doses ¼-1 hr before meals	20,000-50,000 units/kg in 4-6 doses	20,000-50,000 units/kg in 4-6 doses	20-60 million units (in selected cases, 100 million units)
Semisynthetic penicillins: Ampicillin (Amcill) (Omnipen) (Penbritin) (Polycillin) (Principen)	50-200 mg/kg in 4 doses	100-300 mg/kg in 4 doses	100-300 mg/kg in 4-6 doses	Oral: 4.0 g I.M.: 8-14 g I.V.: 8-14 g
Methicillin (Dimocillin-RT) (Staphcillin)		100-300 mg/kg in 4 doses	100-300 mg/kg in 4-6 doses	12.0 g
Oxacillin (Prostaphlin) (Resistopen)	50-100 mg/kg in 4 doses	50-100 mg/kg in 4 doses	50-100 mg/kg in 4-6 doses	6.0 g
Polymyxin B (Aerospurin)	10-20 mg/kg in 4 doses	2.5 mg/kg in 4-6 doses	2.5 mg/kg in 2-3 doses (0.4 mg/ml in 5% dextrose in water for endocarditis)	Oral: 400 mg I.M.: 200 mg I.V.: 200 mg
Tetracycline (Achromycin) (Panmycin) (Polycycline) (Stecilin) (Sumycin) (Tetracyn) (Tetrex)	20-40 mg/kg in 4 doses	12 mg/kg in 2 doses	10-15 mg/kg in 2 doses (1.0 mg/ml)	Oral: 2.0 g I.V.: 2.0 g I.M.: 500 mg

\*NATO Handbook, Emergency War Surgery: First United States Revision, Emergency War Surgery, 1975, pp. 128-131.



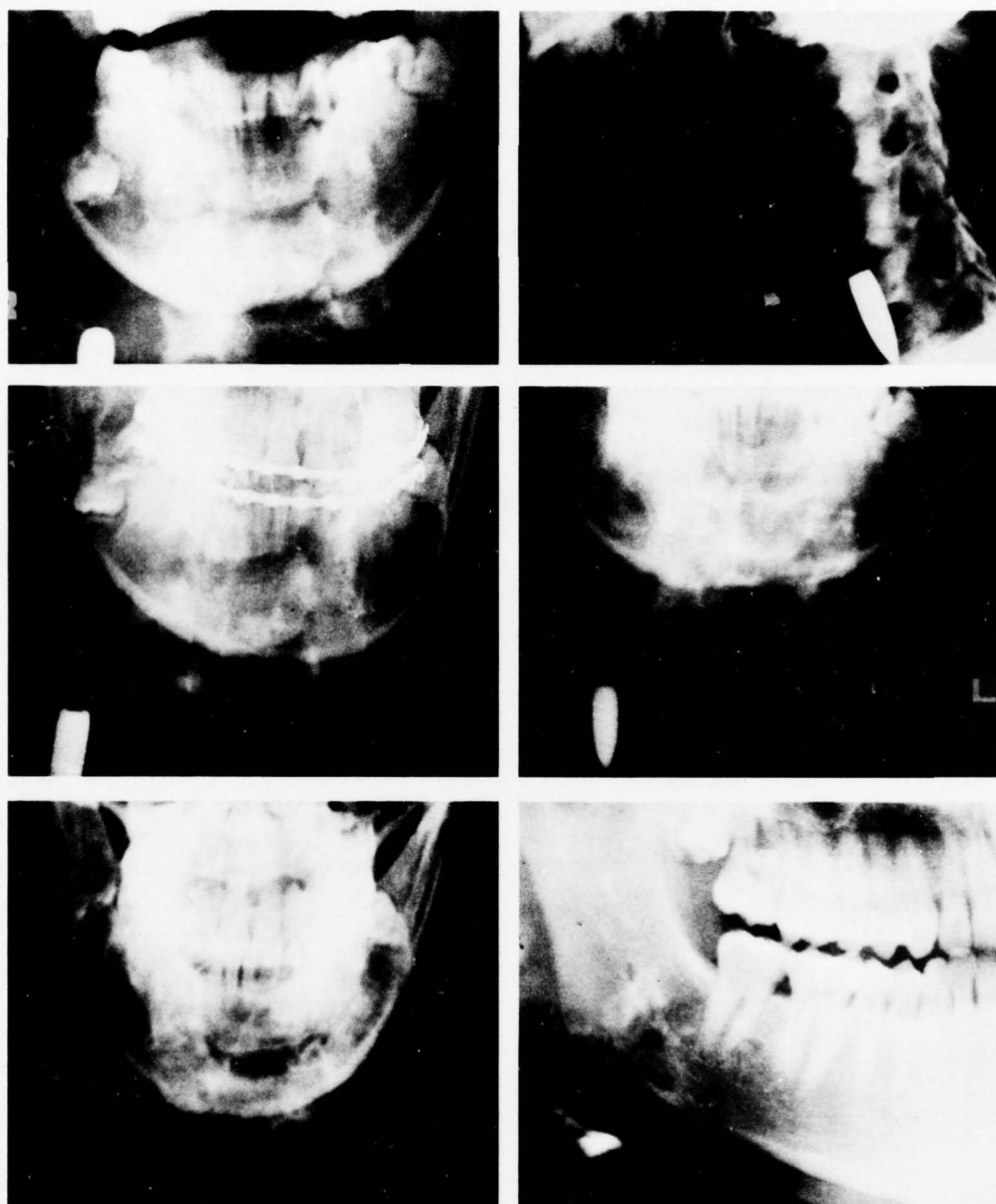


Figure 34.—*Upper left*) Posteroanterior radiograph showing injury to the right mandibular body and ramus, a displaced tooth, and a portion of the responsible missile. *Upper right*) Right lateral radiograph showing the entire missile low in the neck as well as the tooth in a position outside of the mandible. *Middle left*) Posteroanterior radiograph 3 days post treatment. A closed reduction of the mandibular fracture was accomplished and the neck was explored. The missile was not located although major vessel repair was accomplished. No attempt was made to remove the displaced tooth since it did not interfere with fracture reduction and was not encountered during neck exploration. *Middle right*) Posteroanterior radiograph 11 weeks post injury. The displaced tooth was removed at a late care facility via an extraoral submandibular approach. Intermaxillary fixation devices had been removed and the fracture was healing well. No symptomatology was associated with the missile at this interval and its removal was not attempted. *Lower left*) Posteroanterior radiograph 66 months following injury. The mandible was well healed with normal symmetry. The missile (AK-47) had been removed under local anesthesia from the right posterior triangle of the neck without incident 13 months following injury. Persistent neurologic symptoms presumably arising from the cervical spine area prompted removal of the missile. *Lower right*) Panoramic radiograph of right mandible 66 months following injury.

plates. In severely comminuted injuries such osseous devitalization would most assuredly occur since the arterial blood supply to the bone was usually disrupted and the soft tissue attachments to the fragments provided their only blood supply. Complicating the survival of osseous fragments was the fact that because of the contaminated nature of these wounds the retained devitalized fragments were prone to infections, which accentuated the later loss of bony substance. Infection was exaggerated by the presence of injudiciously applied internal metal fixation (Figures 35 and 36).

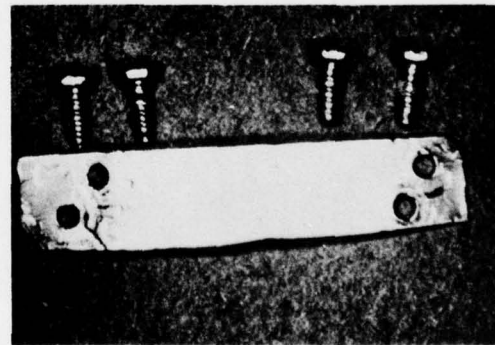
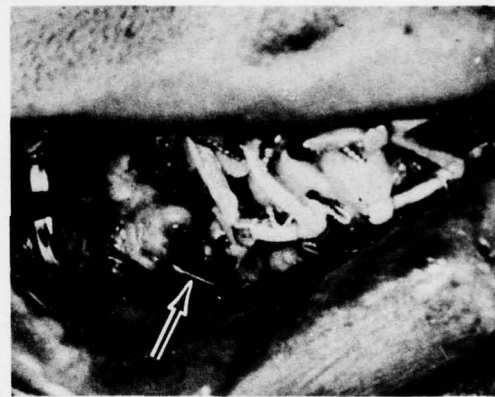
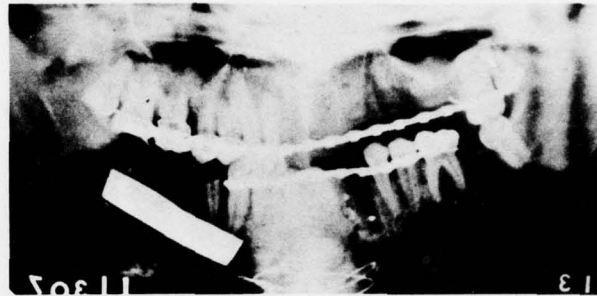
When direct open reduction was accomplished, it was best performed with the smallest gauge wire that would retain the fragments in apposition (26-32GA)—the objective was to directly reduce only a limited number of major fragments that would positively assist restoration of continuity (Figure 37). In some instances the damage to bone and the dentition was so severe that even with a conservative approach to debridement it was necessary to leave a discontinuity defect. When this occurred, a future requirement for bone grafting was assumed and all



*Figure 35.*—Panoramic radiograph that shows multiple wires that were placed at the time of treatment of a fragmentation wound to effect reduction of comminuted mandibular fragments. The devitalized osseous fragments in the region from the vertical ramus to the cuspid tooth (#22) were subsequently sloughed and/or debrided from the wound as a result of persistent infection.

measures were taken to assure primary healing and thus the opportunity for early grafting—residual fragments were correctly aligned and fixed, drainage was performed, and soft tissues (oral and facial) were closed primarily (Figure 38).

Alloplastic implant materials to restore discontinuity (e.g., metallic, plastic) were contraindicated.



*Figure 36.*—Upper) Panoramic radiograph showing a metal plate that was placed to reduce a fracture-avulsion of the right mandible resulting from a high velocity missile. Middle) Plate (MP) that became exposed in the oral cavity 10 days following treatment. The wound was grossly infected and it was necessary to remove the plate and the screws that were securing it to the bone. Lower) Plate and screws after removal from wound.

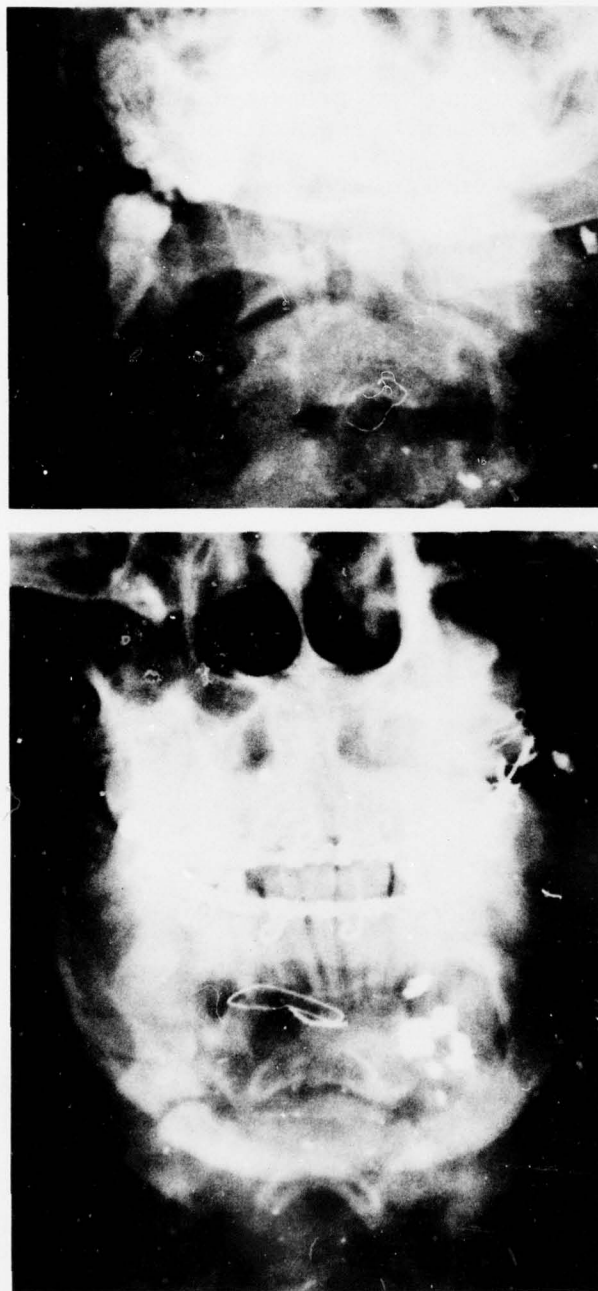


Figure 37.—Upper) Posteroanterior radiograph showing severely comminuted fracture of the mandible in a 24-year-old casualty who sustained a fragmentation wound. There is displacement of the fragments as well as avulsion of bone and teeth. Lower) Posteroanterior radiograph 10 days post treatment. The osseous injury was treated by directly molding the displaced fragments into approximately their normal position and providing internal stability with a single wire. The principal means of fixation was by intermaxillary fixation with arch bars.

cated in these contaminated wounds because they invariably contributed to the development of wound infection and required removal at a subsequent interval to control the extent and severity of the infection as well as the associated osseous destruction (Figure 39; Case report 08).

Although this section is concerned with hard tissue management, a word must be said concerning treatment of lacerations within the dental arches. Before the definitive reduction and fixation of the skeletal injuries were completed, lacerations of the tongue, floor of mouth, lingual mucosa and gingiva, and pharynx were closed because attempts to gain access to these tissues at a later interval resulted in destabilization of the reduced skeletal fractures.

### Midfacial Injuries

**Maxilla.** In keeping with the principle of working upward on the facial skeleton, the next unit to be considered was the *maxilla and associated bones*. As mentioned previously, the classical Le Fort patterns of midfacial injury were not seen as often as direct missile damage. Regardless of the type of injury the treatment was guided by two considerations: 1) *reduction of displaced fragments with occlusal relationships as the guide*, 2) *immobilization of the reduced fragments between the fixed plane of occlusion and the most stable superior point on the facial skeleton*. Methods of achieving these objectives varied according to the severity of the injury. Direct wiring of fragments was employed only with large readily accessible fragments that needed to be directly fixed to maintain the skeletal integrity of the midface. When Le Fort-type fractures existed they were reduced via the usual approaches described in the literature (Dingman and Natvig, 1964; Rowe and Killey, 1970[g]).

Injuries to the maxillary antra were repaired directly only if the wound was open or there was a need for support of other facial fractures or control of hemorrhage by antral packing (Figure 40). If at all possible, it was best to treat fractures through the antrum by closed methods.

**Zygomaticomaxillary and Orbit.** Wounds in the *zygomaticomaxillary area* caused comminution and fracture that frequently involved the orbit. Methods of treatment for injuries of this type varied, but when the zygoma, maxilla, and orbital floor were fractured *reduction and fixation* were



AD-A054 648

NAVAL MEDICAL RESEARCH INST BETHESDA MD  
MANAGEMENT OF WAR INJURIES TO THE JAWS AND RELATED STRUCTURES.(U)  
APR 78 J F KELLY, P W CONNOLLY, W R HIATT

F/G 6/21

UNCLASSIFIED

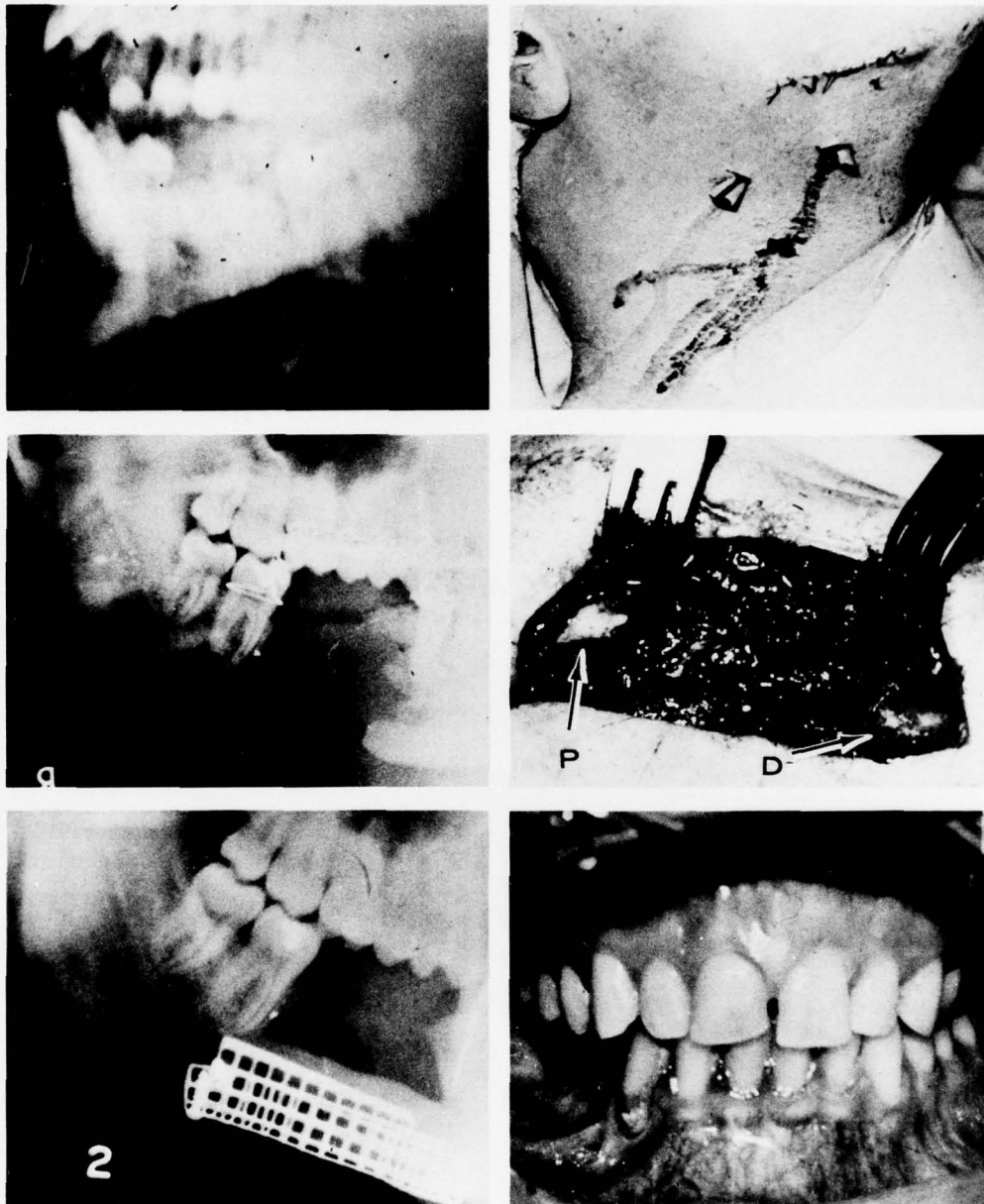
NMRI-78-23

NL

2 OF 3  
AD  
A054648







**Figure 38.**—*Upper left*) Right oblique radiograph showing severe comminution of mandibular body as a result of a fragmentation wound. *Upper right*) Appearance of wound over right jaw 48 hours following closure and drainage. Note the dependent position of the drains and the direction of the drainage flow. Treatment consisted of extensive debridement of the mandible with irrigation of bone and teeth from the wound that produced a discontinuity defect in the midbody. *Middle left*) Panoramic radiograph 1 month post treatment. The discontinuity defect that resulted from the severe wound is evident. The wound has healed uneventfully as a result of the adequate, but in this case not gross, debridement. The fragments are fixed in stable, correct alignment by intermaxillary fixation. *Middle right*) Photograph of discontinuity defect at time of bone graft operation 3 months post injury. The proximal (P) and distal (D) fragments are in excellent position for grafting. The soft tissues are supple and well vascularized after uncomplicated healing. *Lower left*) Panoramic radiograph of right mandible showing successful regeneration of bone at the site of PCM grafting 12 months after the graft operation. *Lower right*) Clinical photograph of occlusion and right alveolar ridge 49 months post injury and 46 months post grafting. At this interval a prosthesis was being worn by the patient and the radiographic appearance of the graft area was unchanged from that seen at the 12-month interval.



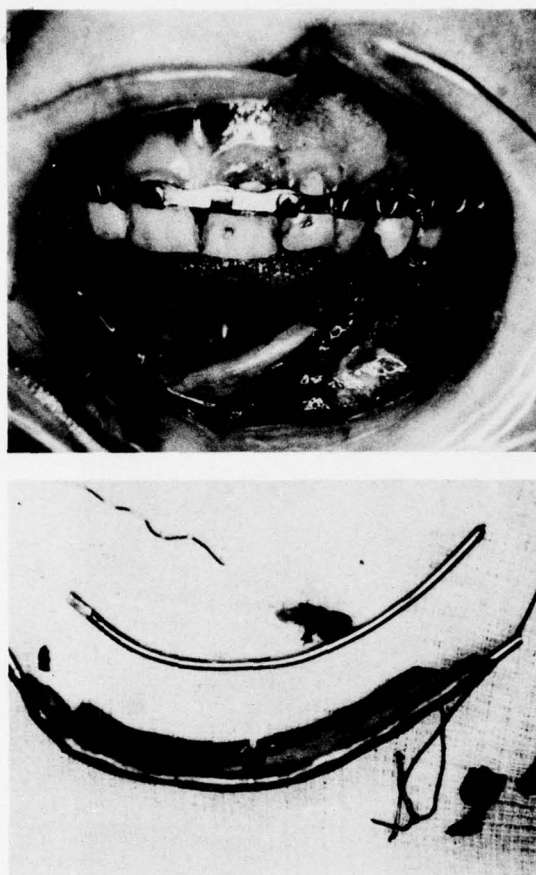


Figure 39.—Upper) Appearance of oral wound 3 days following treatment for a high velocity missile injury of the orofacial area. An alloplastic implant that had been fabricated with heavy Kirschner wires and acrylic was placed in the wound to bridge a discontinuity defect of the symphysis. There is dehiscence of the infected wound and exposure of the implant. Lower) Appearance of implant following its removal. The fragments were satisfactorily maintained in position by intermaxillary fixation following implant removal after which the infection resolved, allowing healing to progress in an uncomplicated manner. A bone graft was subsequently placed to restore the discontinuity defect (see Case report 08).

indicated. The orbital floor could be examined through the maxillary sinus to determine the presence of fracture, collapse of the orbital floor, and/or herniation of orbital contents into the antrum. When the floor was depressed without escape of orbital fat, packing the maxillary sinus usually provided adequate support until the bone fragments became consolidated. In those instances where orbital contents extruded through the orbital floor and fat was visualized in the antral roof the need for an orbital floor implant was recognized, although because of the highly

contaminated nature of these wounds the implant insertion was best deferred until a later interval. In combat conditions where operating room time was limited and wound contamination was certain, packing the maxillary sinus was the procedure of choice for orbital floor fractures. Providing the suspensory ligaments were intact, this approach usually gave adequate support until an orbital implant could be performed (ca. 14 days) at an intermediate or late care facility. Timing of secondary orbital floor surgery was effected by ophthalmologic as well as logistic considerations (Figure 40).

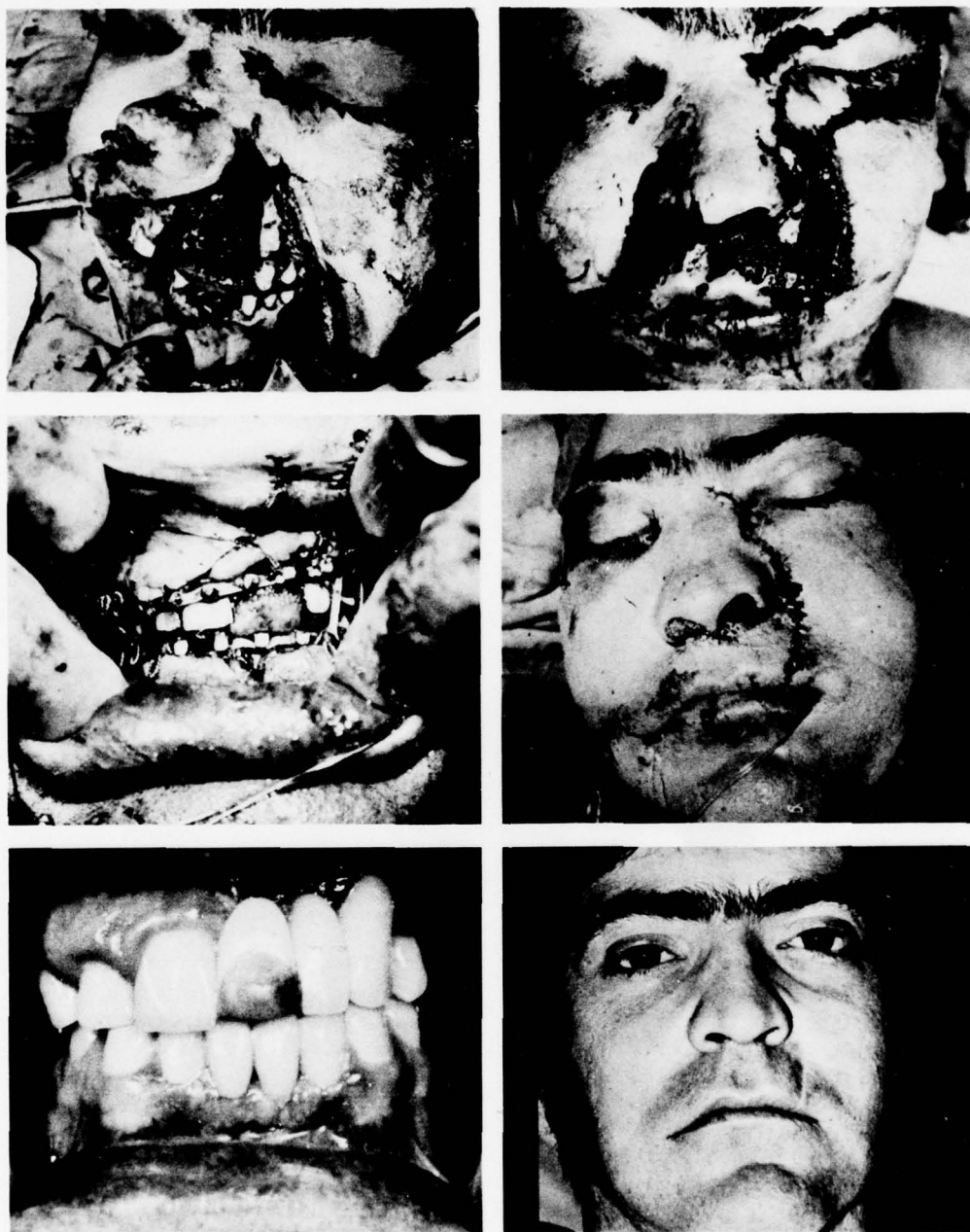
If the wound was not directly open to the sinus a Caldwell-Luc approach was used to enter the antrum. Blood clots and debris were removed and an antral pack placed to support the orbital floor after orbital fat was gently directed back into the orbit. Care was taken to assure that no sharp bony fragments that might cause ocular damage were forced into the orbit with the fat. Antral packing was exited from the antrum either via the oral vestibule or a nasoantral opening that was established beneath the inferior turbinate.

*Ideally orbital injuries were managed in conjunction with an ophthalmologist and the ocular status of the patient was followed by him during hospitalization (CINC PAC, 1971 [c]; Converse 1974 [d]).*

**Naso-Orbital-Ethmoidal Complex.** Naso-orbital-ethmoidal injuries were not common and when they existed were managed with the same principles that applied to injuries resulting from blunt trauma (Converse and Smith, 1963; Rowe and Killey, 1970[h]; Converse, 1974[e]). The essential feature of the treatment of these injuries was to maintain the morphologic and dimensional integrity of the interorbital anatomy, relying on open procedures if there was any doubt concerning the adequacy of reduction (Figure 40). These injuries were best managed in collaboration with an appropriate specialty consultant when available. When cranial damage was present in association with such injuries neurosurgical management was mandatory.

### Stabilization of Fractures

**Intermaxillary and Skeletal Fixation.** In most instances stabilization of the reduced fractures was accomplished with intermaxillary fixation alone. If there were fragments of the mandible



*Figure 40.*—*Upper left*) Appearance of 21-year-old casualty who sustained a missile wound to the face. In addition to the left cheek laceration, the facial skeleton was fractured in a Le Fort II pattern and there was avulsion of dental and osseous tissues from the anterior maxilla. *Upper right*) Intraoperative photograph showing extent of laceration and underlying tissue damage. *Middle left*) Intermaxillary fixation had been established in conjunction with circumzygomatic suspension wiring. Naso-orbital fractures had been treated by wire reduction. *Middle right*) Appearance of patient at completion of operative treatment. Lacerations had been closed and the suspension wires were ready for attachment. Both of the maxillary sinuses were packed with gauze that was exited via nasal antrostomies. Although fractures were noted in the orbital floor at the time of antral examination, gross egress of orbital contents had not occurred thus orbital floor implants were not placed until the patient arrived at a late care facility. *Lower left*) Occlusion and fixed dental prosthesis 87 months post injury. *Lower right*) Appearance of patient 54 months post injury. Facial symmetry was excellent and the extensive laceration of the left cheek had healed with minimal scarring. Vision at that time was within normal limits.

that could not be controlled by intermaxillary fixation because they were edentulous or had been rendered edentulous by the injury (e.g., proximal body-ramus segment) external skeletal-pin fixation was recommended for application at the appropriate interval post injury. These devices were not routinely used for early primary care because of general lack of availability and the fear that, if placed, they would fail because of the increased risk of infection associated with introduction of alloplastic materials at this interval. If external skeletal fixation was to be used at the time of early care, it was best employed where the logistics were such that it was possible to have continuous control over the patient for at least 14-15 days in order to carefully monitor the wounds and fixation devices for the presence of infection. A discussion of the control of edentulous fragments by skeletal fixation will be presented later in the text.

**Splints.** Splints were not recommended for early treatment since their construction was time consuming in the exigencies of combat casualty treatment and they were invariably associated with lessened oral hygiene and thus created a greater risk of infection and wound breakdown. Adjustments, that are always necessary with surgical splints, were difficult to accomplish in the postinjury period because of swelling and pain, thus the splints became ill-fitting and detracted from, rather than assisted treatment.

**Suspension Wiring.** If midfacial stability could not be maintained without control of the mandible, suspension wires from the most appropriate stable point on the facial skeleton above the level of the fracture were placed by standard methods (Adams, 1942; Rowe and Killey, 1970[i]).

**Head Frame Fixation.** External skeletal fixation (cranial frame) for stabilization of severe midfacial

crush injuries was rarely used for the *early primary treatment* of these injuries. It is recognized that this method of fixation is indicated in cases of massive midfacial avulsion or comminution where pterygoid-maxillary integrity has been violated.

### Analysis of Fracture Reduction in MFCS Cases

Mandibular fracture reduction at the time of early care in the MFCS cases was accomplished by open means in 43.48% of cases and closed means in 50.31% (Table 14). Group I patients were treated more frequently by closed (55.95%) than by open (41.67%) methods. This does not imply that open osseous wounds were not treated, but rather that it was not the practice to directly wire the fragments in avulsive injuries. After the value of conservative reduction in conjunction with stable fixation became fully appreciated, aggressive or inappropriate open reduction procedures were seldom attempted.

Open reduction of midfacial fractures was necessary in only 6.83% of patients whereas closed reduction was required in 14.91%. In some instances the severity of other injuries precluded definitive early reduction, thus in 5.59% of patients with fractures no early reduction was accomplished.

### SOFT TISSUE

#### Principles of Primary and Secondary Closure

Soft tissue orofacial wounds were sutured as soon as possible after injury since *primary repair and healing were the goals of treatment* in contrast to wounds in other locations (i.e., extremities) where conditions for primary healing were not as favorable (NATO, 1975[d]). The period following in-

TABLE 14.—Incidence of Open, Closed, and No Reduction for Mandibular and Midfacial Fractures for Groups I, II, III, and IV Patients During the Early Phase of Management

Group	Mandible		Midface		No early reduction
	Open	Closed	Open	Closed	
I (N = 84)	35[41.67]*	47[55.95]	3[03.57]	15[17.86]	2[02.38]
II (N = 32)	12[37.50]	17[53.13]	6[18.75]	2[06.25]	3[09.38]
III (N = 20)	8[40.00]	10[50.00]	1[05.00]	3[15.00]	2[10.00]
IV (N = 25)	5[60.00]	7[28.00]	1[16.00]	4[16.00]	2[08.00]
Total (N = 161)	70[43.48]	81[50.31]	11[06.83]	24[14.91]	9[05.59]

\*Figures in brackets equal percentage of N.



jury during which primary suturing of facial wounds was considered permissible depended on the type of wound and the judgment of the surgeon. Although primary suturing was best performed during the first 4 hours after injury, the rich vascularization of the facial tissues permitted successful primary closure of uncomplicated lacerations as late as 24 hours after injury.

If many hours had elapsed since injury and the open wounds were extensive and badly contused with clinical evidence of infection such as rapid swelling, erythema, or even sepsis, the closure was best delayed until the wound surface was prepared for closure and infection brought under control. Suturing of inflamed and edematous wounds rarely produced satisfactory results. Preparation of a wound for delayed closure usually took about 2-10 days and included cleansing of the wound, moist dressings, maintenance of free drainage, immobilization of tissues with gentle but firm pressure dressings, and systemic antibiotic therapy. During the period of preparation healthy, pink granulation tissue proliferated in the wound as a sign of satisfactory progress. *Quantitative bacteriologic assessment* of biopsied tissue from contaminated wounds, although not widely used in the treatment of orofacial wounds in Vietnam, has reportedly been successful for establishing the timing of delayed wound repair and should be considered in the management of these types of problems (Robson et al., 1973; Krizek and Robson, 1975).

If the patient was first seen several days after injury and healing was well advanced but the tissues distorted, which was often the case with civilian casualties, it was preferable to permit spontaneous healing and anticipate secondary repair.

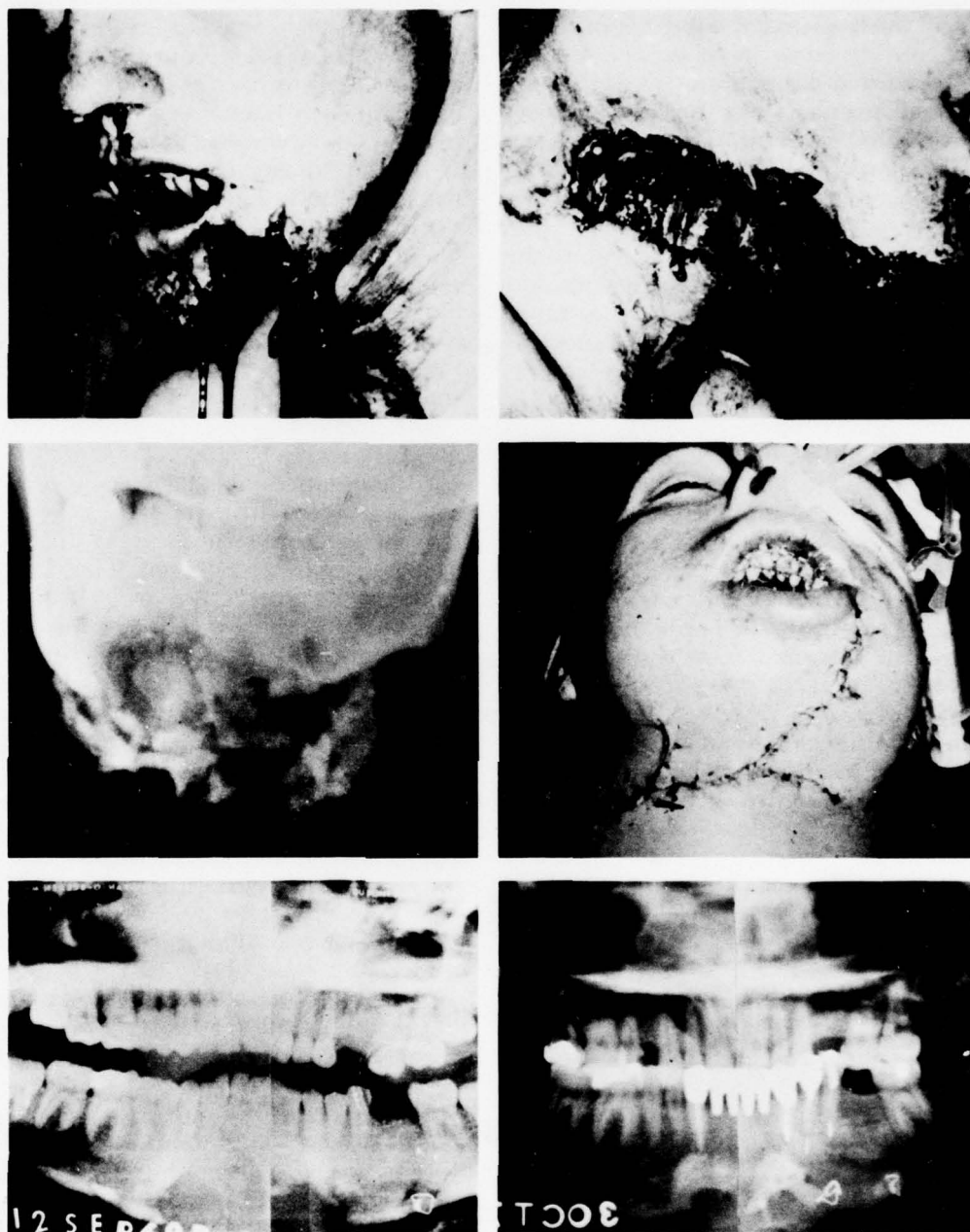
## Wound Closure

**Suturing and Local Flaps.** Ragged, badly contused wound margins were excised to provide a clean smooth surface for closure. In the richly vascular orofacial region it was possible to be more *sparing in the excision of damaged tissues* than would be the case in extremity wounds. The skin was undermined to permit approximation of wound edges without tension. Fine subcuticular sutures were used to eliminate dead space, approximate the base of the dermis, and relieve tension on wound edges and sutures.

In the face there was a greater chance of survival for flaps of partially avulsed tissues that were attached only by narrow pedicles. The decision to maintain such flaps was a difficult one and depended on the surgical judgment of the clinician. If the flap assumed a deep cyanotic color it was usually an indication that the pedicle, although sufficiently wide to allow passage of arterial blood, was too narrow to permit adequate venous return and sustained viability of the flap was unlikely. If the cyanotic tinge was less accentuated or if digital pressure on the flap caused blanching followed by rapid return to color, the efficiency of the dermal vessels was considered adequate for nourishment and the chances of survival were good (Peacock, 1971[b]).

Although these missile wounds resulted in disorganization of the tissues and a great amount of tissue damage, the true loss of tissue was often not as extensive as it appeared. The damage was in effect *more apparent than real*. The exaggerated size of the wounds was due to factors which included retraction of the borders of the wound by contraction of the severed muscles, elasticity of the surrounding skin, local inflammation and edema, the weight of detached soft tissue flaps, and displacement of bone fragments. Perhaps the most important aspect of soft tissue management was determining the actual extent of tissue loss and planning the type of closure that would be required; primary closure was performed whenever possible. This was accomplished by the trial and error positioning of tissue flaps over the underlying *repaired* skeletal structures. Known anatomic landmarks such as the vermilion border of the lip were used as starting points for putting the puzzle back together (Figures 41 and 42, Case report 09).

When a small or moderate amount of tissue had been lost, only the *undermining of skin edges* was necessary to permit suture closure. If this was not possible, a small rotation or *transpositional* flap was used to fill the defect although these were reserved for ideal conditions. Free *split-thickness skin graft* dressings were occasionally applied to areas whenever the defect was too large to be closed by direct approximation or local flaps. The skin grafts provided a temporary dressing for the wound until later reconstructive procedures could be performed. When there was loss of extensive full-thickness tissue around the oral cavity and closure was impossible, it was necessary to



**Figure 41.**—*Upper left and right*) Appearance of 19-year-old casualty who sustained a high velocity missile wound to the lower face and neck. There is evidence of tissue avulsion sufficient to possibly preclude primary closure of the wound. *Middle left*) Posteroanterior radiograph showing extent of osseous injury to the anterior mandible. *Middle right*) Primary wound closure immediately before the placement of a pressure dressing. Irregular and obviously devitalized tissue along the wound margins had been sharply incised and the cutaneous flaps undermined and advanced to permit primary closure. Drainage had been effected through the inferior pole of the laceration at the right side of the neck. *Lower left*) Panoramic radiograph 1 month post injury showing extent of osseous avulsion at mandibular symphysis. Arch bars had been removed and the radiograph taken before construction of a mandibular lingual splint that was used to provide monoarch stabilization until consolidation occurred. *Lower right*) Panoramic radiograph 86 months post injury and 66 months following bone grafting to the mandibular symphysis. The graft had been performed for cosmetic augmentation and to strengthen the symphysis region. (Continued in Figure 42)

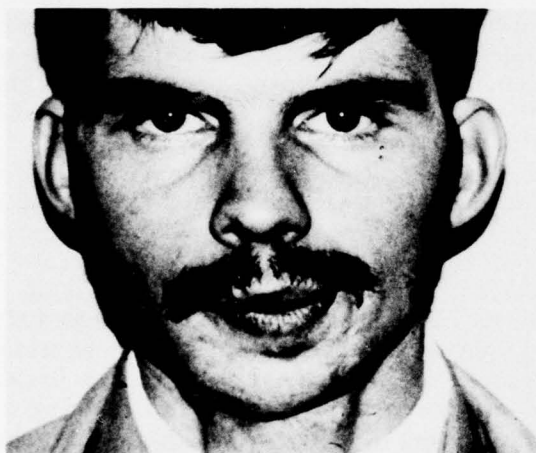


Figure 42. Continuation of Figure 41—Upper) Occlusal radiograph that illustrates a residual bone fragment that at one time was part of the lingual cortex of the mandible. The fragment was drawn lingually by the genial musculature at the time of injury and healed in that position without incident. Middle and Lower) Appearance of patient 86 months post injury.

accept the fact of a deficit and suture mucosa to skin to minimize scar contraction. This type of closure sufficed until a later reconstructive procedure could be performed. This procedure is consistent with the principle of providing an inner mucosal lining as well as an outer skin covering for all tissue deficiencies in and about the orofacial area to prevent excessive scarring and contraction (Case reports 02 and 04).

Failure of wounds to heal following primary closure usually resulted from one or more of the following causes: lack of drainage for wounds in which there had been extensive tissue dissection, inadequate immobilization of the wound by pressure dressing, failure to properly immobilize the jaws, and failure to properly close the oral mucosa thus exposing the facial wound to contamination by oral fluids. Additionally, secondary manipulation of inadequately reduced fractures caused dehiscence of primary facial and oral wound closures. As stated previously, *reduction and immobilization* of facial fractures before primary wound repair were considered essential in all instances, unless the precarious condition of the patient precluded treatment other than expeditious superficial wound repair (Kruger, 1968[b]; Osbon, 1969; Rowe and Killey, 1970[j]; Curtin, 1973; Converse, 1974[f]).

## SPECIALIZED TISSUES

### Salivary Gland

**Parotid.** Whenever a deep injury of the cheek or preauricular area was present the wound was carefully examined for possible injury to the *parotid gland or duct as well as the facial nerve*. It was sometimes possible to see the cut ends of the duct at the time of initial inspection of the wound. The proximal segment was identified by the presence of salivary flow which if not evident could be elicited by pressure over the gland. If integrity of the duct was questionable, a small polyethylene catheter (no. 2 or 4) was introduced into the mucosal ostium and threaded proximally to determine if it passed directly into the gland or entered the wound via a disrupted section of duct. An isolated tear or complete disruption of the duct was repaired with polyethylene catheter in the lumen to act as a support stent. When it was



not possible to locate the proximal duct, the drainage tube was exited from the distal duct or directly through the mucosa into the oral cavity to initiate development of an intraoral salivary fistula and thus prevent accumulation of saliva in the wound. The *principle objective* when treating this type of wound was to *guide drainage of saliva into the oral cavity and thus prevent formation of a salivary-cutaneous fistula* (Kruger, 1968[c]; Osbon, 1969; Converse, 1974[g]). Secondary management of parotid salivary complications will be discussed in the late care chapter.

**Submaxillary.** If the submaxillary salivary apparatus was damaged in extensive open injuries to the floor of mouth or neck it was best to excise the gland rather than attempt to deal with salivary secretions since the procedure was technically less difficult than parotidectomy and usually was associated with inconsequential morbidity. Removal of the gland eliminated the possibility of postoperative salivary swelling in the tissues of the neck and later development of a salivary fistula. If the duct could be easily identified and repaired in the anterior floor of the mouth, it was acceptable to do this although a tedious time-consuming procedure to correct a problem of this nature was not warranted because it was not commensurate with the overall objectives of surgical treatment in an early care facility. Polyethylene catheter drainage of the submaxillary gland via the duct was not usually successful and duct catheter drainage of the gland via the mucosa, such as in the parotid area, was not practical since gravity prevented the free flow of saliva up into the mouth.

### Facial Nerve

The same type of wounds that damaged the parotid area affected the facial nerve. It was desirable to *identify severed major trunks of the nerve and repair them by suture approximation* at the time of primary wound repair (Converse, 1974 [h]). Whenever possible this procedure was best performed under magnification by specialists familiar with microsurgery, and while it was time consuming it was of greater significance than salivary duct repair and therefore higher on the list of necessary surgical priorities. If the logistics of surgical care did not permit sufficient time for definitive nerve repair, silver clips or colored

monofilament sutures were placed on the cut nerve ends to facilitate location at the time of later repair. If the facial nerve damage was diagnosed as intratemporal, the treatment was deferred until the neurologic status of the patient permitted appropriate specialized surgical care and facilities were available.

### Ophthalmologic Injuries

Injuries to the eye and orbit were routinely managed in conjunction with an ophthalmologist. Penetrating injuries to the eye and hyphema were recognized at the time of initial examination and treated definitively by an ophthalmologist (p. 60). There are certain ophthalmologic principles concerning other injuries to the eye that were employed and that should be emphasized in this text in order to provide the maxillofacial surgeon with a basic perspective for the treatment of injuries to this area.

Lacerations of the lid which exposed the globe required early treatment. It was highly important to provide cover of the globe to prevent desiccation of the corneal epithelium, which greatly increased the risk of abrasion. The lid is an extremely viable structure and recovered well after multiple severe lacerations. Treatment usually consisted of suturing the lid with fine braided material as early as possible and covering any exposed area of the cornea with an ophthalmic antibiotic ointment in a petrolatum base. The eye was then covered with a dressing until it was necessary to remove the sutures. While waiting to repair the lid, exposed cornea was covered with generous amounts of ophthalmic ointment and the eye was covered with a sterile dressing.

The most common injury to the cornea was abrasion of the *epithelium*. This occurred following exposure when the lids were lacerated or during repair. To prevent and/or treat this injury the cornea was kept moistened as described above. A mydriatic agent was instilled to counteract spasm of ciliary muscles, thus resting the eye.

Lacerations of the conjunctiva not associated with penetrating wounds of the globe or extensive lacerations of the lid were not sutured, because in the absence of infection they healed spontaneously without complication. If the conjunctival laceration was deep and wide healing was assisted by approximation of the edges with

fine interrupted braided sutures.

If the *canaliculi of the nasolacrimal apparatus* was severed accurate repair at the time of primary closure was desirable. A nylon filament or small polyethylene tube was passed down the canaliculi

into the sac to allow end-to-end continuity to be maintained during the period of the repair and subsequent healing (Rowe and Killey, 1970[k]; CINC PAC, 1971[a]; NATO, 1975[a]).

## POSTSURGICAL CONSIDERATIONS

### INTRODUCTION

Postsurgical management was an *essential component of the early care continuum*. The postoperative course of the combat casualty was determined by the effectiveness of surgical wound repair, the cumulative effect of concomitant injuries, and the physiologic response to injury. The postsurgical period involved the interval between surgical treatment and evacuation to the next level of care which in the cases studied was about 7 days (Table 2, Chapter II.)

As virtually all the patients had been found physically fit prior to combat, the postoperative period was ordinarily not complicated by exacerbation of preexisting chronic disease such as might be seen in a more heterogeneous population. In addition, *attending surgeons in the post-surgical period* had the advantage of dealing with a relatively more stable patient than that encountered in the usual postinjury emergency setting. The patient had survived the physiologic insult of acute traumatic injury and his status was documented by a history and physical examination as well as a record of surgery, anesthesia, medication and subsequent care.

Management of patients at this time was accomplished with the understanding that they would be evacuated within a few days postoperatively. There was no attempt to prepare patients for secondary surgery unless it was necessitated on an emergency basis by the development of complications. Many patients had sustained injuries to multiple systems and though they were not compromised by preexisting chronic diseases it was nonetheless necessary to anticipate probable and possible complications. Time lag between wounding and definitive care, effects of climate, military activities prior to wounding, and the requirements for early evacuation were all factors that influenced the development and management of complications.

### SIGNIFICANT ASPECTS OF MANAGEMENT

*Five separate aspects of management* were related to or occurred during the postoperative period and were most important in caring for the casualty following the primary care of his wounds.

#### Operative Considerations

Many of the casualties arrived at the early care facilities with a full or partially full stomach and it was desirable to place a *nasogastric tube* in the more severe injuries to evacuate stomach contents and lessen the possibility of emesis. This was a particularly important consideration in the case of maxillofacial patients since they were almost routinely placed in *intermaxillary fixation* during treatment and emesis was a threatening event. If a tube had not been placed prior to surgery for the management of concomitant injuries, it was passed at the beginning of the procedure rather than during the postoperative period when the passage was usually more difficult and the patient more vulnerable to associated complications. The tube was later used for feeding during the early postoperative period although, unless maxillofacial injuries were extremely severe, oral alimentation was usually not compromised for a prolonged period.

A *urinary catheter* was placed if multiple injuries were present or extensive resuscitation had been necessary during the initial management at the early care facility and it was desirable to precisely monitor fluid output.

#### Immediate Postoperative Care

The *airway and respiration* were constantly monitored. When there was doubt concerning adequacy, the cuffed endotracheal tube was left in



place until these concerns were resolved, if tracheostomy had not been performed. The cuff was deflated periodically and the tube and trachea were cleansed with sterile saline solution. Moist air in the form of cool vapor was directed to the tracheostomy orifice. Coughing and deep breathing were encouraged to ensure sustained pulmonary ventilation.

In the presence of multiple injuries a pulmonary condition referred to as *progressive pulmonary insufficiency (PPI)* or *shock lung* developed in some patients with particularly morbid effects. Fluid overloading coupled with compromise of alveolar air exchange and/or pulmonary capillary perfusion provided the most frequent setting for development of progressive hypoxia and hypercarbia. The key factors in preventing PPI were avoidance of fluid overload during resuscitation and surgery, extensive use of blood gas monitoring and aggressive pulmonary supportive care (CINC PAC, 1971[d]).

The patients were naturally anxious concerning their survival, the nature of their wounds, and the efficacy of treatment. Thus, it was essential during the immediate postoperative period to develop and establish good rapport between the patient and professional personnel with whom he was in contact. In this regard it should be noted that while specially trained nursing and professional personnel staffed the recovery/intensive care units of the early care facilities, the units were frequently filled to capacity with seriously injured patients and surgeons were frequently required to personally perform routine nursing care themselves or delegate these responsibilities to other paraprofessionals who were not ordinarily assigned to this environment. It was necessary that all these individuals be cognizant of the emotional needs of the patient.

### Supportive Care

All the supportive care was ideally coordinated by a single responsible surgeon. The recovery and intensive unit personnel were instructed to develop an acute awareness of the nature of potential complications for the different types of injuries such as subtle variations in vital signs, respiration, state of consciousness, or laboratory values. Patients who sustained maxillofacial injuries required only minimal to moderate pain control or sedation. In these patients no medica-

tion was used that would depress respiration.

*Fluid, electrolyte, and nutritional needs* were divided into *replacement* and *maintenance* categories. The basic replacement requirements usually had been met during the period of resuscitation, presurgical preparation, and surgery. This requirement was determined by correlating clinical assessment, laboratory studies, and cardiovascular-renal response to fluid therapy. In the uncomplicated maxillofacial injury, replacement therapy was determined by standard postoperative formulas (Shires, 1971). When severe concomitant injuries were present the additional need for replacement fluids was judged by the extent of injury and tissue damage and was determined by the surgeon responsible for managing these problems.

Oral intake was encouraged as soon as possible post surgery, starting with clear liquids and continuing to more nutritional fluids that provided adequate caloric and protein requirements (Wilson, 1970; Randall, 1971). The ability to maintain satisfactory oral hygiene, thus allowing uncomplicated wound healing, and the ability of the patient to take oral feedings were the principal factors that determined the rapidity with which oral intake could be resumed. In general, hydration was more important than nutrition during the first 24-48 hours.

*Pressure dressings*, which had been placed following surgery, were removed after 48 hours to inspect the surgical site and advance or remove drains. If the incision was grossly covered with blood or secretions it was cleansed with sterile water or a mild disinfectant soap solution. It was best not to repeatedly attempt meticulous cleansing of wound surfaces during the period of primary healing. The sutures were not removed until it was possible for adequate tensile strength to develop in the wound, usually no sooner than 6 days (Madden and Peacock, 1971). Alternate sutures were occasionally removed at 3 days and the suture lines supported by tape and dressings. To assure esthetic wound healing, sutures were removed with the same meticulous care with which they were placed.

*Drains* were removed as soon as there was evidence they were no longer required to evacuate exudate from the wound. Most drains were removed or advanced 2-3 days post surgery; whenever possible all drains were removed prior to transfer from the early care facility. If it was



necessary to continue wound drainage during the period of evacuation, it was essential that a specific note be made in the record advising attending personnel of the presence of a drain and the need for its management. Culture of drainage was indicated if any purulence was noted. In the face of persistent drainage antibiotics were not changed until there was definite evidence that the cultured organism(s) were resistant or not sensitive to the antibiotics already being used. If the drain was advanced it was again necessary to secure it to the wound surface with a suture. Irrigation of wounds via drainage tracks was performed only in the presence of infection and with sterile or mildly antiseptic solutions.

Drains from the parotid gland into mouth via the buccal mucosa were left in place as long as they were effective in directing the flow of saliva into the mouth. If salivary flow was not evident, the drainage tract was gently irrigated to clear viscous secretions that might be obstructing the flow of saliva. It was occasionally necessary to reposition a new drain through the drainage wound in the buccal mucosa in an attempt to reestablish salivary flow. However, if the initial drain was not functional, secondary attempts at salivary drainage from the damaged parotid area were usually not successful. Management of obstructive salivary gland complications will be discussed in a later chapter. If drains had been placed in other areas of the oral cavity for purposes other than salivary drainage they were removed as early as possible (2-3 days) to prevent secondary contamination.

Little adjustment of fixation was required during the postoperative phase at the early care facilities since in most cases fixation achieved at the time of surgery was adequate. Because the patients were to be transferred by air evacuation, wires were *not* used to replace previously applied intermaxillary elastics. Virtually all of the fixation was by intraoral or direct reduction wiring, and few attempts were made to apply additional fixation (i.e., external skeletal, splints) at the early care facilities since these adjunctive measures were ordinarily accomplished at the intermediate or late care facilities. At this interval the most important consideration relative to fixation was to maintain adequate oral hygiene in the area where the devices were attached to the teeth.

*Nasal packs* that had been placed to control hemorrhage were usually removed by the 5th

day. At the time of removal preparations were made for replacement in the event bleeding recurred. *Antral packs* for support of skeletal facial fractures were not removed for at least 10 days and were frequently in place at the time of patient transfer—here again notes to this effect were made in the patient's chart in a very conspicuous manner.

### Complications

Few complications attributable solely to the maxillofacial injury developed during treatment at the early care facilities. The various body systems were continuously monitored and, although problems such as pulmonary atelectasis were occasionally seen, the patient whose principal injury was in the maxillofacial areas generally experienced a relatively smooth postoperative course. This was in part attributable to the vigorous early treatment and intensive supportive care that the patients had received as well as the relatively more relaxed circumstances of the postoperative period (in comparison to the triage → operating room phase) which permitted early consultation for management of developing systemic complications. With very few exceptions primary wound closures did not exhibit gross infection and breakdown during the early care phase (see Table 51, Chapter VI).

### Evacuation Procedure

*Aeromedical evacuation was, in almost all instances, an inevitable fact of casualty care.* During the early period of the conflict some patients who did not require secondary reconstruction or rehabilitation were retained at mobile or fixed complete facilities until their wounds were healed (p. 18). As the number of casualties increased it was not possible to retain patients for convalescence because all beds were required for support of early wound care.

The reality of aeromedical evacuation has been well described by White (1968) in the following paragraphs.

Screening of patients for movement is made at the originating hospital and at each successive casualty staging unit or treatment facility. The desired goal is that no patient will be moved by any means until he has reached 'stabilization.' In practice it has been

found that stabilization varies dependent upon circumstances. In the ideal situation, as occasionally exists in South Vietnam (SVN), with a low incidence of casualties with adequate beds and readily available emergency and surgical care, patients can be held in country for a 2-3 week period for stabilization prior to movement. This was particularly valuable in chest, abdominal and severe multiple extremity wounds.

On the other hand, in a forward combat situation or when a large number of recently wounded patients flood in-country (SVN) facilities and rapid movement is required, stabilization is only that which will permit safe transportation for relatively short flights. Between the two extremities is a situation where conditions permit the holding of patients in in-country treatment facilities for 3-10 days. Here, stabilization permits restoration of body fluids, electrolyte balance and gastrointestinal, renal and pulmonary function.

**Timing of Evacuation.** Under normal conditions patients were not recommended for manifesting from the combat zones to CONUS unless they were several days post injury. However, it was not always possible to conform to this schedule because of the disparity between the number of beds at the early care facilities and the number of casualties being received. As a result, earlier evacuation to CONUS or intermediate care Pacific theater facilities often occurred. Management of casualties at the intermediate facilities, which was heavily dictated by logistics, will be discussed in the next chapter.

The timing of the evacuation procedure for the patients in the maxillofacial casualty study was presented in Table 2 of Chapter II. It was seen that the mean patient stay at the early care facilities was 7.75 days. This is consistent with data reported by White et al. (1971) in which they listed a mean departure time from Vietnam for 3,987 patients of all categories of 7 days.

**Effects of Evacuation on the Casualty.** In formulating the decision to evacuate a casualty, the surgeons took into consideration the nature of the evacuation aircraft, the conditions of flight, the duration of the transfer process, and the physical and physiologic changes that might occur during transfer that could influence the condition of the patient. The aircraft were basically cargo planes designed for freight handling and as such were noisier and more dimly lit than passenger planes. Medical supplies and equipment were brought on board and the interior of the aircraft was set up to accommodate the pa-

tients. Care was essentially supportive and consisted of measures such as drug administration, infusion of fluids that had been ordered prior to evacuation, use of suction and oxygen as necessary, and other routine care.

The physical and physiologic changes that might occur in casualty evacuees were related to a variety of factors that influenced the condition of the patient commensurate with the nature and severity of his wounds. These included prolonged exposure to extremes of thermal conditions, rapid change in climate and time zones, dehydration, and the atmospheric condition of the aircraft cabin. All these factors contributed to accentuation of fatigue which in turn increased the susceptibility of the patient to complications (White, 1968; CINC PAC, 1971[e]).

Figure 43 illustrates the evacuation routes that were used and the distances between the principal intermediate stops and CONUS. Transfer from an in-country fixed facility (Vietnam) to a CONUS destination extended over approximately 92-102 hours (4 days), if the patient experienced an optimal travel schedule. It was not uncommon to add as many as 4 additional days for overnight stops and delays that were required as a result of logistic coordination of large-scale casualty evacuation. The intervals for all stages of evacuation are listed in Table 2, Chapter II. Recommendations for coordination of treatment during evacuation with emphasis on intermediate stage management will be discussed in the chapter on intermediate care of the casualty.

**Selection, Preparation, and In-Flight Management of Evacuees.** The basic criteria for selecting patients for evacuation took into consideration the possibility for expansion of gases within body cavities, the presence of fever, bleeding, dehydration, and inhibited respiration.

Patients who were to be transferred via the aeromedical system were at the very least expected to meet *minimum basic criteria* which included the following: 1) stable hemotocrit of 35 v/v and hemoglobin of 11 gm%, 2) stable vital signs, 3) no active bleeding, 4) adequate hydration.

If a tracheostomy tube was in place it was changed immediately before evacuation to assure a clean and well-functioning tube at the beginning of the long and tedious transfer process—a tube with a cleaning cannula was essential. It was necessary to order humidification of the tracheos-



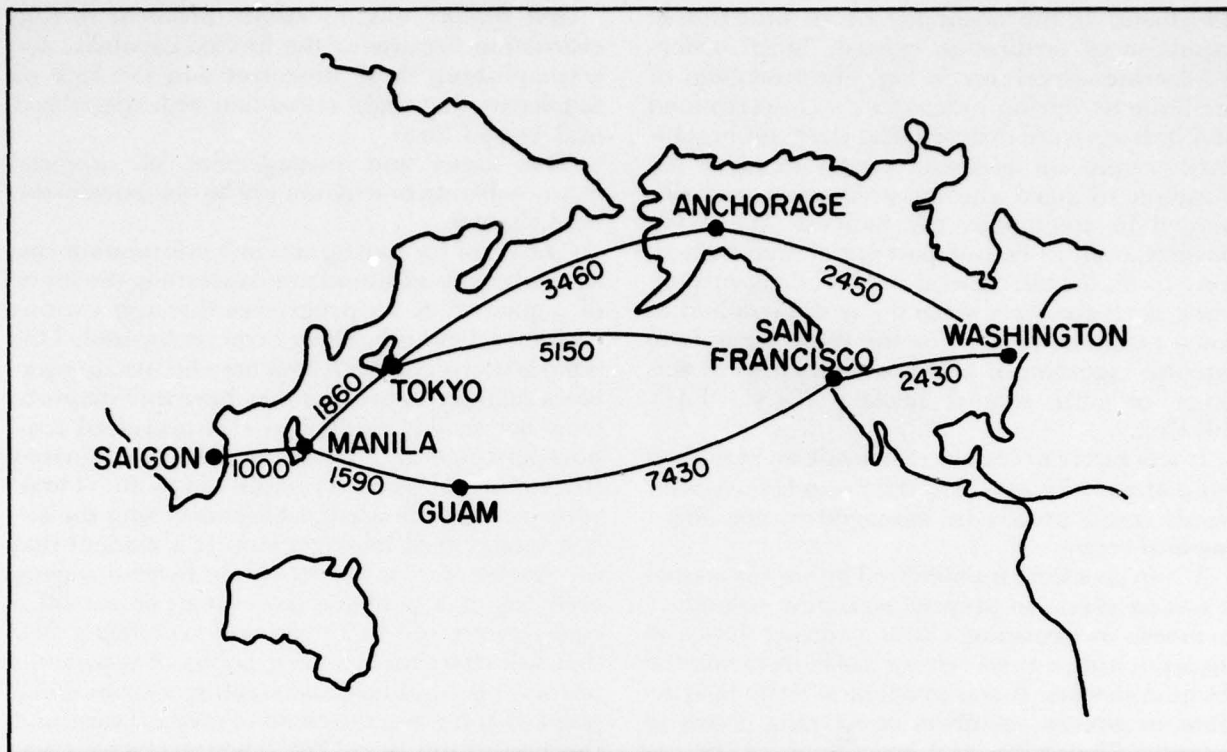


Figure 43.—Routes of aeromedical evacuation from Vietnam through intermediate facilities to CONUS. Air mileage between various points of transfer are listed.

tomy site since the humidity of the aircraft cabin was usually quite low (ca. 10%). Patients were not transferred with endotracheal tubes in place.

*Hypoxemia* during aeromedical evacuation has been shown to develop in injured patients as a result of lowered cabin oxygen tension and recommendations have been made that supplemental oxygen be administered to seriously injured patients during flight to prevent hypoxemia and its potential complications (Henry et al., 1973). The supraglottic airway was physically compromised in patients with maxillofacial injuries treated by intermaxillary fixation without tracheostomy. Podlesch et al. (1975) concluded from studies of patients undergoing extensive maxillofacial surgery that hypoxemia does occur postoperatively but that it can be corrected by an increase in oxygen content in the inspiratory air. Thus it would seem desirable to include supplemental in-flight oxygen in the orders for evacuation of future maxillofacial patients even though they might not be listed in the

seriously injured category.

Transfer of patients with cerebrospinal fluid (CSF) drainage was obviously a neurosurgical decision although aeromedical evacuation was usually discouraged in these cases unless other reasons superseded. As the atmospheric pressure was decreased in the aircraft cabin during flight there was an increase in the CSF egress; it was thought that when the cabin pressure was increased on returning to the ground there was an ingress of fluid and air which carried with it significant elements of contamination.

If *intravenous catheters* were to be required for fluids, they were replaced within 24 hours of evacuation since it was desirable to leave these catheters in place for only a maximum of 48-72 hours.

Medications were ordered by means of the patient's standard evacuation tag, which, although an admittedly imperfect document, was used to give recommended en route treatments and instructions and was an acceptable international



document. If the possibility of an undesirable extension of medication existed, "stop" orders were written clearly on the tag. The availability of medications during evacuation was determined and if drugs were ordered that were not in standard supply, an adequate supply to cover the duration of need during evacuation was dispensed to accompany the patients. Whenever possible oral, in lieu of parenteral medications, were used; for the patients in IMF, drug suspensions were necessary since it was difficult and in some instances dangerous for these patients to attempt ingestion of tablets and capsules at this stage of oral wound healing (CINC PAC, 1971[e]).

It was rarely necessary to provide an attendant for patients with maxillofacial wounds since their needs could usually be managed by the flight medical crew.

When jaws were immobilized by wire or elastics it was necessary to prevent aspiration secondary to emesis by providing either a cutting device or incorporating a quick release mechanism into the fixation devices. It was prudent to write instructions to aircrew members concerning access to intermaxillary wires and positioning of the patient in the event of emesis. Patients were told to assume a *prone position with their head down* over the edge of a bed if they experienced emesis thus helping to prevent gravitational flow of vomitus into the trachea and lungs.

Oral hygiene was a definite problem during evacuation because of the limited capability for accomplishing these measures and the lack of familiarity that flight crews had with specialized oral wound care.

The status and management of orofacial wounds during evacuation will be discussed in the next chapter.

The need for having succinct information easily available to all attendants concerning the status of a patient as he progresses through various medical echelons has long been recognized. This is particularly true with patients who sustain maxillofacial injuries because they have unique problems not readily evident to nonspecialized support personnel and require carefully coordinated treatment that is best accomplished by individuals who are fully knowledgeable concerning the entire spectrum of management. It is evident that the *present evacuation tags*, while helpful during each leg of a patient's movement, *do not tell a complete story* and there is a need to develop a form that will chart the essential points of a patient's history, his condition and treatment from initial point of entry into the chain of medical care, and the final disposition. With contemporary data-processing capabilities, such a form could be used for data analysis in relation to specific problems that have been formally selected and programmed for investigation (White et al., 1971).

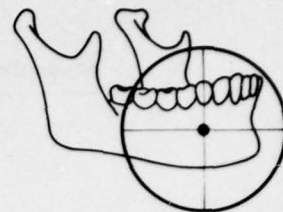
## BIBLIOGRAPHY

- Adams, W. H.: Internal wiring fixation of facial fractures. *Surgery* 12:523, 1942.
- Archer, W. H.: *Oral and Maxillofacial Surgery*, 5th ed. Philadelphia, W. B. Saunders, 1975, pp 1031-1363.
- Arpin, E. J., and Downs, A. R.: Two false aneurysms of the common carotid artery—a delayed complication of cervical trauma. *J Trauma* 15:976, 1975.
- Ashworth, C., Williams, L. F., and Byrne, J. J.: Penetrating wound of the neck. *Am J Surg* 121:387, 1971.
- Awty, M. D., and Banks, P.: Treatment of maxillofacial casualties in the Nigerian Civil War. *Oral Surg* 31:4, 1971.
- Blalock, A.: Experimental shock: The cause of the low blood pressure produced by muscle injury. *Arch Surg* 20:959, 1930.
- Byerly, W. G., and Pendse, P. D.: War surgery in a forward surgical hospital in Vietnam: A continuing report. *Milit Med* 136:221, 1971.
- Carey, L. C., Lowery, B. D., and Gloutier, C. T.: Hemorrhagic shock. *Curr Probl Surg* 1:3-48, 1971.
- Chippis, J. E., Canham, R. G., and Makel, H. D.: Intermediate treatment of maxillofacial injuries. *US Armed Forces Med J* 4:951, 1953.
- CINC PAC—Commander in Chief Pacific (US): *Fifth Conference on War Surgery*, Department of Defense, April 1971 [a] pp 281-290, [b] pp 8-11, [c] p 59, [d] p 28, and [e] pp 1-7.
- Collins, J. A., Simmons, R. L., James, P. M., Bredenberg, C. E., Anderson, R. W., and Heisterkamp, C. A., III.: The acid-base status of seriously wounded combat casualties: I. Before treatment. *Ann Surg* 171:595, 1970.
- Converse, J. M.: *Surgical Treatment of Facial Injuries*, 3rd ed. Baltimore, Williams & Wilkins, 1974, [a] pp 132-353, [b] pp 337-353, [c] pp 92-96, [d] pp 307-336, [e] pp 337-353, [f] pp 59-85, [g] pp 115-120, and [h] pp 1252-1254.
- Converse, J. M., and Smith, B.: Naso-orbital fractures. *Trans Am Acad Ophthalmol Otolaryngol* 67:622, 1963.
- Curtin, J. W.: Basic plastic surgical techniques in repair of facial lacerations. *Surg Clin North Am* 53:33, 1973.
- Dimond, F. C., Jr., and Rich, N. M.: M-16 rifle wounds in Vietnam. *J Trauma* 7:619, 1967.
- Dingman, R. O., and Natvig, P.: *Surgery of Facial Fractures*. Philadelphia, W. B. Saunders, 1964, pp 261-266.
- Dorland's Illustrated Medical Dictionary*, 25th ed. Philadelphia, W. B. Saunders, 1974, p 182.

- Dudley, H. A. F.: Some aspects of modern battle surgery. The Vietnam experience. *J Royal Coll Surg (Edinb)* 18: 67, 1973.
- Dziemian, A. J., and Herget, C. M.: Physical aspects of primary contamination of bullet wounds. *Milit Surg* 106:294, 1950.
- Fitchett, V. H., Pomerantz, M., Butsch, D. W., and Eiseman B.: Penetrating wounds of the neck: A military and civilian experience. *Arch Surg (Chicago)* 99:307, 1969.
- Fleet, J. D.: The dental officers role in a disaster situation. *Int Rev Army, Navy and Air Force Ser* 48:357, 1975.
- Gelin, L. E., and Border, J. R.: Shock-rheology and oxygen transport. *J Trauma* 10:1078, 1970.
- Gilbert, D. N., Moore, W. L., Jr., Hedberg, C. L., and Sanford, J. P.: Potential medical problems in personnel returning from Vietnam. *Ann Intern Med* 68:662, 1968.
- Green, V. A., Carlson, H. C., Briggs, R. L., and Stewart, J. L.: A comparison of the efficacy of pulsed mechanical lavage with that of rubber-bulb syringe irrigation in removal of debris from avulsive wounds. *Oral Surg* 32:158, 1971.
- Gross, A.: The effect of pulsating water jet lavage on experimental contaminated wounds. *J Oral Surg* 29:187, 1971.
- Gross, A.: The effect of antiseptic agents and pulsating jet lavage on contaminated wounds. *Milit Med* 137:145, 1972.
- Guralnick, W. C.: *Textbook of Oral Surgery*. Boston, Little and Brown, 1968, pp 227-284.
- Hagan, E. H., and Huelke, D. F.: An analysis of 319 case reports of mandibular fractures. *J Oral Surg* 19:93, 1961.
- Henry, J. N., Krenis, L. J., and Cutting, R. T.: Hypoxemia during aeromedical evacuation. *Surg Gynecol Obstet* 136:49, 1973.
- Huelke, D. F., Burdi, A. R., and Eymann, C. E.: Association between mandibular fractures and site of trauma, dentition and age. *J Oral Surg* 20:478, 1962.
- Jones, R. F., Terrell, J. C., and Salyer, K. E.: Penetrating wounds of the neck: An analysis of 274 cases. *J Trauma* 7:228, 1967.
- Kjellgren, G. L. M.: The practical range of small arms. *J Natl Rifle Assoc Am* 118:40, 1970.
- Knight, J. S., and North, J. F.: The classification of malar fractures: An analysis of displacement as a guide of treatment. *Br J Plast Surg* 13:325, 1961.
- Knight, R. J.: Reception and resuscitation of casualties in South Vietnam. *Lancet* 2:29, 1972.
- Knight, R. J.: Resuscitation of battle casualties in South Vietnam: Experiences at the First Australian Field Hospital. *Resuscitation* 2:17, 1973.
- Kovacic, J. J., Matsumoto, T., Dobek, A. S., and Hamit, H. F.: Bacterial flora of one hundred and twelve combat wounds. *Milit Med* 133:622, 1968.
- Krizek, T. J., and Robson, M. C.: Evolution of quantitative bacteriology in wound management. *Am J Surg* 130:579, 1975.
- Kruger, G. O.: *Textbook of Oral Surgery*, 3rd ed. St. Louis, Mosby, 1968, [a] pp 296-368, [b] pp 266-288, and [c] p 287.
- Lehr, H. B.: Outside the ivory tower: Airway management between accident and hospital (editorial). *J Trauma* 12:736, 1972.
- Lewin, W.: Cerebrospinal fluid rhinorrhoea in closed head injuries. *Br J Surg* 42:1, 1954.
- Lilly, G. E., and Kelly, J. F.: Unpublished data.
- Lowery, B. D., Cloutier, C. T., and Carey, L. C.: Electrolyte solutions in resuscitation in human hemorrhagic shock. *Surg Gynecol Obstet* 133:273, 1971.
- McClean, L. D.: *The Patient in Shock. Manual of Preoperative and Postoperative Care: American College of Surgeons*. Philadelphia, W. B. Saunders, 1971, pp 211-232.
- McInnis, W. D., Cruz, A. B., and Aust, J. B.: Penetrating injuries to the neck. *Am J Surg* 130:416, 1975.
- McKelvey, L. E.: *Maxillofacial injuries. In Emergencies in Dental Practice: Prevention and Treatment* (McCarthy, F. M., ed.). Philadelphia, W. B. Saunders, 1972, pp 369-374.
- Madden, J. W., and Peacock, E. E.: Studies on the biology of collagen during wound healing. *Ann Surg* 174:511, 1971.
- Matsumoto, T., Wyte, S. R., Moseley, R. V., Hawley, R. J., and Lackey, G. R.: Combat surgery in communication zone. I. War wound and bacteriology. *Milit Med* 134:655, 1969.
- Moss, G. S.: An argument in favor of electrolyte solution for early resuscitation. *Surg Clin North Am* 52:3, 1972.
- NATO Handbook. *Emergency War Surgery* (US Revision). Washington, D. C., US Govt Print Off, 1975, [a] pp 281-290, [b] pp 120-121, [c] p 126, and [d] p 270.
- Neel, S.: Army aeromedical evacuation procedures in Vietnam. *JAMA* 204:309, 1968.
- Neel, S.: Helicopter improved Viet care. *US Med* 11:14, 1975.
- Nunn, J. F., and Freeman, J.: Problems of oxygenation and oxygen transport during haemorrhage. *Anesthesia* 19:206, 1964.
- Osbon, D. B.: Early treatment of soft tissue injuries of the face. *J Oral Surg* 27:480, 1969.
- Osbon, D. B.: Facial trauma. *In Current Advances in Oral Surgery* (Irby, W. B., ed.), St. Louis, Mosby, 1974, pp 214-241.
- Peacock, E. E.: Wound healing and care of the wound. *In Manual of Preoperative and Postoperative Care* (Kinney, J. M., Egdaahl, R. H., and Zuidema, G. D., eds.). Philadelphia, W. B. Saunders, 1971, [a] p 6, and [b] p 15.
- Podlesch, I., Reil, B., and Kind, J.: Blood gases, acid-base balance and serum electrolytes following extensive maxillofacial surgery. *J Maxillofac Surg* 3:50, 1975.
- Randall, H. T.: Surgical nutrition: Parenteral and oral. *In Manual of Preoperative and Postoperative Care* (Kinney, J. M., Egdaahl, R. H., and Zuidema, G. D., eds.). Philadelphia, W. B. Saunders, 1971, pp 75-108.
- Rich, N. M.: Personal communication, 1976.
- Rich, N. M., and Johnson, E. V.: Wounding power of missiles used in the Republic of Vietnam. *JAMA* 199:157, 1967.
- Richards, D. W.: Circulation in traumatic shock in man. *Harvey Lect* 39:217, 1944.
- Robson, M. C., Krizek, T. J., and Heggors, J. P.: Biology of surgical infection. *Curr Probl Surg* 3:1-62, 1973.
- Rowe, N. L., and Killey, H. C.: *Fractures of the Facial Skeleton*, 2nd ed. Baltimore, Williams and Wilkins Co., 1970, [a] p 468, [b] pp 35-37, [c] pp 25-31, 345-55, [d] pp 270-75, [e] pp 22-23, [f] pp 227-232, [g] pp 366-424, [h] pp 251-275, [i] pp 408-424, [j] pp 658-668, and [k] pp 669-685.
- Salem, J. E.: Intubation of conscious patients with combat wounds of upper respiratory passage way in Vietnam. *Oral Surg* 24:701, 1967.
- Salem, J. E., Lilly, G. E., Cutcher, J. L., and Steiner, M.: Analysis of 523 mandibular fractures. *Oral Surg* 26:390, 1968.
- Schmidt, W. H., Loizeaux, A. D., and Kramer, H. S.: The management of missile wounds of the face. *Oral Surg* 27:548, 1969.
- Shelton, D. W., and Albright, C. R.: Study in wound ballistics. *J Oral Surg* 25:341, 1967.
- Shira, R. B.: *Surgical emergencies. In Emergencies in Dental Practice: Prevention and Treatment* (McCarthy, F. M., ed.). Philadelphia, W. B. Saunders, 1972, p. 345.
- Shires, G. T. (ed.): *Care of the Trauma Patient*. New York, McGraw-Hill, 1966, [a] p 4 and [b] p 19.
- Shires, G. T.: *Fluid and electrolyte therapy. In Manual of Preoperative and Postoperative Care* (Kinney, J. M., Egdaahl, R. H., and Zuidema, G. D., eds.). Philadelphia, W. B. Saunders, 1971, pp 42-74.
- Sicher, H.: *Oral Anatomy*. St. Louis, Mosby, 1952, pp 468-75.
- Small, E. W.: Inside-out and bottom-up: The management of maxillofacial trauma patients. *Milit Med* 36:533, 1970.
- Stewart, J. F., Carlson, H. C., Briggs, R. L., and Green, V. A.: The bacteria-removal efficiency of mechanical lavage and rubber-bulb syringe irrigation in contaminated avulsive wounds. *Oral Surg* 31:842, 1971.
- Stump, T. E.: Maxillo-facial care for Vietnamese patients on USS Sanctuary. *US Navy Med* 57:23, 1971.
- Swan, H. J. C.: The role of hemodynamic monitoring in the management of the critically ill. *Crit Care Med* 3:83, 1975.
- Swan, H., and Ganz, W.: Use of balloon flotation catheters in critically ill patients. *Surg Clin North Am* 55:501, 1975.

- Terry, B. C.: Facial injuries in military combat: Definitive care. *J Oral Surg* 27:551, 1969.
- Thoma, K. H.: *Oral Surgery*. St. Louis, Mosby, 1969, pp 479-483, 525-530.
- Thompson, G. E.: Anesthesia for battle casualties in Vietnam. *JAMA* 201:215, 1967.
- Tilson, H. B., McFee, A. S., and Soudah, H. P.: *The Maxillo-Facial Works of Rene Le Fort*. Houston, University of Texas, 1972.
- Tinder, L. E., Osbon, D. B., Lilly, G. E., Salem, J. E., and Cutcher, J. L.: Maxillofacial injuries in the Vietnam conflict. *Milit Med* 134:668, 1969.
- Waite, D. E.: *Textbook of Practical Oral Surgery*. Philadelphia, Lea & Febiger, 1972, pp 410-430.
- White, M. S.: Medical aspects of air evacuation of casualties from Southeast Asia. *Aerosp Med* 39:1338, 1968.
- White, M. S., Chubb, R. M., Rossing, R. G., and Murphy J. E.: Results of early aeromedical evacuation of Vietnam casualties. *Aerosp Med* 42:780, 1971.
- Wilson, T. H., Jr.: *Advances in the Treatment of War Wounds*. Surgery Annual. New York, Appleton-Century-Crofts, 1970, pp 223-238.





## Care at Intermediate Facilities

By W. ROBERT HIATT  
EUGENE J. MESSER  
JAMES F. KELLY

### INTRODUCTION

The mean interval of patient care at intermediate phase facilities for MFCS patients was 17.42 days though this interval was occasionally prolonged (see Table 2, Chapter II). *In discussing intermediate care we are actually referring to patient management at the intermediate facilities within the military echelon structure rather than any specific type of treatment.* During this interval, sutures, packs, and drains were removed, antibiotic coverage was evaluated, and fixation was adjusted, replaced, or removed. Ideally, this period of convalescence was characterized by gradual increase in strength, satisfactory wound healing, and psychologic as well as physiologic acceptance of the injury. Unfortunately, this optimum postinjury situation was not routinely observed since these combat injuries were complicated by a multiplicity of problems that were often unique, frequently bizarre, but always required careful early diagnostic evaluation, intensive therapy, and close observation.

Numerous factors had affected the achievement of ideal treatment results under the circumstances of early management and therefore surgeons at the intermediate facilities became responsible for more than just maintenance of ideally treated patients. It was not uncommon to receive casualties at a hospital over 2,000 miles from the combat zone 48 hours post injury with wounds that, because of the tempo of war, had been expeditiously managed and required extensive treatment. Even as late as 10 days following injury, the condition of the combat casualty often

remained equivocal in contrast to the civilian trauma patient who might be considered for discharge at this time. Additionally, necessary logistic considerations associated with evacuation occasionally created circumstances that contributed to the development of wound complications. Thus surgeons in the intermediate facilities were prepared to manage a variety of complications and to provide, when necessary, secondary definitive treatment.

The logistics of the evacuation procedure actually predicated the need for a distinct intermediate phase of treatment. Three groups of patients could be identified in the evacuee population. The *first group* had sustained extensive injuries for which they had received satisfactory early care, and were in good condition when they arrived at the intermediate facility. These patients were not considered for return to duty because they required late management and were transferred to CONUS as soon as possible. The *second group* consisted of patients in whom complications to early care had developed or were developing and temporary retention at the intermediate facility was required for diagnostic evaluation and/or treatment before transfer to CONUS. This group will receive the major attention in this chapter. The *third group* had received satisfactory early care for injuries that would be expected to heal within 60 days. These patients were retained for convalescent care and then returned to duty within this time frame.

## RATIONALE OF MANAGEMENT

Patients arrived at the intermediate facilities at virtually any time of day or night. At Guam, a logistic pattern evolved wherein the patients were received in the late afternoon. Although the time of arrival and specific logistics for Guam are not typical of all intermediate facilities, this experience will be described since it is considered sufficiently representative of the general principles of casualty reception and management at such hospitals.

A special van was used to transport patients from the airport. Prior to arrival of the transfer van at the hospital, all specialists had been alerted and were available for consultation before the patients were received. All patients were taken to one ward and evaluated by an experienced triage officer who then referred cases to the appropriate specialists. The *triage officer*, usually a general surgeon, *assigned patients on the basis of the specialty that would be responsible for primary care of the principal injury*. In many instances the maxillofacial injury superseded other injuries or conditions such as uncomplicated fractures, lacerations, or malaria, and the patient was admitted to the maxillofacial service with the understanding that the maxillofacial surgeon would seek consultation as required. At the time of reception on the air evacuation ward, decisions were made concerning isolation, intensive care, or immediate surgery. Initial patient evaluation or screening

included a search for occult injury, impending medical or surgical complications, and evaluation of the mental status of the patient. All decisions concerning management made at this time were subject to modification since additional information was frequently obtained during subsequent workups that had been accomplished less expeditiously and thus more comprehensively. It was necessary for the attending surgeon to be decisive yet flexible in his approach to patient management. Transfer to a specific ward from the air evacuation ward did not occur until the following day unless immediate surgery was required. In these cases the patients went to the operating room and then to the ward of the parent service. Occasionally patients were placed directly on the next day's air evacuation flight for transfer to a CONUS facility.

Understanding the status of the patient relative to his future treatment needs was of utmost importance when therapy was administered during this phase of casualty care. Major modifications in management were instituted only if initial efforts were obviously unsuccessful. In summary, the *principal goal of activities during the intermediate phase was to accomplish treatment in coordination with early and late care* rather than to establish and implement an independent program of definitive management.

## PROTOCOL OF MANAGEMENT

### HISTORY OF INJURY

Of utmost importance during treatment of maxillofacial wounds at intermediate phase facilities was *knowledge of the history of wounding, wound management, and posttreatment patient progress*. It was not uncommon for these patients to have been treated by a variety of doctors, nurses and corpsmen at several different facilities. The medical record was viewed as the single most important source of information concerning the progress of the patient but, unfortunately, consistent records were not always available at the in-

termediate facility because of the complexities of the evacuation process. Without adequate records unique means of transmitting information from early to intermediate surgeons were commonly employed. These included special notes on air evacuation tags as well as handwritten messages delivered by medical personnel or even the patients themselves. As much information as possible was obtained concerning the patient by whatever means available, only then could the intermediate surgeon proceed intelligently with his diagnostic evaluation.



## CLINICAL EVALUATION

An immediate impression of the patient's general condition was formulated from vital signs, information from flight attendants, and the patient's general appearance. Although airway obstruction, hemorrhage, and impending or continuing shock were usually under control, they were nonetheless uppermost in the mind of the attending clinician.

### Airway

Acute airway problems were seldom seen at this time, but many patients had tracheostomies (see Table 10, Chapter IV) that required careful management because of the serious and even fatal complications that could result. We do not have data on *complications of tracheostomy* in Vietnam casualties, but some idea of the nature and incidence of such problems can be appreciated from a report of Stemmer et al. (1976). They reviewed the fatal complications of tracheostomy in a general care Veterans Administration hospital over a 20-year period and found that hemorrhage, infection, airway obstruction, and cardiopulmonary collapse were among the most common causes of death attributable to the procedure. Chew and Cantrell (1972) reviewed reports of 1,928 tracheostomies, which included 100 at their own Naval facility. The overall complication rate was 15.8%, and the most frequent complications were similar to those that Stemmer et al. had reported as commonly associated with tracheostomy fatalities. Tube displacement was noted as a most striking direct complication, and in those patients where this occurred there was a 25% mortality rate. Skaggs (1969) observed that the rate of complications with emergency tracheostomy was 2–5 times higher than with elective procedures.

Because of the potential morbidity and mortality associated with tracheostomies special *precautions against complications* were taken at the intermediate care facilities. Obviously, the position and security of the tube were carefully monitored at all times, particularly at the intervals designated for tracheostomy care. To obviate obstruction and reduce infection, careful aseptic toilet of the tube and orifice, along with cultures, was routinely performed.

Diagnostic dilemmas did arise concerning cultures and infections in the tracheobronchial tree, i.e., the need to treat vigorously with antibiotics or continue only local care with appropriate hygiene and irrigations.

Pulsation of the tube, the presence of blood-tinged mucus, or persistent bleeding about the tracheostomy orifice were noted as possible signs of impending major vessel hemorrhage. Blood gas monitoring was instituted in those patients who were not completely stabilized following their injuries. Expert nursing care was essential for the patient with a tracheostomy and this could only be assured by the surgeon writing specific orders to include all aspects of tracheostomy care.

The decision to maintain or discontinue the tracheostomy was based on many factors including the need for additional, sequential surgical treatment as well as the timing and type of air evacuation. In most instances tracheostomies were not removed until the patient reached his final CONUS destination and/or impending surgical treatment requiring general anesthesia was completed.

### Wound Evaluation

Soon after admission to the intermediate facility dressings were removed and wounds inspected. When there was no sign of infection in wounds that had been debrided and sutured, simple cleaning of the surface and redressing were indicated. When drains were present they were advanced or removed. The microbiologic status of infected wounds was evaluated by culture and sensitivity (C&S) methods to determine the specific etiology of infection. Antibiotic therapy included both local and systemic administration of agents selected on the basis of C&S studies, if available. A myriad of antimicrobial agents were available each with individualized dosage schedules. In the absence of sensitivity testing, or while awaiting results of C&S studies the selection of the proper agent and dose was problematic. Table 11, Chapter IV, lists the suggested choices of antimicrobial agents for use against the various types of microorganisms, whereas Table 13, Chapter IV, lists the dosages and routes of administration for the different agents.

According to Matsumoto et al. (1969), the or-



TABLE 15.—Review of 1,531 Initial Wound Cultures,  
at an Intermediate Facility  
(1 January 1967 to 31 March 1968)\*

Microorganism	Total number	Percentage of total initial culture	Percentage of total positive initial culture
<i>Staphylococcus aureus</i>	387	25.3	29.2
<i>S. epidermidis</i>	64	3.1	4.8
<i>Pseudomonas aeruginosa</i>	243	15.9	18.3
<i>Proteus</i> species	84	5.5	6.3
<i>Escherichia coli</i>	230	15.0	17.3
<i>Aerobacter aerogenes</i>	73	4.8	5.5
<i>Klebsiella pneumoniae</i>	17	1.1	1.3
<i>S. aureus</i> + <i>P. aeruginosa</i>	76	4.9	5.7
<i>S. aureus</i> + <i>A. aerogenes</i>	42	2.7	3.2
<i>P. aeruginosa</i> + <i>E. coli</i>	43	2.8	3.2
No Growth	204	13.3	
Others	64	4.5	4.8

\*Matsumoto, T., et al.: Combat surgery in communication zone I. War wound and bacteriology (Preliminary report). Milit Med 134(9):655-65, 1969.

ganisms most frequently isolated from wounds at an intermediate phase facility were *Staphylococcus aureus* (29.2%), *Pseudomonas aeruginosa* (18.3%), and *Escherichia coli* (17.3%) (Table 15). At these facilities they found penicillin and ampicillin to be ineffective against the microorganisms cultured, whereas streptomycin-resistant organisms were cultured from 50% of the patients. *P. aeruginosa* was sensitive to neomycin, colistin, and mandelamine upon initial and repeated cultures. *E. coli* was sensitive to colistin, cephalothin, nalidixic acid, and nitrofurantoin. Methicillin, chloramphenicol, cephalothin, cloxacillin, and vancomycin were all effective against *S. aureus* on the initial and repeated cultures.

Heggers et al. (1969) obtained aerobic and anaerobic cultures from biopsy specimens of wounds in war casualty patients when they arrived at a CONUS facility from Vietnam. Of the tissue specimens cultured, 92% grew at least a single bacterial species and, in 8%, more than one species were isolated. Table 16 lists data from their study concerning the frequency distribution of bacterial species in the culture and tissue biopsy homogenates. *P. aeruginosa* (46.9%), and *S. aureus* (19.6%) were the most commonly identified organisms. Gram-negative rods were cultured from 75% of the homogenates as opposed with 25% gram-positive cocci. Thus, late or chronic wound infections in Vietnam patients were more likely from enteric gram-negative bacteria than from gram-positive species.

TABLE 16.—Bacterial Species Isolated in Pure Culture  
From Tissue Biopsy Homogenates\*

Species	Numbers	% Pure isolates
<i>Pseudomonas aeruginosa</i>	43	46.9
<i>Staphylococcus aureus</i>	18	19.6
<i>Proteus</i> species	12	13.0
<i>Klebsiella</i> Enterobacter group	11	11.9
<i>S. pyogenes</i>	5	5.4
<i>Escherichia coli</i>	3	3.2
Total	92	100

\*Heggers, J.P., et al.: Microbial flora of orthopaedic war wounds. Milit Med 134(8):602-3, 1969.

Complicating the problem of infection was the enemy's practice of fabricating homemade explosive devices with a variety of materials that even after wound debridement elicited foreign-body response; these included nails, rubber, wood, stones, leather, and plastic. As mentioned in the early care chapter (p. 70), fecal contamination was rather common and, in fact, the wounding agents were reportedly contaminated with human or animal excreta that further magnified the potential for infection. As a result of these unusual complicating agents, wounds did not uniformly respond to conventional therapy.

#### Additional Considerations

The adequacy of arch bars or other fixation

devices that were attached to the remaining dentition was determined with the understanding that for effective treatment these devices must be stable and not detrimental to the teeth, soft tissues, or investing bone. Splints, if present, were evaluated for appropriateness, cleanliness and utility.

The functional *integrity of all cranial nerves* was determined and, if neurologic abnormalities were observed, necessary consultations (i.e., ophthalmology, neurosurgery, etc.) were obtained.

Swelling in the area of the *major salivary glands* was carefully evaluated. Lacerations of the major salivary glands and/or ducts can result in collection of interstitial saliva with considerable distress to the patient. The differential diagnosis included, in addition to salivary gland injury, edema, hematoma, infection, and aneurysm. Most injuries to the parotid gland healed spontaneously if the major collecting ductal structures were intact. This matter will be discussed in more detail in the late care chapter.

Finally, *arteriovenous fistulas* were occasionally seen and therefore auscultation was included, especially over the great vessels of the neck. Post-traumatic A-V fistulas may be late in developing and it was necessary to be alert to this possibility throughout all phases of management (Arpin and Downs, 1975).

## RADIOGRAPHIC EVALUATION

Panoramic films were obtained on all ambulatory patients if this capability existed. In patients who were unable to be positioned for panoramic examination, a limited number of appropriate facial bone films were obtained. In patients with midfacial injuries the standard *Waters projection* (upright, if possible) was an excellent screening, as well as diagnostic view, since the entire facial skeleton was well visualized in this projection. For lower face injuries standard views included in the "mandible series" were obtained. The need for additional specialized views was determined by clinical evaluation and a study of all current as well as any previous films that accompanied the patient. *Laminagrams* could be obtained in any projection and were occasionally required, but the need for these views was the exception rather than the rule and was predicated on inability to obtain necessary information

by more conventional techniques.

The diagnosis of a mandibular or maxillary fracture was seldom an incidental finding on radiographic examination. These examinations were used to confirm clinical impressions, determine the extent of osseous damage, and guide the course of treatment rather than as primary diagnostic tools. There were times, however, when serendipitous information was obtained and the need for appropriate radiographs was thus reinforced.

If there was a normal PA and lateral *chest radiograph* in the patient's jacket from a previous facility and there was no clinical or historical evidence to suspect change, it was the practice not to repeat this study. In general, the number of radiographic examinations was limited and based on specific indications.

## LABORATORY EXAMINATION

Admission laboratory examinations at the intermediate facilities were essentially no different than at other secondary hospitals. Admission studies included CBC, differential, hematocrit, hemoglobin, and VDRL. Sequential multiple analyzer (SMA) examinations were not generally available at this time, but they have subsequently replaced piecemeal testing and should be used when available. Routine urinalysis was ordinarily adequate and if other abnormalities were seen, especially the presence of red blood cells, a urologic consultation was obtained. Abnormally high urine-specific gravity was not uncommon because many of these patients were hypovolemic as a result of long air evacuation and the tropical environments.

*Blood gas studies* were obtained on patients with tracheostomies (Stemmer et al., 1976) and/or with intermaxillary fixation if there was evidence of compromised respiratory exchange.

A *stool sample* for ova and parasites was required by hospital instruction because of the high incidence of intestinal parasitic disease in the South East Asian theater (Gilbert et al., 1968).

In the multiply injured patient consultants were frequently required. In such cases it was best to allow the consulting specialist to indicate which additional laboratory studies he would require rather than to anticipate his needs by an order for a battery of seemingly indicated tests. With the



advent of SMA, a wider variety of laboratory data was routinely available.

## SECONDARY TREATMENT OF MAXILLOFACIAL INJURIES

### Skeletal Fracture

Fracture treatment at the early facilities was usually by intermaxillary fixation (IMF) methods and was aimed at obtaining a reasonable reduction and establishing the patient's occlusion in what most closely approximated the preinjury relationship. In a small percentage of MFCS patients it had been possible to provide only temporary reduction and immobilization and the intermediate surgeon was required to accomplish *secondary reduction and fixation*. Open mandibular reduction was accomplished in 7.45% of patients and closed reduction was performed in 5.59%. Secondary reduction of midfacial fractures was even less common—open (1.86%) and closed (3.11%) (Table 17).

TABLE 17.—Incidence of Fracture Reduction Performed at the Intermediate Care Facility for Patients in the MFCS

Groups	Mandibular Reduction		Midfacial Reduction	
	Open	Closed	Open	Closed
I (N=84)	6[7.14]*	8[9.52]	0[00.00]	4[4.76]
II (N=32)	1[3.13]	1[3.13]	2[6.25]	1[3.13]
III (N=20)	1[5.00]	0[00.00]	0[00.00]	0[00.00]
IV (N=25)	4[16.00]	0[00.00]	1[4.00]	0[00.00]
Total (N=161)	12[7.45]	9[5.59]	3[1.86]	5[3.11]

\*Figures in brackets equal percentage of N.

In those cases where there was *severe comminution or avulsive osseous injury*, the objective of treatment was to immobilize the remaining fragments in close anatomic position during healing. If this was done in areas of comminution, consolidation occurred and the patient was left with near normal form and function. In instances of avulsion, where full-thickness discontinuity existed, an attempt was made to at least correctly align the residual fragments for later bone grafting procedures. Bone grafting concepts will be discussed in the chapter on late care.

Various methods were used to immobilize the osseous fragments including arch bars, wire fixation, splints, and external skeletal-pin fixation. No one method was exclusively employed be-

cause unique situations dictated the appropriate techniques for the particular surgical situation (see Case reports).

**Splints.** In some patients with loss of bony continuity, IMF utilizing remaining teeth was not always possible and intraoral acrylic splints were used as satisfactory adjuncts to treatment. In spite of edema, secretions, etc., it was possible to obtain fairly accurate impressions by modifying the impression procedure. Initial impressions were sometimes used only as a matrix to construct a tray for the final impression. Accuracy was of relative importance since it was often necessary to modify or section casts because of arch displacement. In addition, uniform precise tissue adaptation was not required since the tissues were expected to undergo changes in character and contour during the progress of healing.

Because of the variable and unique anatomy that was present after injury, it was necessary to be innovative in splint construction while at the same time following prosthodontic principles. Future prosthodontic considerations as well as immediate treatment needs were incorporated in the planning of these temporary prostheses, i.e., maintenance of intermaxillary space, creation of spaces for feeding, and airway and incorporation of fixation attachments such as arch bars. Appropriate circumferential wiring (i.e., mandibular, peralveolar) was used for stability in addition to circumdental ligation. There was concern for tissues underlying these splints, and it was necessary to assure that splints were properly relieved and that meticulous oral hygiene was maintained. The basic function of splints at this interval was to *passively stabilize bony fragments and not to serve as active reduction devices* in which case they invariably caused ulceration regardless of the adequacy of relief and hygiene.

In those patients with oroantral communication *maxillary obturator splints* were constructed after the primary wounds had healed sufficiently to effect a transition from packing to obturation.

**External Skeletal Fixation.** Unfixed edentulous fragments usually could be maintained in reasonable position during the first several days post injury as a consequence of the splinting action of the tissues resulting from pain and edema. During this time the patients arrived at the intermediate or late care facilities and, in the absence of gross wound infection or local infection at sites of anticipated pin placement, it was then possible



to apply skeletal fixation when indicated. Under the logistic conditions in which these patients were managed, it was best to apply this type of fixation at the late care facilities unless the patient was to be under observation at the intermediate hospital for a relatively long period (Case reports 10 and 16). More specific comments concerning the application of external skeletal fixation will be presented in the bone graft reconstruction section of the late care chapter.

*Craniofacial head frame fixation* of midfacial skeletal injuries was seldom utilized. However, when extensive fractures occurred in this region, head frame fixation was a useful method and was probably best applied at this interval. The principles of this type of fixation were the same as those applied in nonbattle injury.

**Operative Treatment—open reduction, debridement.** In cases of badly comminuted fractures, treatment was continued by closed methods if at all possible. If *secondary extraoral open reduction* procedures were necessary to reduce and fix major fragments, they were not undertaken until infection was under control. *Intraoral open reduction*, while somewhat difficult at this postinjury interval as a result of pain, trismus, etc., could be performed under local anesthesia thus lessening the potential for morbidity. The patient's ability to withstand an awake reduction greatly influenced the selection of the type of operative procedure.

As previously mentioned it was *inadvisable to remove all fractured teeth* during early and intermediate intervals because large segments of viable bone were often lost when this was attempted. It was noted that the retention of root fragments did not ordinarily complicate early healing. Patients were carefully observed for signs and symptoms of dentally related infection, and residual, uncomplicated fragments were electively removed several weeks post injury when their removal was less difficult and could be accomplished with greater conservation of bone (p. 73, Chapter IV).

No attempt was made to remove *residual foreign bodies*, such as bullet fragments, unless they were easily accessible or directly associated with infection or functional impairment. Alloplastic implants were placed by some surgeons at the early facilities for maintaining space or effecting reduction of fragments. When this was done *infection* invariably ensued and it was necessary to re-

move most of these implants at the intermediate or late facilities (p. 77, Chapter IV). However, if they were providing a positive adjunct to treatment, they were allowed to remain until such time as they interfered with function or were seriously complicating the healing of bone or soft tissue as a result of infection.

### Soft Tissue

Management of soft tissue wounds was of major importance at intermediate facilities and many unique problems were encountered. When dealing with unsutured wounds it was necessary to perform *delayed primary closure* as soon as it was possible to control sepsis (Chippis et al., 1953; Robson et al., 1973; Krizek and Robson, 1975). Late secondary closure and/or skin grafting was reserved for the more complicated cases.

Eradication of wound infection began with culture of exudates and selection of specific antibiotics as previously described. If there were no systemic signs of infection or cellulitis, antibiotics were sometimes withheld and only local wound care was accomplished. Irrigations and/or *antiseptic soaked packings alone often controlled sepsis* in such wounds very effectively and quite rapidly.

Irrigation was performed with various empirically selected solutions. When dealing with *P. aeruginosa* infection, it was common practice to perform lavage with a weak *acetic acid solution*. It was the opinion of many surgeons that this method of treatment was very effective against the ubiquitous *P. aeruginosa* organisms even in deep wounds. Perhaps the most commonly used antiseptic irrigating solution was *Betadine®*, which was used as an antiseptic for all types of facial and oral wounds even in the absence of overt infection. Another irrigating solution commonly used in oral wounds was *9-aminoacridine*, which was employed as a solution of benzalkonium chloride, water, and the chemical 9-aminoacridine that was easily formulated by a hospital pharmacy. The irrigation protocol of one author included *normal saline* for routine irrigation of contaminated wounds or a *solution of bacitracin, neomycin, and polymyxin in saline* for grossly contaminated, potentially life-threatening infected wounds. Caution should be exercised in the use of local antibiotics since systemic absorption may cause

severe toxic reactions, for example, nephrotoxicity from topical bacitracin or polymyxin B and deafness from neomycin (NATO 1975).

*Normal saline* was an excellent irrigant and was used in very large volumes (several liters), particularly when extensive mechanical flushing was required. *Hydrogen peroxide* ( $H_2O_2$ ) was also used for irrigation, especially when anaerobic organisms were suspected or confirmed or when the wound tissues were relatively avascular. When using  $H_2O_2$  in and about the oral cavity, especially in the presence of IMF or in patients with tracheostomy, the foaming property of peroxide may occasionally produce respiratory complications.

*Betadine® soaked packs* were often employed and were changed as often as four times a day, depending on the condition of the wound. As the wound healed the amount of packing was reduced until a clean granulating surface was present. Once the wound was clean and free of sepsis, it was secondarily closed or covered with a skin graft as indicated. If the granulating surface area was quite small, the wound was covered with a sterile dressing until it epithelialized.

## NONOPERATIVE MANAGEMENT

### Fluid Therapy

Fluid and electrolyte imbalance was common and was usually the result of patients having been transferred over long distances through tropical climates. The deficits observed were not ordinarily severe and were amenable to correction by the administration of fluids that were selected by empirically judging the patient's condition, monitoring input and output, and determining serum electrolyte levels. As a result of their orofacial wounds, these patients frequently were not taking sufficient fluids by mouth during the period of transfer either because of a reluctance on their part or a lack of encouragement by general duty nursing personnel. Assuring adequate oral intake through positive encouragement by all personnel facilitated the correction of fluid imbalance and at the same time helped to reestablish the functional integrity of the injured orofacial tissues.

### Management of Fever

The differential diagnosis of fever was complicated not only by the multiplicity of injuries but also by the potential for patients to have contracted various "fever diseases" endemic to the combat theater. If the elevation of body temperature was over 1 degree and lasted for more than 2 days, then diagnostic studies were undertaken to determine etiology. It is, of course, obvious that fever can result from both *infectious and noninfectious causes*.

**Postoperative.** The differential diagnosis during an immediate postoperative period, that is the first 12 hours, included metabolic or endocrine factors secondary to anesthesia and/or organ system disruption, inadequate tissue perfusion resulting from hypovolemia, or transfusion reactions if blood had been administered. Minor elevations in temperature often responded to antipyretic agents and/or increases in either oral or intravenous fluids, which inferred a noninfectious etiology related to fluid imbalance or minor metabolic alterations. If a general anesthetic had been administered *pulmonary complications* were considered one of the most likely causes of fever. Fevers associated with pulmonary derangements could be of the infectious or noninfectious variety depending upon the extent and complication of the disease process. The patients were carefully examined for tachypnea, tachycardia, rales, and decreased breath sounds indicative of atelectasis, the most common postanesthetic complication. It was desirable to establish an early diagnosis for suspected incipient pulmonary complications and to initiate appropriate pulmonary therapy to preclude the development of bacterial pneumonitis. The possibility of developing pulmonary complications was enhanced by a variety of conditions that existed in these patients such as depression of the cough reflex by narcotics, dyspnea secondary to muscular splinting associated with constricting bandages, aspirated foreign bodies, or pulmonary parenchymal pathology (shock lung) secondary to extensive trauma.

**Phlebitis.** Virtually all these patients had undergone multiple phlebotomies for the administration of intravenous infusions (IV), and as a



result, the potential for developing thrombophlebitis existed. The most common presenting symptom of post IV phlebitis was tenderness along the course of a vein, but fever was occasionally present, subsiding with treatment of the vascular inflammation.

**Genitourinary Tract.** Symptoms of dysuria, chills, increased frequency, and flank or suprapubic pain in conjunction with fever drew attention to genitourinary complications. Low grade urinary-tract infections that existed previous to surgery were occasionally unmasked during the postoperative period. This was especially true if catheterization had been performed or there was prolonged urinary retention and stasis.

**Medical Disease.** The most common diseases and disease categories observed in U.S. Army troops in Vietnam, other than pulmonary and venereal, were malaria, diarrheal diseases, and fever of unknown origin (Gilbert et al., 1968).

Table 18 cites the incidence, timing, and type of concomitant medical disease entities found in MFCS patients. The overall incidence was 16.13%, with a majority of diagnoses being established at the intermediate or late (12.90%) as compared to the early (3.23%) facilities. Of the 30 diagnoses listed, malaria (8), parasitic disease (5), hepatitis (4), and pneumonia (4) were most common.

*Malaria* was viewed as the most important communicable disease in U.S. troops and chemoprophylaxis against malaria was routinely

provided to all personnel in Vietnam because of the endemic nature of the disease. Despite these precautions malaria was a prime consideration in the diagnosis of all fevers. The active disease typically presented with irregular fever, malaise, headache, and chills. Two types of malaria, *Plasmodium vivax* and *P. falciparum* were most commonly encountered in Vietnam returnees. It was important to establish an accurate species diagnosis to select the appropriate therapeutic regimen. Primary *P. vivax* attacks began abruptly with shaking chills, followed by fever and profuse sweating. The initial chill was usually preceded by a short period of malaise or headache. The fever lasted from 1 to 8 hours and after it subsided the patient felt entirely well until the next paroxysm, which in uncomplicated cases usually occurred every 48 hours. *P. falciparum* malaria was associated with shaking chills that were preceded by a chilly sensation. The paroxysms lasted from 20 to 36 hours and were associated with prostration and headache as prominent symptoms. The temperature rose more gradually and tended to fall by lysis rather than crisis. Intervals between paroxysms were exceedingly variable and the patient remained ill and usually ran a low grade fever during these periods. Except in rare instances the species diagnosis was established in blood smear and the patient then remained under medical care with the maxillofacial injuries being managed in consultation.

The etiology of diarrheal disease included the entire spectrum of enteric pathogens including *Salmonella*, *Shigella*, amebiasis, and *Entamoeba histolytica*. Diagnosis was established by medical consultants and medical management followed.

*Acute, undifferentiated febrile disease* was among the most frequent causes of admission among army personnel in Vietnam. A diagnosis of "FUO" was reserved for febrile illnesses that persisted for longer than 3 weeks and in which the diagnosis was uncertain after 1 week of study in the hospital following initial complete history, physical examination, and laboratory studies including malaria smears (Gilbert et al., 1968).

**Initial Rehabilitation.** If the physical condition permitted, early ambulation was encouraged for all maxillofacial patients. It was the opinion of the maxillofacial surgeons that bedridden patients with associated orthopedic injuries or other seri-

TABLE 18.—Incidence, Timing, and Type of Concomitant Medical Diseases that Occurred in Patients Included in the MFCS

A. Incidence and timing			
	Early	Intermediate	Total
N = 186	6[3.23]*	24[12.90]	30[16.13]
B. Type			
Malaria	- 8		
Parasitic diseases	- 5		
Hepatitis	- 4		
Pneumonia	- 4		
Meningitis	- 2		
Urethritis	- 2		
Other	- 5		
	30		

\*Figures in brackets equal percentage of N.



ous disease, in comparison to ambulatory patients had slower recovery from their facial wounds, developed more complications, were reticent in their communication, and tended to be more reluctant to accept their wounds. This simple act of ambulation, of being up and about for a short period no matter how difficult, dramatically changed patient attitude and improved well being. Ambulation produced psychologic benefits as well as physical improvement resulting from enhanced circulation, facilitated ventilatory

exchange, and increased basal metabolic rate. *The will to live and the desire to "get better"* and overcome physical adversity combined with the reality of physical improvement were hallmarks of satisfactory patient convalescence.

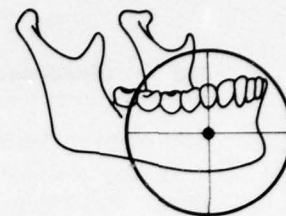
Numerous other factors influenced patient care during the intermediate phase. Those we have discussed were considered most significant and therefore have been emphasized by discussion in this chapter.

## BIBLIOGRAPHY

- Arpin, E. J., and Downs, A. R.: Two false aneurysms of the common carotid artery—a delayed complication of penetrating cervical trauma. *J Trauma* 15:976, 1975.
- Chew, J. Y., and Cantrell, R. W.: Tracheostomy—complications and their management. *Arch Otolaryng* 96:538, 1972.
- Chipps, J. E., Canham, R. G., and Makel, H. D.: Intermediate treatment of maxillofacial injuries. *US Armed Forces Med J* 4:951, 1953.
- Gilbert, D. N., Moore, W. L., Jr., Hedberg, C. L., and Sanford, J. P.: Potential medical problems in personnel returning from Vietnam. *Ann Int Med* 68:662, 1968.
- Heggers, J. P., Barnes, S. T., Robson, M. C., Ristorph, J. D., and Omer, G. E.: Microbial flora of orthopaedic war wounds. *Milit Med* 134:602, 1969.
- Krizek, T. J., and Robson, M. C.: Evolution of quantitative bacteriology in wound management. *Am J Surg* 130:579, 1975.
- Matsumoto, T., Wyte, S. R., Moseley, R. V., Hawley, R. J., and Lackey, G. R.: Combat surgery in communication zone. 1. War wound and bacteriology. *Milit Med* 134:655, 1969.
- NATO Handbook: *Emergency War Surgery* (US Revision). Washington, D.C., US Govt Print Off, 1975, p 126.
- Robson, M. C., Krizek, T. J., and Heggers, J. P.: *Biology of Surgical Infections. Current Problems in Surgery*. Chicago, Yearbook Medical Publishers, 1973.
- Skaggs, J. A.: Tracheostomy: Management, mortality, complications. *Am Surg* 35:393, 1969.
- Stemmer, E. A., Oliver C., Carey, J. P., and Connolly, J. E.: Fatal complications of tracheostomy. *Am J. Surg* 131:288, 1976.

## CHAPTER VI

# Late Care (Reconstruction- Rehabilitation)



By PETER W. CONNOLE  
BILL C. TERRY  
JAMES F. KELLY

## WOUND MANAGEMENT AND SPECIAL PROBLEMS

### INTRODUCTION

The mean interval for admission to the late care facility for all groups in the MFCS was 24.55 days (Table 2, Chapter II). The total length of treatment varied depending on the severity of the injuries. Those few patients who were retained at the intermediate care facilities for longer than the average period had their reconstructive and rehabilitative treatment initiated at those locations. Once at the late care facility, many patients required extensive reconstruction and prolonged rehabilitation for periods longer than 6 months, particularly those included in the MFCS groups I and II (Table 4, Chapter IV). Others required less involved surgical management and were discharged from the hospital within 3-6 months; they were typically those included in group III but a limited number were in groups II and IV. In the remaining patients, management was usually less complicated and their hospital care, which was completed within 3 months, was mainly convalescent. The majority of group IV and V patients were discharged within 3 months.

Most patients were sent to a hospital near their home and at that time entered an even more complex emotional and psychologic period than that already experienced. Up to that time they had survived the initial trauma, resuscitative and surgical care at the early facility, and had been involved in and preoccupied by the transportation to and continued care at the intermediate facilities. When the patients were reunited with relatives and friends, they were immediately con-

fronted with many questions concerning their ultimate recovery and for probably the first time were beginning to seriously consider what impact their wounds would have on their future. It was therefore not unusual to recognize varying degrees of depression during the initial phase of this period. Adjustments were easier, just as in the early and intermediate period, if *casualties with similar problems and injuries were placed in the same hospital area*. This provided them with the opportunity to associate with similarly injured patients whose wounds were in various stages of healing and rehabilitation. They were thus able to observe the therapeutic benefits of treatment and to develop a more optimistic attitude toward their own problems. These relationships and observations relieved some of their initial anxiety and assisted them in accommodating to the reality of their role in the process of orofacial rehabilitation.

### CLINICAL EVALUATION AND TREATMENT OF WOUNDS

The clinical problems encountered in the management of these patients were varied and often uncertain. It has been repeatedly emphasized throughout the text that *there was a need for constant reevaluation of injuries, general medical condition, and response to therapy*. In this section we shall review and discuss problems that were of concern during this later care period other than those specifically associated with bone graft reconstruc-

tion or preprosthetic surgery.

In the previous sections of this book, an attempt has been made to follow a chronologic order of management. However, during the late care period the sequence of management was variable and depended on the condition of the patient at the initiation of late care as well as his progress during hospitalization. For this reason, the following discussion is not as chronologically structured as the preceding sections.

### Airway Assessment and Management

**Tracheostomy.** Patients with tracheostomies were evaluated to determine the need for this method of airway management. Tracheostomy was retained for the following reasons: 1) the necessity to manage problems or complications other than those related to the maxillofacial injuries; 2) the immediate or contemplated need for extensive surgical procedures under general anesthesia such as exploration and debridement for infection control, secondary wound closure or soft tissue grafts, or placement of splints and fixation appliances for alignment and stabilization of fractured bony segments.

When tracheostomies were discontinued, the orifice of the tube was either gradually closed or completely occluded for increasing periods and the patient was closely observed for signs of respiratory distress. If there was any question of respiratory insufficiency, blood gas monitoring was utilized to assist in confirming the clinical impression. Only after it was firmly established that the patient could tolerate the occluded tube was it removed.

**Intubation for Surgery.** Essentially all of these patients were in intermaxillary fixation and presented airway problems for subsequent surgery under general anesthesia. The *nasotracheal route was preferred for intubation* and was usually accomplished as a blind, awake procedure. Although not generally utilized during the Vietnam conflict, fiberoptic visualization systems are now available. Intubation using this aid significantly simplifies the procedure particularly in patients in intermaxillary fixation, with restricted mandibular movements, or with anatomic variations that complicate the usual intubation procedures (Taylor and Towey, 1972; Davis, 1973).

Following surgery the nasotracheal tube was maintained until the patient was stable, respon-

sive, and alert. After the tube was removed placement of a *buccal airway*, as described by Doneker and Hiatt (1966), held the lips apart and allowed additional air exchange through the mouth (Figure 44). This also provided easy access to the oral cavity for removing blood and secretions. This device was usually left in place for 12–24 hours following surgery or until the patient could manage secretions and satisfactorily maintain his own airway.

### Wound Evaluation and Management

**Objectives of Management.** During the late care period the overall objectives of wound evaluation and management were as follows: 1) providing supportive care to promote healing; 2) irradiating infection; 3) identifying conditions where there were compromised function or esthetics; and 4) planning for appropriate rehabilitation. Achieving these objectives was made difficult by the location of wounds, complexity of the tissues involved, and associated functional and esthetic requirements.

There were often both extraoral and intraoral components to the wounds that could involve skin, muscles, mucosa, gingiva, bone, and teeth, as well as other associated specialized structures,

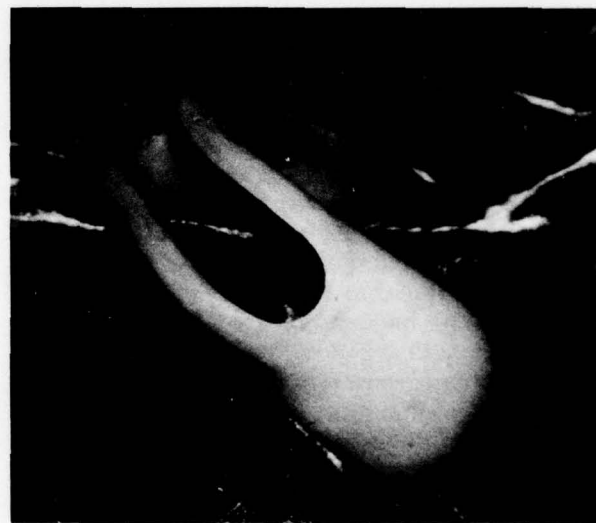


Figure 44.—Buccal airway device that was used to support the lips and cheeks in patients who had undergone jaw surgery and been placed in intermaxillary fixation. This device facilitated maintenance of the upper airway, thus reducing airway complications and often obviating the need for tracheostomy.



such as salivary glands, their excretory ducts, and both motor and sensory nerves. In this section consideration will be given to the most significant management problems. Some that were discussed in the preceding intermediate care chapter will be reviewed in the section on bone graft reconstruction.

**Wound Infection.** The threat of infection existed during all phases of casualty management and the underlying principles of treatment were the same regardless of the interval at which the diagnosis was established. A diagnosis of wound infection was made in 41.98% of MFCS patients. *The greatest number of infection diagnoses (21.60%) was made during the 8- to 21-day postinjury period.* Late care facilities were the locations where the diagnoses were most frequently established (25.93%) (see Table 31). It was the observation of the authors that there seemed to be a higher incidence of wound infection in those patients who, because of the exigencies of battle activity, were transferred directly to a late care facility without intermediate hospital admission. The reason for the higher incidence of infection in such patients was probably related to the following: 1) large numbers of patients of necessity being cared for by fewer personnel under less than ideal situations during the aeromedical evacuation period; 2) delays en route because of unpredictable logistic problems related to mechanical difficulties, inclement weather, etc., which extended the aeromedical evacuation period. In addition, if one or more patients became critically ill during the period of evacuation, they could monopolize the efforts of attending personnel for a considerable period of time while the remainder of the patients necessarily received less attention than they would under less difficult circumstances. These comments are not meant as criticism of the aeromedical evacuation system which performed remarkably in transporting and caring for casualties, but rather as a reflection of the reality of the circumstances of evacuation.

**Extraoral Wounds.** The principles of management for extraoral wounds were essentially no different from those described in the intermediate care chapter. These wounds were readily accessible and could be debrided and kept clean by careful local care. *It must be reemphasized that continued drainage from wounds that did not respond to antibiotic and local conservative care usually reflected an underlying skeletal infection related to devital bone,*

*teeth, or retained foreign matter.* Successful therapy included elimination of the contributing factors by appropriate surgical intervention.

The optimal time for delayed primary wound closure had passed by the time patients entered the late phase and for this reason was rarely accomplished at this interval. Wounds that were granulating were selectively covered by skin grafts once they were free of infection. In the MFCS patients skin grafts constituted 19.09% of the secondary soft tissue procedures that were performed (see Table 33). In most instances the skin grafts were used to cover raw surfaces and were subsequently revised.

**Intraoral Wounds.** The management of intraoral wounds was more complicated because of: 1) limited access; 2) exposed bone, damaged teeth, or root fragments; 3) accumulation of debris around the fixation devices, remaining teeth, and in the wound bed itself. Debridement of devitalized tissue was accomplished to encourage and maintain healing. If the wound was not managed properly, adjacent healthy tissues were jeopardized because they became involved in the necrotic process and were severely damaged and/or lost. In those instances where this happened a greater tissue defect resulted and in some instances discontinuity actually resulted from uncontrolled osseous infection.

The oral hygiene regimen used to maintain wound cleanliness included: 1) irrigation and mechanical suction after each feeding; 2) cleansing the remaining teeth and fixation devices with a small child-size toothbrush at least 3 times daily (patients were encouraged to do this themselves as soon as they were physically able); 3) irrigation of the wound bed and/or exposed bone with an antiseptic solution at least daily or more often if purulent exudation was present. Covering the soft tissue bed and/or bone with a petrolatum gauze dressing, which was changed periodically, provided a waterproof barrier and aided in protecting the underlying tissues from debris (Mainous and Terry, 1974). In some instances there had been extensive orofacial tissue destruction followed by secondary wound breakdown, and maintenance of satisfactory wound hygiene in the face of oral feeding was virtually impossible. Nasogastric tube feedings (Randall, 1971; Converse, 1974[a]) were initiated in these patients until the wounds were sufficiently healed to permit oral intake.

**Debridement. Tooth and Root Fragments.** Periodontal and pulpal health of remaining tooth and root fragments were carefully evaluated. The objective of this evaluation was to determine if they could be retained to assist in stabilizing bony segments or provide support for future prostheses. In some instances salvagable teeth or roots which were critical to the rehabilitation but manifested paradicular pathology were endodontically treated. *If there was any question that retained dental structures would compromise healing, they were removed.* This included tooth and root fragments that had been retained during early care with the understanding they would possibly be removed later with less potential damage to surrounding adjacent structures (p. 73, Chapter IV). Serial radiographs and clinical examination were utilized in evaluating the status of these structures. The clinical examination included standard periodontal evaluation with recording of pocket depth and tooth mobility. Usual methods of pulp testing were not applicable in many of these patients because of the regional sensory deficits that had been caused by the injury.

Periodontal and periapical pathology that developed late in the course of treatment, after consolidation of osseous injuries, maturation of soft tissue wounds, and restoration of masticatory function, were managed in a conventional manner. Additional considerations regarding the management of tooth and root fragments will be discussed in the bone graft reconstruction section of this chapter.

**Bone and Foreign Debris.** The policy of conservative bone debridement previously discussed in the early and intermediate care chapters was continued. Bony sequestra that presented either intraorally or extraorally were removed when they could be lifted from the wound with gentle manipulation. Unexposed devital bone that was contributing to a chronic suppurative process presented a more complex problem regarding diagnosis and surgical management. It was not always possible to identify bony sequestra radiographically because of their small size or the superimposition of adjacent bony structures. In the presence of a suppurative process that could not be resolved by nonsurgical means, it was necessary to surgically explore the area even though no obvious source of infection could be identified clinically or radiographically. Such surgical redebridement was accomplished

either intraorally or extraorally although the extraoral route was preferable because there was usually better access for a wider exploration, the wound was easier to manage, and there was not the problem of oral contamination.

During wound exploration all free bone fragments were removed as well as other embedded matter (i.e., metal, clothing, tooth fragments) that was easily accessible and could be removed without jeopardizing adjacent healthy tissue. Debris that had been identified clinically or radiographically but was not in the immediate area of debridement was generally not removed unless it was or became symptomatic.

Following debridement, wounds were irrigated frequently with saline or antiinfective solutions and packed open with dressings. Occasionally, irrigation catheters were placed and wounds were closed following debridement. Specimens removed at surgery were submitted for culture and sensitivity testing for selection of appropriate antibacterial therapy. It was not unusual to have additional bony fragments spontaneously expelled from the wound during the subsequent phase of healing. *If adequate osseous debridement was not accomplished, it was not possible to control these chronic suppurative processes in a reasonable period of time.*

**Retained Missile Fragments.** Large retained missile fragments remote to the wound that interfered with function or might present future complications, i.e., vascular or neurologic, were evaluated clinically and radiographically for removal. *If vascular injuries were suspected, angiography was performed to confirm the existence of aneurysms, arteriovenous fistulas or other vascular abnormalities (Arpin and Downs, 1975).*

Posteroanterior, lateral cephalometric radiographs, and submental vertex views were valuable for locating fragments in the maxillofacial area. These films were technically simple to obtain and often provided sufficient information to determine if removal was warranted (Figure 45).

*The decision to remove retained fragments was not taken lightly since locating them in the tissues at the time of surgery could be extremely difficult. If the decision was made not to remove a fragment, it was important to make the patient aware of its presence and encourage him to return for follow-up evaluation (Figures 33 and 34).*

### Alignment and Stabilization of Osseous Fragments

Secondary reduction to align and stabilize bony fragments by either open or closed methods was

performed in 15.53% of MFCS patients with fractures. The highest incidence (21.43%) was in group I patients. Midfacial fracture reduction during late care was rare—2.48% (Table 19).



*Figure 45.*—Upper left) Appearance of 23-year-old casualty who sustained a penetrating missile wound (arrow) to the right cheek. Lower left) 45-caliber missile that was recovered without incident. This relatively low velocity missile was "spent" when it entered the cheek and thus did little damage and did not perforate the head. Upper, Middle and Lower right) Posteroanterior, true lateral and submento-vertex radiographs used to provide 3-dimensional localization of the missile which had come to rest within the pharynx.



TABLE 19.—Incidence of Secondary, Open or Closed, Fracture Reduction for Mandibular and Midfacial Injuries at Late Care Facilities for MFCS Patients in Groups I, II, III, and IV

Group	Mandible (open or closed)	Midface (open or closed)
I (N = 84)	18[21.43]*	2[02.38]
II (N = 32)	3[09.38]	1[03.13]
III (N = 20)	3[15.00]	1[10.00]
IV (N = 25)	1[04.00]	0[00.00]
Total (N = 161)	25[15.53]	4[02.48]

\*Figures in brackets equal percentage of N.

*Methods and devices used to maintain alignment and stabilization of bony segments were constantly evaluated.* It was not unusual to progress to other means of fixation during this period or to reapply or reinforce the devices already being used. The ingenuity of each surgeon in managing fixation and stabilization problems was reflected in the great variety of devices used during all stages of treatment. It is apparent that *there was no one way to manage these problems*, and the solution had to be adapted to the needs of each patient.

Fixation periods were prolonged for the non-graft patients because of the slow consolidation that occurred in the face of severe comminution and avulsion and the high incidence of infection. The mean period of fixation in the non-graft patients was 51.78 days. The patients with the more severe avulsive injuries (group II) experienced the longest episodes of fixation—the mean interval was 60.25 days and the range was from 19 to 168 days (Table 20).

TABLE 20.—Period of Intermaxillary Fixation Following Early Care for Non-Graft Patients in MFCS Groups II, III, and IV (days)

Group	Mean	Range
II (N = 28)	60.25	19 - 168
III (N = 17)	45.82	21 - 74
IV (N = 9)	47.78	17 - 150
Total (N = 54)	51.78	17 - 168

Arch bars ligated to the remaining teeth were the most common form of fixation. They had often been placed under hurried circumstances in the busy acute care facilities and frequently

became loose and ineffective by the time of late care admission. In fact, when loosened they acted as orthodontic appliances and caused shifting of teeth and associated bony segments, thus defeating their intended purpose. Splints were used ubiquitously as an adjunct to IMF. Arch bars or cast metal lingual appliances were most commonly employed to allow earlier function and monoarch stabilization once osseous consolidation had progressed to the point that IMF could be discontinued (Case report 06 and 13).

When teeth anchoring fixation appliances were lost as a result of debridement during intermediate or late care, the use of IMF as the only means of fixation was precluded and other methods were employed such as splints or external skeletal fixation. The biphasic external skeletal fixation device was very useful, especially in the severely comminuted mandible or when discontinuity existed. The advantages and disadvantages of this appliance for controlling osseous fragments are discussed in the bone graft reconstruction section.

## RESTRICTIVE JAW FUNCTION

### Introduction

Although MFCS patients required prolonged therapy to restore normal function of the jaws, including conservative resolution of jaw restriction, *severe* limitation of mouth opening requiring aggressive intervention was rarely seen in this rather homogeneous population. However, severe restriction of jaw function was encountered in other Vietnam conflict patients, both military and civilian, and it has also been identified as a serious problem in maxillofacial casualties since World War I (Converse, 1974[b]; Connoles, unpublished data). Therefore, a review of the management principles applicable to the treatment of jaw restriction is included as a necessary component of late care rehabilitation.

When encountered, successful resolution of jaw restriction depended on *accurate diagnosis and adequate management*. There were a plethora of conditions which could result in inability of the war trauma patient to open the mouth normally. Although radiographic examination was helpful in establishing the etiology of restriction, accurate diagnosis was most often gained with an orderly

evaluation of the patient's history, his symptoms, and a careful clinical examination that included an assessment of residual mandibular function.

*Of particular importance was the anatomic location of injury.* When not grossly obvious (i.e., facial scarring, etc.) the involved area could often be pinpointed by the location of pain elicited during forceful attempts at jaw movement. Identifying the anatomic location of the stricture within the masticatory apparatus was the key to successful management of these patients. The adequacy of management varied considerably depending on the anatomic sites of stricture; however, once the location was established, a progressive treatment rationale could be selected with confidence that generally satisfactory results could be obtained depending on the severity of the condition. For the foregoing reasons, management of these problems will be discussed by anatomic site. Prior to doing so, it is necessary to place in perspective the matters of ankylosis and trismus and also to discuss the general methods of mechanically approaching the problem of jaw restriction.

### Ankylosis

True bony ankylosis of the temporomandibular joint of traumatic etiology results most commonly from an indirect force such as a blow to the chin that causes condylar fracture or intracapsular injury. Ankylosis was exceedingly rare in combat casualties and the vast majority of conditions causing restrictions were extra-articular. Although missile injury caused extensive tissue damage, there seemed to be less tendency for energy to be transmitted through bone and cause indirect fracture (p. 35, Chapter IV). *Thus, unless the temporomandibular joint was directly involved in missile injury, ankylosis was an unlikely cause of restriction.*

Most para-articular restrictions (pseudoankylosis, etc.) were due to fibrosis, although mechanical bony impactions and ossifications did occur.

### Trismus

Trismus often accompanied restricting fibrosis and its treatment was essential for successful resolution of the overall problem.

Trismus is defined as "motor disturbance of the trigeminal nerve, especially spasm of the mas-

tatory muscles with difficulty in opening the mouth." (Dorland, 1974). Except when conversion reaction (hysterical trismus) (Thoma, 1958 [a]; Salmon et al., 1972) or tetanus (Richter, 1971) are suspected due to lack of local clinical findings, trismus was the ubiquitous companion of inflamed masticatory muscle whether the cause was trauma, infection, foreign body, or scarring. Pain caused increased spasm and promoted a vicious cycle of further pain and spasm. Trismus was considered a component of restricted opening whenever pain was present. *Eliminating or neutralizing painful spasm was a prerequisite to treatment of any restrictive lesion.* In management, causes of continuing inflammation were controlled or removed (chronic infection, foreign bodies, etc.) and muscle relaxation was encouraged with heat and gentle exercise.

### Jaw Exercisers and Physical Therapy

Over the years, numerous jaw exercise appliances and protocols for their use have been advocated (Gray, 1969; Alexander et al., 1970; Rowe and Killey, 1970; Kwapis and Dyer, 1974; Mincey et al., 1975). These can be characterized briefly as those for *intermittent use* and those for *continuous use*. Both have been employed effectively. *The important feature of each was to avoid traumatic force which could generate additional muscle spasm or microhemorrhage and fibrosis within muscle.* Alexander et al. (1970) described an excellent physical therapeutic protocol consisting of diathermy, local heat, and muscle relaxing exercise, which can be used as a prelude to dilating jaws in trismus.

It was often found that injuries which initially appeared to require more aggressive surgical therapy responded to the patient employment of conservative physical therapy. Preliminary physiotherapy was of limited value in extreme cases with massive fibrosis or bony impingement; however, in most circumstances, initial treatment of painful trismus simplified management of restrictive lesions.

### Anatomic Locations of Restriction

**Temporoparietal.** Whether due to blunt trauma, missile wound, or a surgical incision for craniotomy *scarring in the temporal muscle origin*



frequently resulted in restricted mandibular function (Khosla, 1970; Kwapis and Dyer, 1974) (Figure 46). Often this type of restriction was remedied by conservative treatment. If this was not successful, it was necessary to place the patient under general anesthesia and employ a short-acting muscle relaxant. An attempt was made to lyse the fibrous adhesions by forcefully dilating the jaws

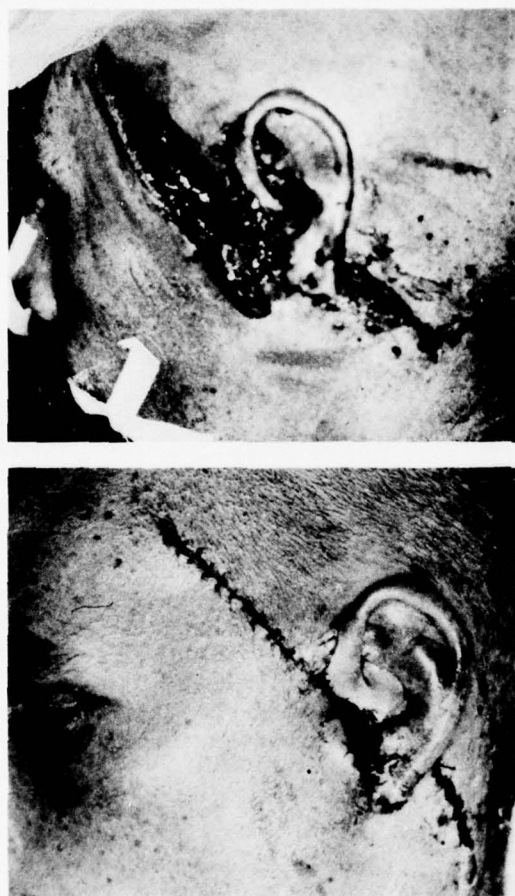


Figure 46.—Upper and Lower) Twenty-four-year-old casualty with a high velocity missile injury of the soft tissues in the left temporal region involving the temporalis and superior proximal portion of the masseter muscles. There was also an associated brain concussion. The soft tissue wound was debrided and closed primarily with provisions for drainage. The wound healed uneventfully, but the patient was unable to depress his mandible more than 10 mm as measured between the maxillary and mandibular central incisors. After reassessment for the possibility of overlooked mandibular fracture, a diagnosis of mandibular restriction associated with temporalis and masseter muscle fibrosis was made. Treatment consisted of daily forced opening using a side opening mouth dilator for 2 weeks until a 45 mm of mandibular depression was achieved. At 6 weeks the patient could easily effect a 40 mm opening with unrestricted functional movement.

with a mechanical ratchet (Thoma, 1958[b]). If this was unsuccessful, the insertion of the temporal muscle was released by coronoidectomy. In either circumstance, bite blocks were placed to maintain maximum jaw dilation while the patient was under anesthesia and postoperatively. Although an inconvenience to the patient, keeping bite blocks in place for 4–5 days postoperatively greatly reduced relapse tendency due to muscle spasm caused by postoperative pain. Following this, a gentle regimen of jaw-dilating exercise was provided until normal, pain-free range of mandibular function was achieved and no further tendency toward relapse was noted.

**Zygoma–Coronoid Process–Maxillary Tuberosity.** A common site for extra-articular restrictions to occur was the region where the coronoid process in its normal excursion came in close proximity to the zygoma and maxillary tuberosity. Fibrosis or bony adhesion of the coronoid process to the zygoma or maxilla occurred following injury. Treatment generally consisted of coronoidectomy followed by jaw-dilating exercises. *By itself, conservative physiotherapy was not usually effective in treating lesions of this area.*

Occasionally a fractured, severely depressed zygomatic complex that was not adequately treated impinged on the coronoid process sufficiently to mechanically block its normal excursion. If delayed zygomatic complex fracture reduction was impossible, coronoidectomy and conservative physiotherapy were necessary before mandibular function could be restored (Brown et al., 1946; Warsaw, 1971; Findley, 1972; Sperling, 1973).

In addition to the effects of trauma, *infection and foreign bodies at this site caused or accentuated fibrosis and/or bony consolidation.* It was necessary to eliminate the contributing factors (infection, foreign bodies) in conjunction with conservative physiotherapy in order to resolve the problem.

**Pterygomasseteric.** Direct trauma, infection, and missile fragments were the most common causes of restrictive lesions associated with the pterygomasseteric muscle complex. Because of its external position the masseter was more frequently involved. *Aggressive surgical intervention was seldom necessary in treating lesions of this area since conservative therapy to relieve trismus in association with gentle exercise was generally effective after infection had been controlled and sig-*



nificant foreign bodies had been removed.

If fibrosis was extensive as indicated by severe rigidity, either medial or lateral to the ramus, it was necessary to very gradually initiate physical therapy to allow maturation and spontaneous softening of the scar tissue. While this conservative approach could take up to a year, an acceptable degree of function was often recovered, particularly when a continuous use jaw-exercising appliance was used. It was extremely important *not* to employ traumatic jaw dilation or attempt to strip fibrous adhesions under general anesthesia because this caused additional fibrosis and the natural softening of the scar tissue was delayed.

**Buccal Circatrix.** Constricting buccal scar bands which bound the maxilla to the mandible developed from such injuries as lacerations, avulsions of buccal tissue, and burns. These scar bands not only limited mandibular movement but also compromised dental prosthetic restoration. *Preprosthetic management of this type of problem is discussed in the section on preprosthetic surgery.*

Rowe and Sowray (1965) proposed the following means of managing restrictive intraoral scar bands: 1) Use of mechanical aids, 2) excision of scars, 3) excision of scars and Z-plasty, 4) excision of scars with Thiersch type of skin grafting, and 5) Esser inlay graft. They also noted that pedicled tissue may be required when structures other than the mucosa are involved.

*The most effective and reliable method of relieving moderate to extensive intraoral restrictive scar bands was a modification of the intraorally placed epithelial inlay as originally used by Waldron in World War I (Ivy and Eby, 1924; Converse, 1974 [c]).* The purpose in this instance was not to establish a deeper vestibule as was the original intent, but rather to interpose the fold of skin graft between the scar band and its previous attachment to bone. The maxillary approach was preferred for two reasons: 1) It allowed greater latitude, i.e., if the coronoid process was noted to be involved in the stricture it could be removed as a portion of the maxillary procedure; 2) the buccal inlay skin graft is an ineffective procedure for vestibular extension as a preprosthetic consideration in the mandibular arch (MacIntosh and Obwegeser, 1967). If mandibular preprosthetic surgery was also required, we employed the buccal inlay technique in the maxillary arch to achieve mouth opening and the skin graft vestibuloplasty (Re-

hrmann, 1959; MacIntosh and Obwegeser, 1967) to achieve an adequate prosthetic foundation in the mandible.

Restriction of mouth opening due to extensive loss of substance or full-thickness scarring of the cheek was treated successfully only by surgical recreation of the defect and replacement with pedicled tissue for both covering and lining (Crockett, 1963; Tempest, 1966; Converse, 1974 [d]).

### Summary

The majority of limitations had a large component of true trismus and were amenable to conservative therapy. Trismus was treated prior to a definitive determination of the nature and extent of the restrictive lesion.

When a restrictive fibrous or bony lesion was encountered, successful treatment depended on the following protocol: 1) Deferment of treatment until the patient was at a facility capable of providing the necessary clinical support and long-term observations that were required for successful management; 2) solicitation of active patient cooperation; 3) performance of functional surgery prior to correction of cosmetic defects; 4) implementation of a flexible and thorough procedure that did not need to be repeated; 5) forceful dilation of the jaws under anesthesia was not to be repeated if relapse was encountered since additional fibrous or bony adhesions often resulted; 6) surgery was indicated only when previous conservative efforts had failed; and 7) utilization of a gentle continuous jaw-exercising appliance as opposed to an intermittent device during the postsurgical period.

### SALIVARY GLANDS

Of those patients included in the MFCS, 10.66% sustained salivary gland injuries: 2.54% in the parotid and 8.12% in the submandibular gland (Table 9, Chapter IV).

*These injuries involved the gland or their excretory ducts and sometimes resulted in a draining extraoral fistula.* If the injury was to the gland, any fistula that formed usually closed spontaneously after wound repair and return of normal excretory function. Injuries to the parotid duct forward to the anterior border of the masseter muscle or to

the submaxillary duct usually formed a spontaneous fistula. If this did not occur, drainage was established surgically through the mucosa adjacent to the severed duct and was maintained with an indwelling catheter or drain until a permanent fistulous tract developed.

Injuries to the parotid duct posterior to the anterior border of the masseter muscle with extraoral fistulization were more difficult to manage and were best approached by direct surgical repair with the goal of reestablishing ductal continuity to permit gland drainage as described in the literature (Converse, 1964; Musgrave, 1969; Converse, 1974 [e]).

When the injury had actually destroyed a major portion of the duct and only a short proximal stump remained, the usual methods of repair were not applicable. In this situation the duct had to be reconstructed to provide a path from the anterior border of the masseter through the buccinator muscle into the oral cavity to restore the normal anatomy (Figures 9, 10, and 14; Chapter III). A procedure for accomplishing this was described by Kuttner (1906) and a modification of this technique was utilized successfully in MFCS patients for this type of reconstruction (Figures 47 and 48).

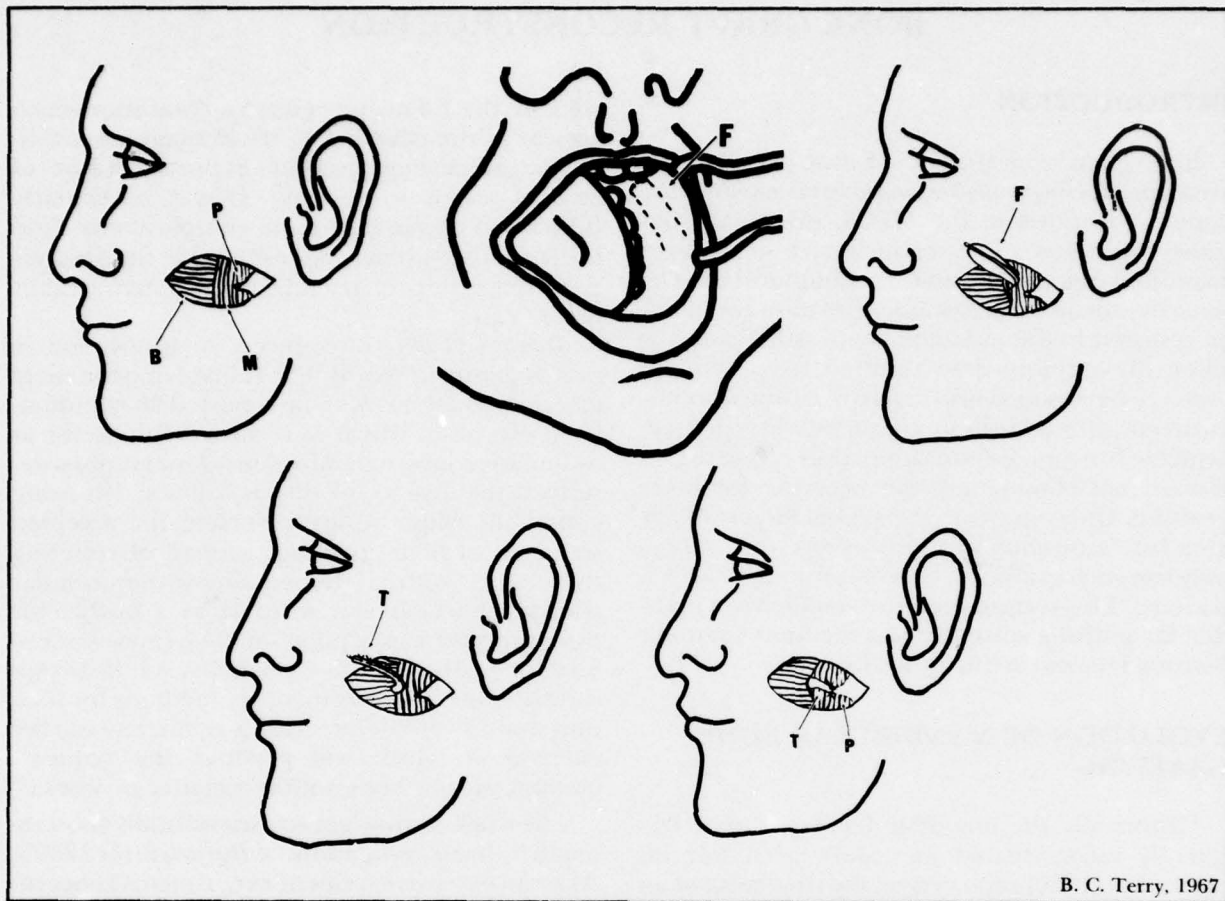
### CONCOMITANT INJURIES AND MEDICAL DISEASE

In all patients appropriate consultation was requested to evaluate and assist in managing associated head and neck injuries and disturbances such as ophthalmologic, neurologic, and ear, nose, and throat. Other medical specialists were called to manage general medical problems such as those discussed in the previous chapter (p. 96, Chapter V). The incidence of medical complications was 16.13%—*rarely did they compromise successful management and eventual healing of the maxillofacial injury.*

The severity, multiplicity, and complications of concomitant injuries were the major factors that effected maxillofacial wound management and healing. For example, in a patient with empyema and multiple infected extremity wounds maintenance of oral hygiene and meticulous care of the maxillofacial wound were difficult. In addition, the deleterious effects of chronic infection or compromised physiology of any etiology obvi-



Figure 47.—Upper) Appearance of a 26-year-old casualty on admission to a secondary early care facility, showing massive left facial swelling that was present 36 hours after a missile injury to the face that had been treated without provisions for drainage of a severely damaged parotid duct system. Middle) Photograph 5 weeks post injury showing cutaneous salivary fistula on the cheek. Lower) Posteroanterior radiograph showing a fluid level in the left maxillary sinus that on surgical drainage was found to result from saliva.



B. C. Terry, 1967

Figure 48.—Upper left) Diagrammatic illustration of operative site in left cheek of patient shown in Figure 47 at time of parotid duct repair. The stump of the parotid duct (P) is seen overlapping the vertical fiber of the masseter muscle (M). The horizontal fibers of the buccinator muscle (B) are seen anterior to the masseter. Upper middle) Diagrammatic illustration of an anteriorly based, full-thickness buccal mucosa pedicle flap (F) that was designed to be of sufficient length to bridge the distance from the oral cavity to the remaining parotid duct stump. Upper right) A tract was developed through the buccinator muscle and the end of the mucosal flap (F) pulled into the extraoral wound. Lower left) The flap was formed into an oral mucosa lined tube (T) by suturing around an appropriate sized polyethylene catheter. Lower right) End-to-end anastomosis of the mucosa lined tube (T) and parotid duct stump (P) was accomplished after the catheter was directed into the end of the residual proximal duct.

ously had a negative effect on wound healing in general.

Illustrating the *sometimes precarious physiologic status of war casualties during late care*, even after satisfactory early care, is a report by Biron et al. (1972) concerning a clinical syndrome that they observed in Vietnam casualties with orthopedic and associated injuries. The usual number of maxillofacial injuries were included in this group (ca. 10–15%). They observed that many of these patients manifested inordinately complicated and delayed wound healing as well as serious episodes of hypotension during periods of

surgery under general anesthesia and postoperatively. They measured blood volumes and found unexpectedly large reduction in red cell mass (ca. 40%) that were not commensurate with hemoglobin and hematocrit values. When red cell mass deficits were corrected by red cell transfusion, the clinical management of the patients was far less complicated. An explanation for this phenomenon, referred to as the “*anemia of trauma*,” has not been established. Surgeons managing trauma patients should be familiar with this clinical syndrome since it can greatly affect the success of surgical rehabilitation.



## BONE GRAFT RECONSTRUCTION

### INTRODUCTION

*Bone graft reconstruction of the maxillofacial area was most frequently performed in the mandible for patients included in the MFCS, principally because there was a greater incidence of avulsive mandibular injury (Table 8, Chapter IV). Ordinarily, adequate masticatory function could not be restored to the mandible by prosthetic means when discontinuity had resulted from avulsive injury, whereas in avulsive maxillary injuries construction of a prosthesis frequently effected acceptable functional restoration, thus reducing, although not eliminating, the necessity for bone grafting. Onlay grafts to the zygomatic-maxillary area for restoration of morphology were rare—only two such grafts were accomplished on MFCS patients. This section therefore emphasizes mandibular grafting since this was the most common osseous reconstructive procedure.*

### EVOLUTION OF MANDIBULAR BONE GRAFTING

Historically the mandible has been most frequently reconstructed in maxillofacial war injuries. Ivy (1920) reported on the treatment of an estimated total of 1,125 gunshot fractures of the mandible by the American Expeditionary Forces in Europe during World War I. Of these patients 123 or 11% required bone grafting. The methods of grafting included the osteoperiosteal (37%), local pedicle graft method (30%), cortex of the tibia (17%), crest of ilium (7%), rib graft (6%), and ramus sliding graft (3%). Of these operations, 76% were considered successful though the criteria of success were not indicated. These procedures were performed without the use of antibiotics. At that time the success of long-term bone grafting was noted by Kirk (1924) as 65% in a series of 156 patients.

Mandibular bone graft reconstruction in United States military facilities during World War II was surveyed by Blocker and Stout (1949). This survey covered 1000 grafts including one-piece iliac (81%), rib (15%), tibia (2%), and iliac chip (1%). Results were reported in terms of the success of union. "Primary take" was achieved in 90.7% of patients though they qualified these re-

sults by the following remarks, "Statistics which appear in the table below are in many cases estimates rather than accurate reports because of lack of access to records. It was particularly difficult to obtain figures on complications. And lack of follow-up may be responsible for a higher percentage of primary take than should actually be the case."

Mowlem (1944) introduced an innovation in grafting during World War II involving the use of *iliac cancellous bone chips*; he reported 36 mandibular grafts all of which were successful insofar as union was concerned. Mowlem's observations described the essence of this as follows: "In using cancellous chips we are reversing the accepted standard of bone grafting. Instead of splinting the defect with a dense, almost non-cellular transplant which may also act as a bridge for osteogenesis or as a poor source of new bone—and for neither of these purposes is it histologically suitable—we rely on other methods for fixation and fill the defect with a cellular mass, the survival of which will produce the requisite amount of new bone within a matter of weeks."

The work of Mowlem was scientifically substantiated by the investigations of Burwell in the 1960's. After an extensive series of experiments concerning the fate of bone grafts, he concluded, "*cancellous bone after its transplantation has the capacity to promote osteogenesis in red marrow.*" He further stated, "the new woven bone produced by an autograft of fresh marrow containing iliac bone is derived not only from osteoblasts on the surfaces of grafted bone, but also from osteoblasts created by the differentiation of littoral cells lining the vascular sinusoids of its surviving red marrow" (Burwell, 1964).

A more elaborate discussion of bone physiology would be relevant to the subject of bone grafting, but we concluded that such a presentation is best reserved for a treatise specifically concerned with bone as a tissue rather than in a text primarily concerned with a survey documentation of clinical experience. Burwell (1969) compiled an excellent review of bone transplantation in which he presents a very reasonable discussion of the state of the art that remains valid to date.

Thus a *variety of methods have been used to reconstruct the mandible* in battle casualties. To date, the

most commonly employed transplant has been autogenous iliac bone, either as a solid one-piece segment or augmented with highly osteogenic cancellous marrow chips. Recently there has been renewed interest in the efficacy of allogeneic (homogenous) bone grafts augmented with autogenous cancellous marrow as a means of reducing morbidity associated with donor operations (Jones et al., 1972; Burwell, 1976; Friedlaender, 1976; Kelly, 1976). These methods hold promise for the future, particularly in light of the extensive developments that have occurred in the field of transplantation immunology (Najarian and Simmons, 1972).

### CRITERIA OF SUCCESSFUL RECONSTRUCTION

Before we discuss the MFCS bone graft patients, it is first necessary to identify what we consider the objectives of mandibular reconstruction and the criteria for judging successful treatment. A review of the literature relative to this subject suggests that in most instances restoration of continuity by achievement of union has been considered the definitive measure of success. From the data acquired in our study, we concluded that although establishing continuity through graft union is important, this does not always provide the patient with a satisfactory functional and esthetic result. We offer the following objectives of graft reconstruction as necessary to assure that complete rehabilitation is achieved. 1. *Establishment of mandibular continuity.* 2. *Establishment of an osseous alveolar base for a prosthesis.* 3. *Correction of alveolar and vestibular soft tissue deficiencies in preparation for prosthetic reconstruction.*

Establishment of continuity should be accomplished in such a manner that it is possible to achieve both an *esthetically acceptable contour as well as a maxillary-mandibular relationship suitable for prosthetic dental restoration.*

It was often difficult to achieve all these objectives by a single operation and in the patients successfully rehabilitated it was frequently necessary to proceed through as many as *three stages of surgical treatment* to obtain the desired results. If the *first-stage* operation had achieved only the establishment of continuity, then it was necessary to perform *second-stage* bone graft augmentation to provide an osseous alveolar base for a prosthesis. A *third stage* of surgical treatment was

necessary, if the soft tissues associated with the reconstructed alveolus were unstable over the crest or were residually positioned in the vestibular areas in a manner that precluded construction of a satisfactory prosthesis.

The necessity for a second- or third-stage procedure, or both, could not always be established before initial bone grafting. However, the procedures needed to be identified as possible extension of treatment so that the patient could appreciate the endpoint that was to be achieved. To ensure cooperation during a potentially long period of reconstruction, the patient was made aware of the objectives of the program and the procedures necessary to accomplish them. This explanation was clearly presented and every effort made to accomplish treatment objectives as soon as possible, in keeping with adequate healing and maturation of tissue, because this was the time of optimum cooperation and motivation.

The opportunity to afford a rational program of staged mandibular bone graft reconstruction directed toward total rehabilitation has been greatly enhanced by the recent *reemphasis of preprosthetic surgery*. These methods of reconstruction are aimed at restoration of proper oral and maxillofacial form and function through a variety of hard and soft tissue surgical procedures (Rehrmann, 1959). Diagnostic criteria have been refined and new surgical techniques have evolved (MacIntosh and Obwegeser, 1967). The various treatment approaches are not described here since they will be discussed later, but we emphasize the need for including them in any program of oral and maxillofacial rehabilitation if a desirable, functional, and esthetic endpoint is to be achieved (Kelly, 1973).

### PROCEDURAL FORMAT FOR RECONSTRUCTION-REHABILITATION

Figure 49 illustrates what we consider to be the *correct progress of treatment during the late phase of management*. The essential continuity of treatment is exemplified in this diagram, as well as the opportunity and necessity for including all types of reconstruction at the appropriate interval.

*Three basic principles*, previously discussed in this chapter, must be applied *prior to* bony consolidation or grafting. Infection must be controlled, debridement of devitalized hard tissue accomplished, and the bony fragments stabilized



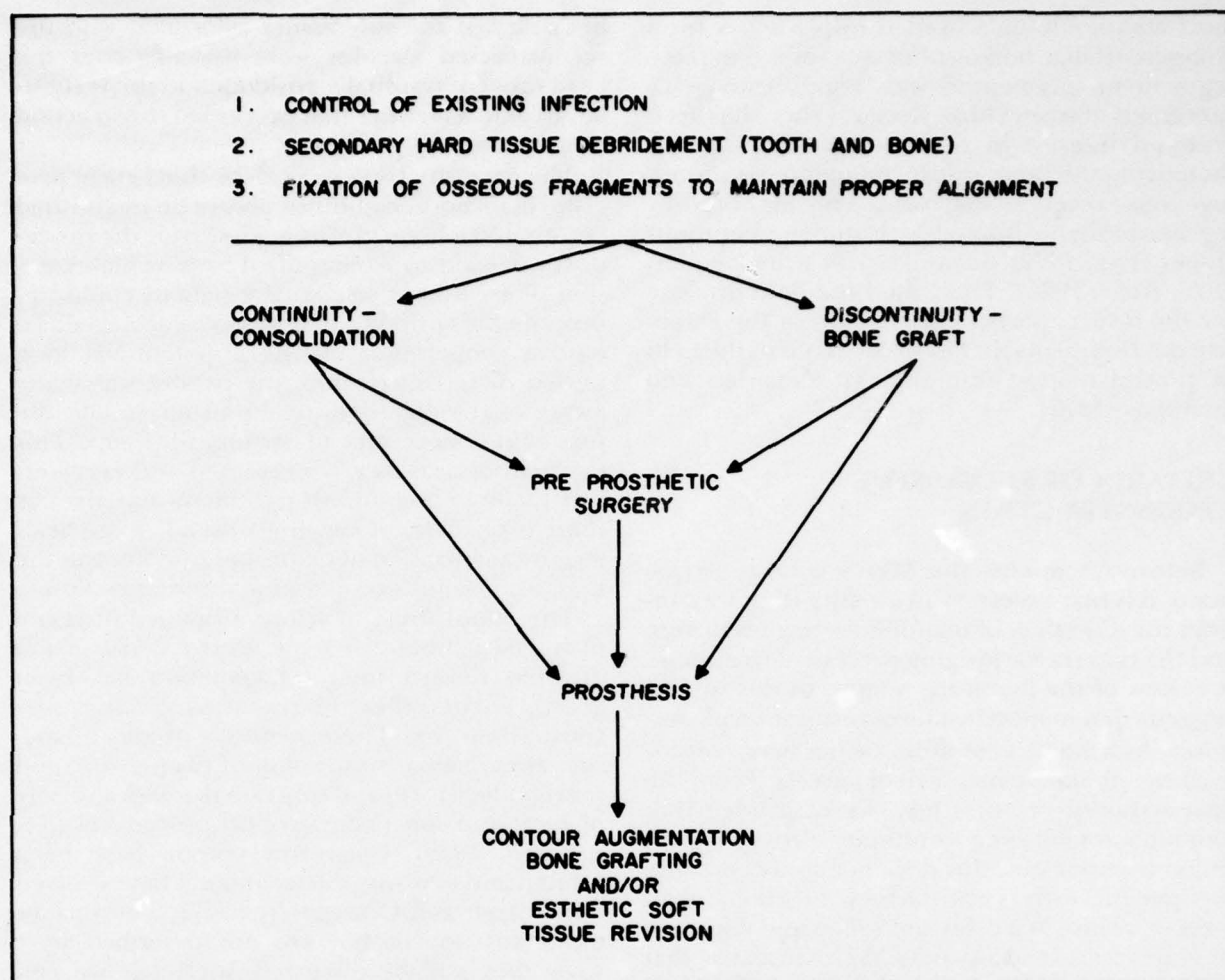


Figure 49.—Procedural format diagram

in proper alignment.

*If consolidation occurs and continuity is restored with the osseous fragments in satisfactory position, a prosthesis may be constructed and esthetic soft tissue revision performed if required. When conditions are unfavorable for construction of a prosthesis, indicated preprosthetic surgical procedures should be accomplished before definitive prosthetic restoration and soft tissue revision. Contour augmentation bone grafting can be performed as an adjunct to final scar revision but should precede the soft tissue operation.*

*If discontinuity exists after the preliminary principles have been applied and bone grafting is required, prosthetic restoration, preprosthetic*

surgery, contour augmentation and scar revision may be accomplished as required after the graft operation.

Application of this simple formula has led to improved and complete results in the reconstruction and rehabilitation of maxillofacial casualties.

#### ANALYSIS OF BONE GRAFT CASES

There were 93 patients reported in the MFCS who required bone graft reconstruction. In this group, 114 grafts were performed, with 20 patients requiring multiple grafting procedures. All of these grafts were performed with autogenous material (iliac, rib, particulate cancellous marrow



[PCM]), except for 6 composite grafts that consisted of allogeneic (banked) mandible combined with autogenous cancellous marrow. In 80 patients who received 101 grafts it was possible to acquire sufficient data for valid analysis of the long-term results of surgery (Table 21). The mean length of follow-up postgrafting for the 80 patients was 1,992.01 days or 5.46 years (Table 22).

Table 23 lists the incidence for various types of primary and secondary bone grafts performed for augmentation or continuity restoration. Of the total of 101 grafts, 83 (82.18%) were performed for continuity restoration and 18 (17.82%) for augmentation. The great majority of the primary or first bone graft operations were for continuity restoration (90%) whereas the secondary operations were about equally divided between those performed for augmentation (47.62%) and for continuity restoration (52.38%). Of the 18 augmentation grafts, 11 were performed with iliac crest bone, 4 with rib, and 3 with the PCM system.

Table 24 presents the success of mandibular bone grafting in terms of continuity restoration, which it will be recalled is only one of the criteria that was used for evaluating the grafts performed. Thirty-five iliac crest grafts were performed for continuity and 30 (85.71%) were successful for this purpose. Of the 5 secondary iliac grafts for continuity, 100% were successful as compared to 83.33% of the 30 primary procedures. A total of 8 rib grafts were performed for continuity—in 6 patients (75%) continuity was achieved. PCM grafts were performed for continuity in 37 patients—31 (83.78%) of these were successful. Only 3 composite (autogenous-homogenous) grafts were performed on patients included in the MFCS—all to restore continu-

TABLE 21.—*Success of Achieving Long-Term Follow-Up for Patients Included in the MFCS Who Underwent Bone Graft Reconstruction of the Mandible*

	Original data	Long-term data available
Number of patients reported .....	93	80 [86]*
Number of grafts .....	114	101 [89]
Patients requiring regrafting .....	20	20 [100]

\*Figures in brackets equal percentage of N.

TABLE 22.—*Mean Interval—Date of Graft to Last Follow-Up*

Type of graft	Days	Years
Iliac crest (N=34)	2095.29	5.74
Rib (n=8)	2568.38	7.04
PCM (N=36)	1808.17	4.95
Other (N=2)	1240.00	3.40
Total (N=80)	1992.01	5.46

ity—and only 1 was successful. Of the total of 83 grafts, continuity was achieved in 68 (81.93%). For those grafts that were the primary or initial reconstructive procedure, continuity was achieved in 80.56%, whereas in patients who received secondary grafting following an initial unsuccessful operation the success rate was 90.91%.

The incidence of bone grafts for continuity in various anatomic regions of the mandible is listed in Table 25. In 32 patients, 38.56% of the total, the graft included the symphysis alone or in combination with other adjacent regions. Of these 32 patients, 19 received grafts that included the symphysis plus the body or the parasymphysis area. Six of the eight rib grafts reported were performed for defects involving the symphysis. Forty-four grafts, 53.01% of the total, included the body or the body in combination with the angle or ramus. Twenty-four of the 37 PCM grafts were employed for reconstruction of the body combination defects as compared with 15 of 35 iliac and 2 of 8 rib grafts. Iliac grafts were performed with equal frequency in the body and symphysis regions.

More grafts were performed on the right side (56.63%) than on the left (30.12%) although there is no explanation for this predilection and it would appear to be a random distribution rather than one produced by any specific factors associated with wounding. In 13.25% of patients the grafts included both sides (Table 26).

Table 27 presents data for success in achieving continuity for grafts in various anatomic sites of the mandible. The success of achieving continuity for iliac grafts was 80% for the symphysis combinations, 93.33% for the body combinations, 80% for the angle-ramus region, and 85.71% for all sites. For rib grafts 66.67% were successful for the symphysis combinations, 100% for the body, and 75% overall. PCM graft success was 81.82% for symphysis, 83.33% for body, 100% for angle-

TABLE 23.—Frequency of Bone Grafts Performed for Augmentation or Continuity Restoration

Type of graft	Augmentation only	Continuity restoration	Total
<i>A. Iliac crest</i>			
Primary	4[11.77]*	30[88.23]	34[100]
Secondary	7[58.33]	5[41.67]	12[100]
	11[23.91]	35[76.09]	46[100]
<i>B. Rib</i>			
Primary	1[12.50]	7[87.50]	8[100]
Secondary	3[75.00]	1[25.00]	4[100]
	4[33.33]	8[66.67]	12[100]
<i>C. PCM</i>			
Primary	3[08.33]	33[91.67]	36[100]
Secondary	0[00.00]	4[100.00]	4[100]
	3[07.50]	37[92.50]	40[100]
<i>D. Composite</i>			
Primary	0[00.00]	2[100.00]	2[100]
Secondary	0[00.00]	1[100.00]	1[100]
	0[00.00]	3[100.00]	3[100]
<i>E. All grafts</i>			
Primary	8[10.00]	72[90.00]	80[100]
Secondary	10[47.62]	11[52.38]	21[100]
Total	18[17.82]	83[82.18]	101[100]

\*Figures in brackets equal percentage of N.

ramus combinations, and 83.78% overall. For all grafts, continuity was achieved in 68 of 83 instances (81.93%).

Eighteen bone grafts were performed for augmentation (Table 28). Ten of these operations (55.56%) were secondary procedures to a primary continuity graft whereas 44.44% were primary operations done solely for augmentation. Thirteen (72.22%) were for functional augmentation of the alveolar segment of the mandible and 5 (27.78%) were for cosmetic augmentation.

The number of patients requiring a denture after bone grafting is listed in Table 29. In 5

(7.35%) of the total patients a denture was not required because the injury and subsequent graft had not affected the denture-bearing area, whereas in 12 patients (17.65%) masticatory function was possible without a denture because there was sufficient residual dentition, i.e., graft proximal to first molar or second bicuspid with full complement of teeth. Thus, in 51 of 68 grafts (75%) a denture was indicated for restoration of masticatory function following bone grafting. Prosthetic rehabilitation will be discussed in the preprosthetic surgery section of this chapter.

TABLE 24.—Bone Graft Success (Continuity Restoration)

Type of graft	Total for continuity	Continuity achieved	Failed to achieve continuity
<i>A. Iliac crest</i>			
Primary	30[100]*	25[83.33]	5[16.67]
Secondary	5[100]	5[100.00]	0[00.00]
	35[100]	30[85.71]	5[14.29]
<i>B. Rib</i>			
Primary	7[100]	5[71.43]	2[28.57]
Secondary	1[100]	1[100.00]	0[00.00]
	8[100]	6[75.00]	2[25.00]
<i>C. PCM</i>			
Primary	33[100]	27[81.82]	6[18.18]
Secondary	4[100]	4[100.00]	0[00.00]
	37[100]	31[83.78]	6[16.22]
<i>D. Composite</i>			
Primary	2[100]	1[50.00]	1[50.00]
Secondary	1[100]	0[00.00]	1[100.00]
	3[100]	1[33.33]	2[66.67]
<i>E. All grafts</i>			
Primary	72[100]	58[80.56]	14[19.44]
Secondary	11[100]	10[90.91]	1[09.09]
Total	83[100]	68[81.93]	15[18.07]

\*Figures in brackets equal percentage of N.

## TECHNICAL MANAGEMENT

### Introduction

The success of bone graft reconstruction was largely due to the adequacy of previous treatment and the thoroughness of evaluation and preparation prior to grafting. The period of time over which the patients were prepared for grafting was prolonged, principally as a result of chronic infection and slow healing. The mean length of time from date of injury to bone grafting for MFCS patients was 253.16 days and the range was

from 38 to 799 days (Table 30).

*Basic principles* necessary to follow for successful grafting were: 1) Awaiting and/or providing adequate vascularity and nutrition of the graft bed, 2) establishing stable immobilization of grafted segments, 3) assuring asepsis in conjunction with grafting. Comprehensive postoperative care and follow-up were strongly emphasized to prevent or reduce complications that might lead to graft failure. Satisfactory management of these patients was carried out within a well-developed but flexible treatment plan. In the following discussion of the essence of such a plan, we recognize



TABLE 25.—Incidence of Type of Bone Grafts in Various Anatomic Regions of the Mandible

Anatomic site	Type of graft			Composite	Total
	Iliac	Rib	PCM		
<i>A. Symphysis</i>					
S only	2	—	2	—	4 [04.82]*
S + B	9	4	6	—	19 [22.89]
S + B + A	3	1	1	—	5 [06.03]
S + B + A + R†	1	1	2	—	4 [04.82]
	15	6	11	—	32 [38.56]
<i>B. Body</i>					
B only	5	1	12	3	21 [25.30]
B + A	5	1	9	—	15 [18.07]
B + A + R	5	—	3	—	8 [09.64]
	15	2	24	3	44 [53.01]
<i>C. Angle-ramus</i>					
A only	2	—	2	—	4 [04.82]
A + R	2	—	—	—	2 [02.41]
R only	1	—	—	—	1 [01.21]
	5	—	2	—	7 [08.43]
<b>Total</b>	<b>35</b>	<b>8</b>	<b>37</b>	<b>3</b>	<b>83 [100.00]</b>

\*Figures in brackets equal percentage of N.

†S = Symphysis; B = Body; A = Angle; R = Ramus.

TABLE 26.—Anatomic Location of Mandibular Bone Graft—Side of Grafting

Location	Iliac	Rib	PCM	Composite	Total
Bilateral*	5	4	2	—	11 [13.25]†
Right	18	3	23	3	47 [56.63]
Left	12	1	12	—	25 [30.12]
<b>Total</b>	<b>35</b>	<b>8</b>	<b>37</b>	<b>3</b>	<b>83 [100.00]</b>

\*Defect involved both sides including the midline.

†Figures in brackets equal percentage of N.

that this does not constitute the only valid approach but rather an overview of a management philosophy representing a distillation of cumulative experience that has served well.

As previously mentioned, in this and the intermediate care chapter, the initial consideration in management was the *overall systemic evaluation of the patient*. It was highly desirable to the success of bone grafting that the patient be in optimal physiologic condition prior to operation. Of particular concern, in addition to establishing the integrity of all organ systems, were fluid and

electrolyte status, nitrogen balance as determined by adequate intake-output and active weight gain, and blood volume. Patients with multiple wounds and chronic infection were restored to positive physiologic balance slowly even though they were under continuous medical supervision.

Fortunately, in most instances the maxillofacial patients were in good health by the time reconstructive surgery was planned as they had been under continuous medical observation since the time of injury.

TABLE 27.—Success of Mandibular Bone Grafts for Continuity by Anatomic Site

Location of grafts by anatomic regions*														
Type of graft	Symphysis combinations					Body combinations				Angle-ramus				TOTAL ALL SITES
	*S only	S+B	S+B+A	S+B+A+R	Total	B only	B+A	B+A+R	Total	A only	A+R	R only	Total	
<b>A. Iliac</b>														
Continuity	2	7	2	1	12[80.00]†	5	4	5	14[93.33]	2	1	1	4[80.00]	30[85.71]
No continuity	0	2	1	0	3[20.00]	0	1	0	1[6.67]	2	1	1	4[20.00]	5[14.29]
	2	9	3	1	15[100]	5	5	5	15[100]	2	2	2	5[100]	35[100]
<b>B. Rib</b>														
Continuity	0	4	0	0	4[66.67]	1	1	0	2[100]	0	0	0	0[00.00]	6[75.00]
No continuity	0	0	1	1	2[33.33]	0	0	0	0[00.00]	0	0	0	0[00.00]	2[25.00]
	0	4	1	1	6[100]	1	1	0	2[100]	0	0	0	0[00.00]	8[100]
<b>C. PCM</b>														
Continuity	2	5	1	1	9[81.82]	9	8	3	20[83.33]	2	0	0	2[100]	31[83.78]
No continuity	0	1	0	1	2[18.18]	3	1	0	4[16.67]	0	0	0	0[00.00]	6[16.22]
	2	6	1	2	11[100]	12	9	3	24[100]	2	0	0	2[100]	37[100]
<b>D. Composite</b>														
Continuity	0	0	0	0	0[00.00]	1	0	0	1[33.33]	0	0	0	0[00.00]	1[33.33]
No continuity	0	0	0	0	0[00.00]	2	0	0	2[66.67]	0	0	0	0[00.00]	2[66.67]
	0	0	0	0	0[00.00]	3	0	0	3[66.67]	0	0	0	0[00.00]	3[100]

\*S = Symphysis; B = Body; A = Angle.

†Figures in brackets equal percentage of N.

TOTAL, ALL GRAFTS WITH CONTINUITY ..... 68[81.93]

TOTAL, ALL GRAFTS WITH NO CONTINUITY ..... 15[18.07]

TOTAL, ALL GRAFTS ..... 83[100]

TABLE 28.—Incidence With Which Augmentation Bone Grafting to the Mandible Was Performed for Either Functional or Cosmetic Restoration in Both Primary and Secondary Grafting Situations\*

Graft	Functional	Cosmetic	Total[%]
Primary	6	2	8[44.44]†
Secondary	7	3	10[55.56]
Total	13[72.22]	5[27.78]	18[100]

\*18 of 101 grafts were performed for augmentation in patients in whom continuity was present.

†Figures in brackets equal percentage of N.

### Preoperative Evaluation

The bone grafting candidate shared in common with other maxillofacial casualties, the requirement for a complete and thorough orofacial examination.

*Evaluation of the remaining dentition* took an additional significance in the grafting candidate because of the following considerations:

- 1) The long-term positive jaw immobilization required in association with graft reconstruction.
- 2) The potential advantage of retaining specific teeth for both jaw immobilization and subsequent prosthetic rehabilitation.
- 3) The adverse influence of odontogenic infection on grafting—when infection occurred near the time of grafting, total graft failure could result.

*Radiographic examination* of the teeth and supporting bone was essential and included standard extraoral and panoramic views as well as periapical radiographs of *all* teeth, particularly those adjacent to graft sites. Although panoramic films were more easily obtained and provided a convenient serial assessment of osseous repair, they were not utilized to establish a definite assessment of the state of the dentition. When appropriate radiographs were combined with clinical evaluation of the remaining dentition to determine vitality, mobility, and periodontal status,

TABLE 29.—*Patients Needing Dentures Following Successful Bone Grafting for Continuity Restoration*

Type of graft	No dentures required		Number of patients requiring dentures
	Denture N/A	Adequate occlusal function without pros.	
Iliac crest (N = 31)	3 [09.68]*	5 [16.13]	23 [74.19]
Rib (N = 6)	0 [0.00]	1 [16.67]	5 [83.33]
PCM (N = 30)	2 [06.67]	6 [20.00]	22 [73.33]
Other (N = 1)	0 [0.00]	0 [0.00]	1 [100]
Total (N = 68)	5 [7.35]	12 [17.65]	51 [75.00]

\*Figures in brackets equal percentage of N.

TABLE 30.—*Mean Interval (Days) from Date of Injury to Date of Graft for Patients in the MFCS Who Received Mandibular Bone Grafts*

Type of graft	Mean	Range
Iliac (N=34)	392.35	73 - 799
Rib (N=8)	312.28	157 - 697
PCM (N=36)	202.92	38 - 444
Other (N=2)	236.00	136 - 336
Total (N=80)	253.16	38 - 799

intelligent appraisal of their potential advantage or liability could be made.

*Study casts* were also obtained because they provided an excellent guide in planning anatomic reduction of the remaining jaw segments, served as models for intraoral surgical splint fabrication,

and were helpful in assessment of the residual dental occlusion in relation to future prosthetic requirements. Most patients undergoing bone graft reconstruction required dental prosthetic appliances subsequent to grafting as an integral part of their management (Table 29). Prosthetic evaluation during the preoperative phase of treatment established the basis of coordinated surgical and prosthetic treatment, thus assuring preservation of essential teeth and creation of alveolar ridge relationships favorable to denture construction.

### Control of Sepsis

Forty-six (56.10%) of MFCS patients with avulsive mandibular defects requiring bone grafting (group I) presented with infection at varying times during their postinjury course. The greatest number of these infections (27) were diagnosed at the late or CONUS facility (Table 31). Infections were usually chronic but acute exacerbations were not unusual—they were treated as previously described in this chapter.

Once initial soft tissue healing had occurred, subsequent episodes of infection were usually associated with the presence of nonvital tissue (teeth, bone) or foreign material such as alloplastic implants or wires (Case report 11); it was uncommon for missile fragments to cause latent infection (p. 73, Chapter IV). Surgical wire or other foreign debris was carefully scrutinized for possible removal, even in the absence of clinical infection, if they were in the bone grafting area (Figures 50 and 51). The matter of foreign-body removal was sometimes conjectural and, in retrospect, some decisions were regretted. For example, a questionable fragment of debris that was

TABLE 31.—*Incidence and Timing of Maxillofacial Wound Infection Diagnosis Following Definitive Early Care*

Group	Interval during which diagnosis made				Locale where infection diagnosed		
	0-7 days	8-21 days	22+ days	Total	Early	Intermediate	CONUS
I (N=82)	13[15.85]*	23[28.05]	10[12.20]	46[56.10]	8[9.76]	11[13.41]	27[32.93]
II (N=35)	1[02.86]	6[17.14]	3[08.57]	10[28.57]	1[02.86]	2[05.71]	7[20.00]
III (N=20)	0[00.00]	3[15.00]	4[20.00]	7[35.00]	0[00.00]	1[05.00]	6[30.00]
IV (N=20)	0[00.00]	3[15.00]	2[10.00]	5[25.00]	0[00.00]	3[15.00]	2[10.00]
V (N=5)	0[00.00]	0[00.00]	0[00.00]	0[00.00]	0[00.00]	0[00.00]	0[00.00]
Total (N = 162)	14[8.64]	35[21.60]	19[11.73]	68[41.98]	9[05.56]	17[10.49]	42[25.93]

\*Figures in brackets equal percentage of N.



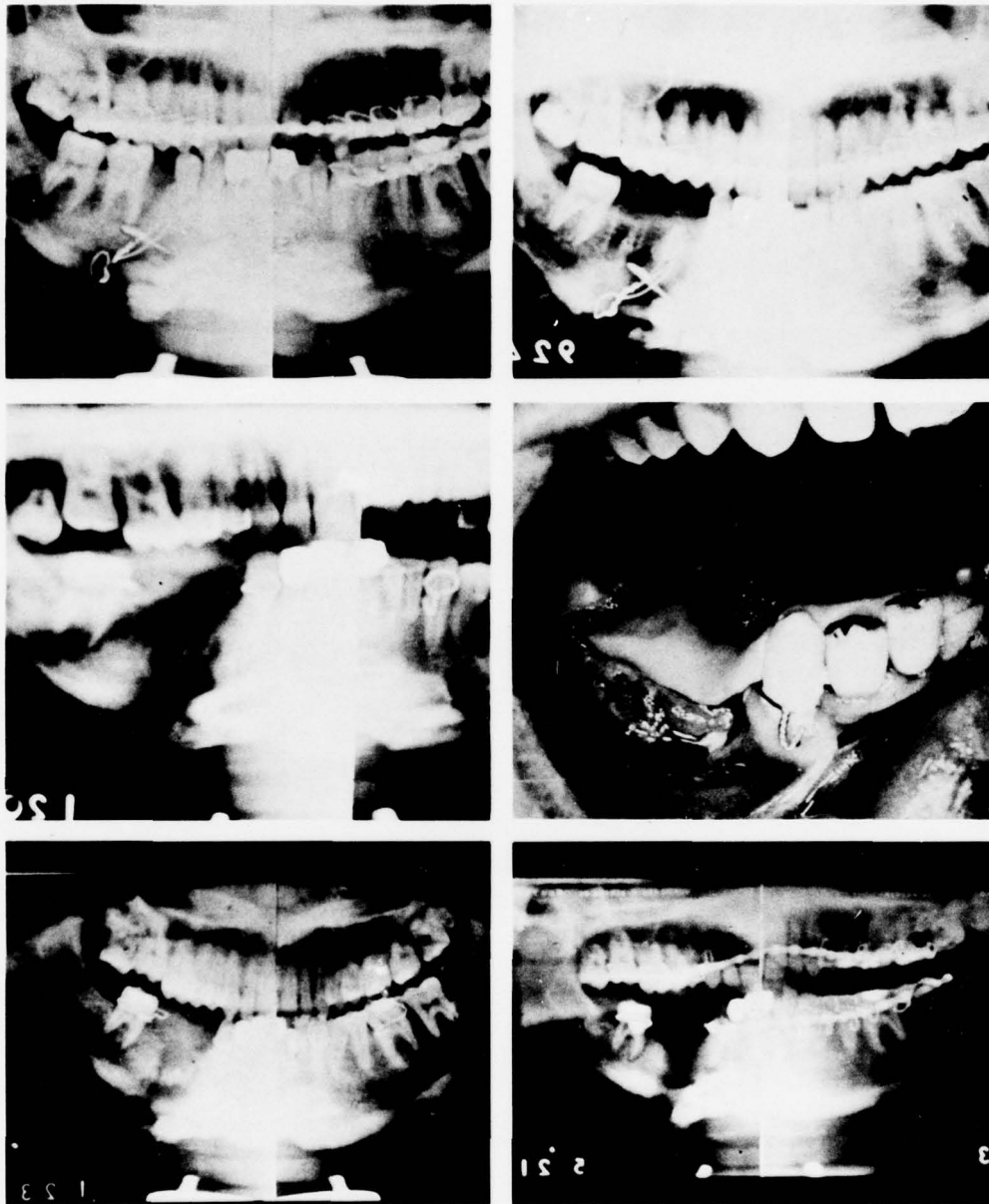


Figure 50. — *Upper left*) Panoramic radiograph of 22-year-old casualty taken 8 weeks following a high velocity missile injury to the jaw at the time the patient was admitted at the late care facility. Debridement, open reduction and IMF with arch bars had been accomplished at the time of injury. Chronic infection had developed and the mandibular right second bicuspid had been removed at an intermediate facility in conjunction with limited wound debridement and supportive care. *Upper right*) Panoramic radiograph 4 months post injury. The mandibular right first bicuspid and first molar had been removed. *Middle left*) Panoramic radiograph 6 months post injury following debridement of bone and wire from the mandibular wound. The circumferential wires seen about some of the mandibular teeth were securing a lingual acrylic splint which was providing monoarch fixation. Presence of the single molar tooth in the proximal fragment was critical as it provided control of this fragment by splint fixation and occlusion with the opposing dental arch. *Middle right*) Appearance of acrylic splint described in narrative for middle left radiograph. *Lower left*) Panoramic radiograph 9 months following injury at approximately the time drainage from the wound finally ceased. *Lower right*) Panoramic radiograph 1 year following injury just prior to bone grafting. Although the wound was now healed a non-union existed at the fracture site. (Continued in Figure 51.)

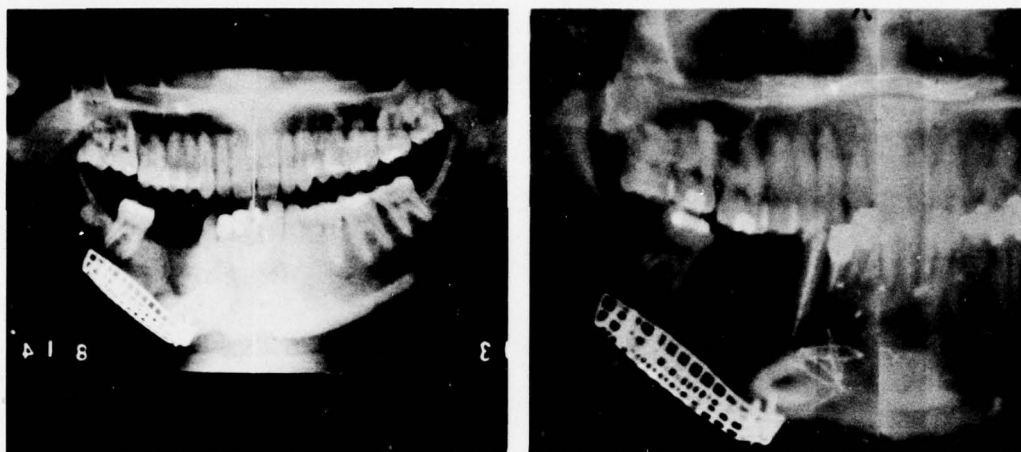


Figure 51. Continuation of Figure 50.—Left) Panoramic radiograph 3 months following PCM bone graft reconstruction of the mandible with evidence of graft repair. Right) Panoramic radiograph 74 months post injury and 26 months following bone grafting. Endodontics had been performed on teeth adjacent to the graft in the distal fragment and the proximal ramus fragment was in proper alignment as a result of its control during the pre- and postgrafting period.

in remote relation to the graft bed subsequently contributed to a postgraft infection as a result of a previously undetected fistulous tract (Figures 52 and 53).

*Teeth adjacent to the injury site* with questionable radiolucencies were definitely potential sources of late infection and thus required a most critical appraisal. Determination of vitality by conventional means was not possible when sensory innervation to the area had been disrupted. It was then necessary to rely on such imprecise criteria as tooth stability and color with the hopeful assumption that sufficient viability had been provided the dentition via the vascular network of the labial and the lingual mucosa. Bell (1969, 1971, 1973, 1976) showed that the viability of dento-osseous jaw segments can be maintained if a soft tissue vascular pedicle is intact on at least one surface of the fragment.

*Endodontic therapy* was recommended, even without confirmed nonvitality or abscess formation, when such teeth were viewed as being critical to adequate jaw fixation or for eventual prosthetic restoration. Conversely, when questionable teeth were of minimal advantage, it was prudent to remove them before grafting. There was no absolute formula applicable to this particular problem and these cases were decided on an individual basis. If endodontic therapy was not possible or had previously failed, it was considered desirable to resolve such situations in favor of tooth re-

moval to enhance the potential for graft survival.

When frank residual infection was observed in the potential graft area, removal of involved teeth was accomplished in conjunction with *surgical debridement* preliminary to reconstruction. To suppress the infection with antibiotic treatment without appropriate surgical therapy was unwise and could cause an exacerbation in the midst of reconstruction. *Bone grafting was not recommended until at least 6 weeks after debridement*, to permit revascularization and maturation of the tissues in the area. The final decision for grafting in these instances was made only after a careful clinical evaluation of the prospective graft bed to ensure it was well healed and free from infection. If grafting was accomplished too soon after such procedures there was very little chance of graft success.

### Selection of Critical Dentition

Selection of teeth, which were most critical to surgical reconstruction, necessitated a detailed appraisal of the dentition in relation to the functional capacity of the jaws.

Teeth in the proximal fragment adjacent to an avulsive defect in the mandibular body presented either an advantage or a liability. In general, non-functional teeth or those that had the potential of developing pericoronitis were removed. Teeth that were in functional occlusion were of great

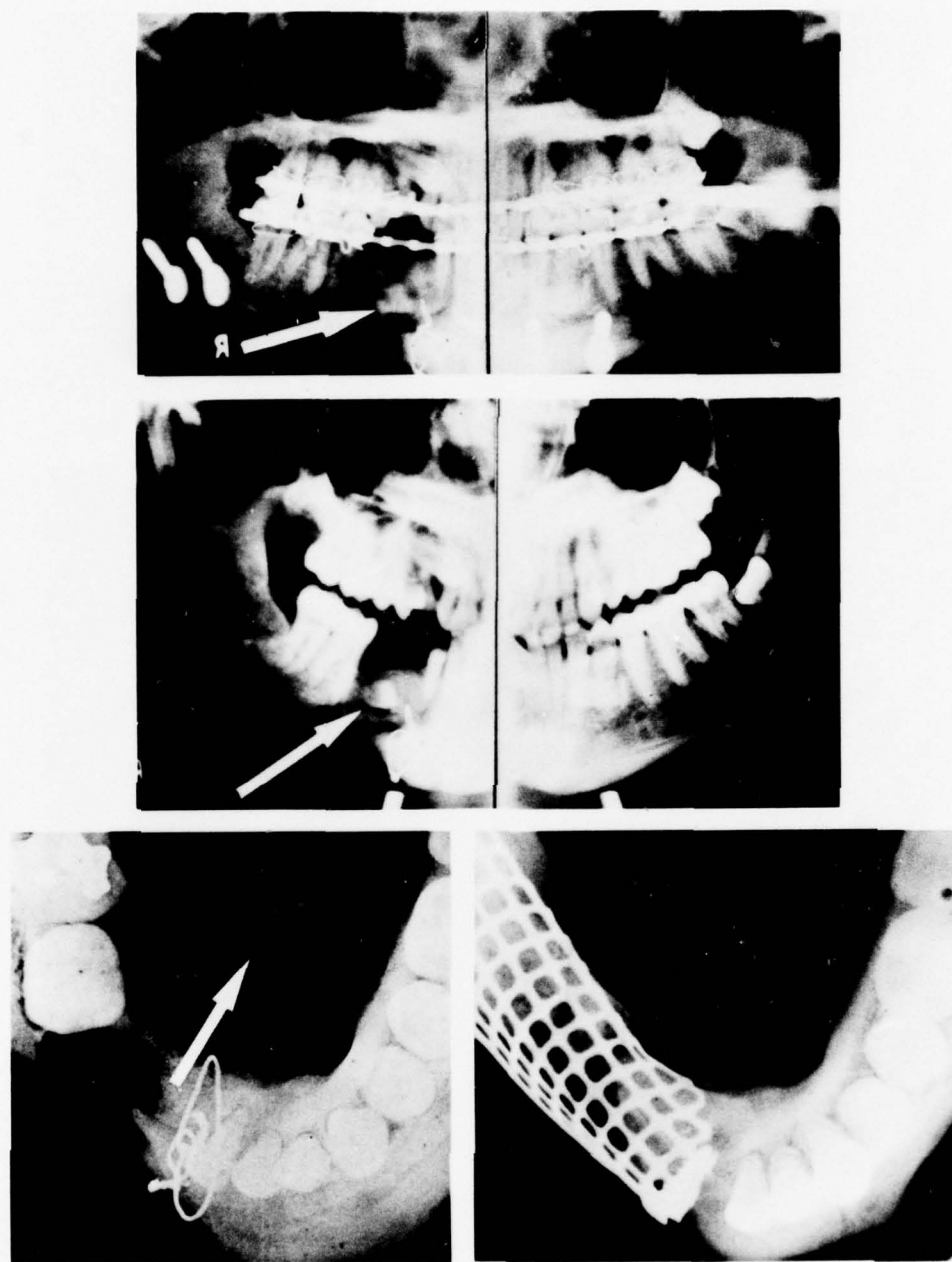
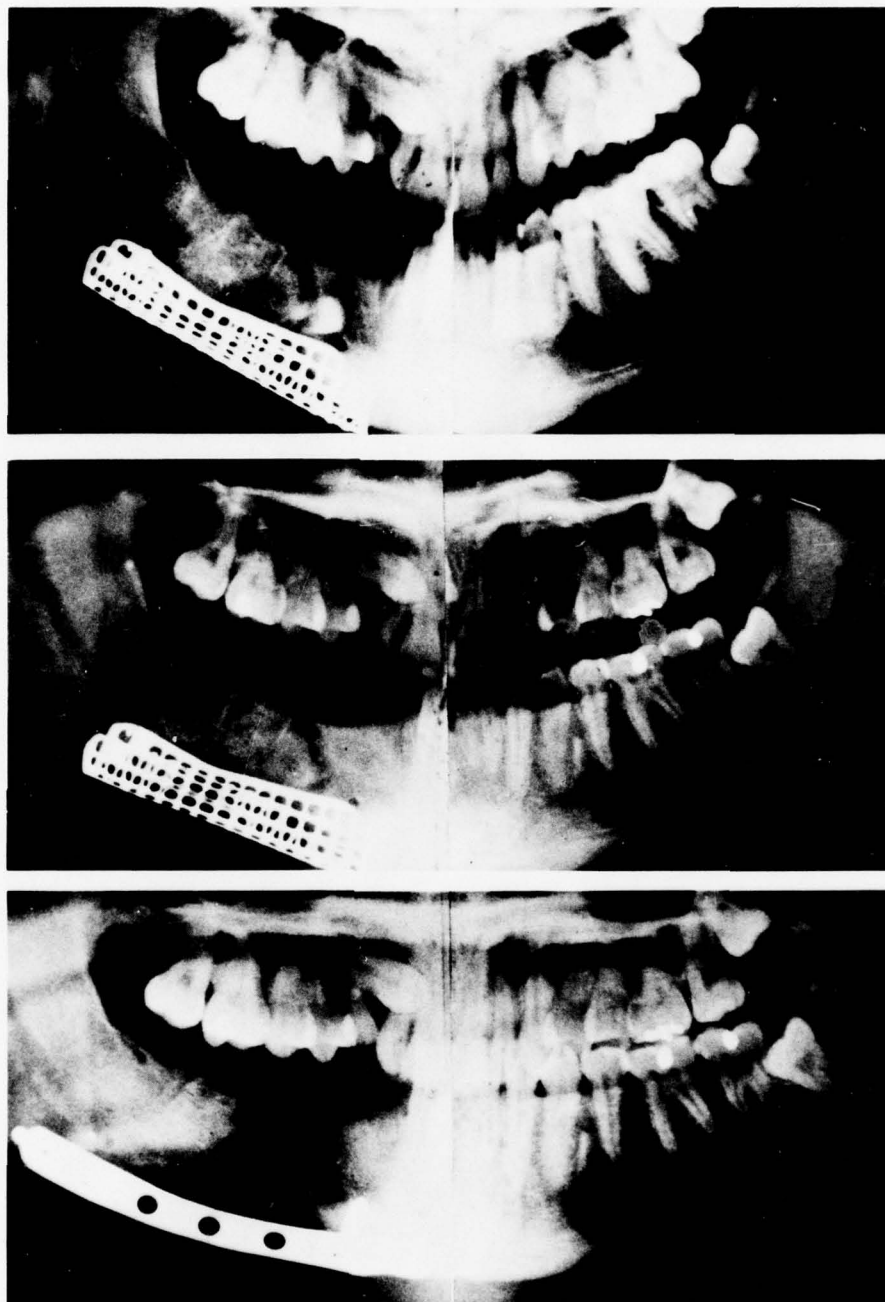


Figure 52.—*Upper*) Panoramic radiograph of a 22-year-old casualty taken 2.5 months post injury. Mandibular, extremity, and trunk injuries had resulted from fragmentation wounds that occurred when the patient stepped on a booby trap. The right mandibular injury had been treated by open reduction, biphase pin fixation and intermaxillary fixation with arch bars. Secondary debridement had been performed and teeth and bone had spontaneously sequestered from the floor of the mouth. A calcified fragment that appeared like a tooth (*arrow*) was seen at the fracture site. *Middle*) Panoramic radiograph 5 months post injury. A mandibular right second bicuspid had been extracted and all fixation had been removed although mobility was still evident at the fracture site. The tooth-like fragment (*arrow*) was still evident. *Lower left*) Occlusal radiograph of the floor of the mouth taken at the same time as the radiograph in the middle frame. The calcified fragment (*arrow*) that had been noted on panoramic radiograph was localized as being in the floor of the mouth at this time. It was elected not to remove the fragment. *Lower right*) Occlusal radiograph showing calcified fragment in floor of mouth just prior to its removal 5 months following unsuccessful PCM graft. (Continued in Figure 53).





*Figure 53. Continuation of Figure 52.—Upper)* Panoramic radiograph 9 months following injury and 4 months post bone grafting. The mandibular right first molar had been removed 4 months before the time of grafting. The calcified fragment was still evident. A chronic infection developed at the site of the bone graft and the graft did not stabilize. *Middle)* Panoramic radiograph 6 months post bone grafting. The fragment had been removed from the floor of the mouth since it was thought to be a contributing source of the chronic infection which had resulted in failure of the bone graft. A fistulous tract was identified from the fragment to the area of non-union at the graft site. *Lower)* Panoramic radiograph 3 months following a second bone graft (rib) that succeeded the first procedure by 15 months. All IMF had been removed and the mandible was stable. The graft was consolidated and mature and the mandible functional when the patient was last seen 45 months following the second bone graft.

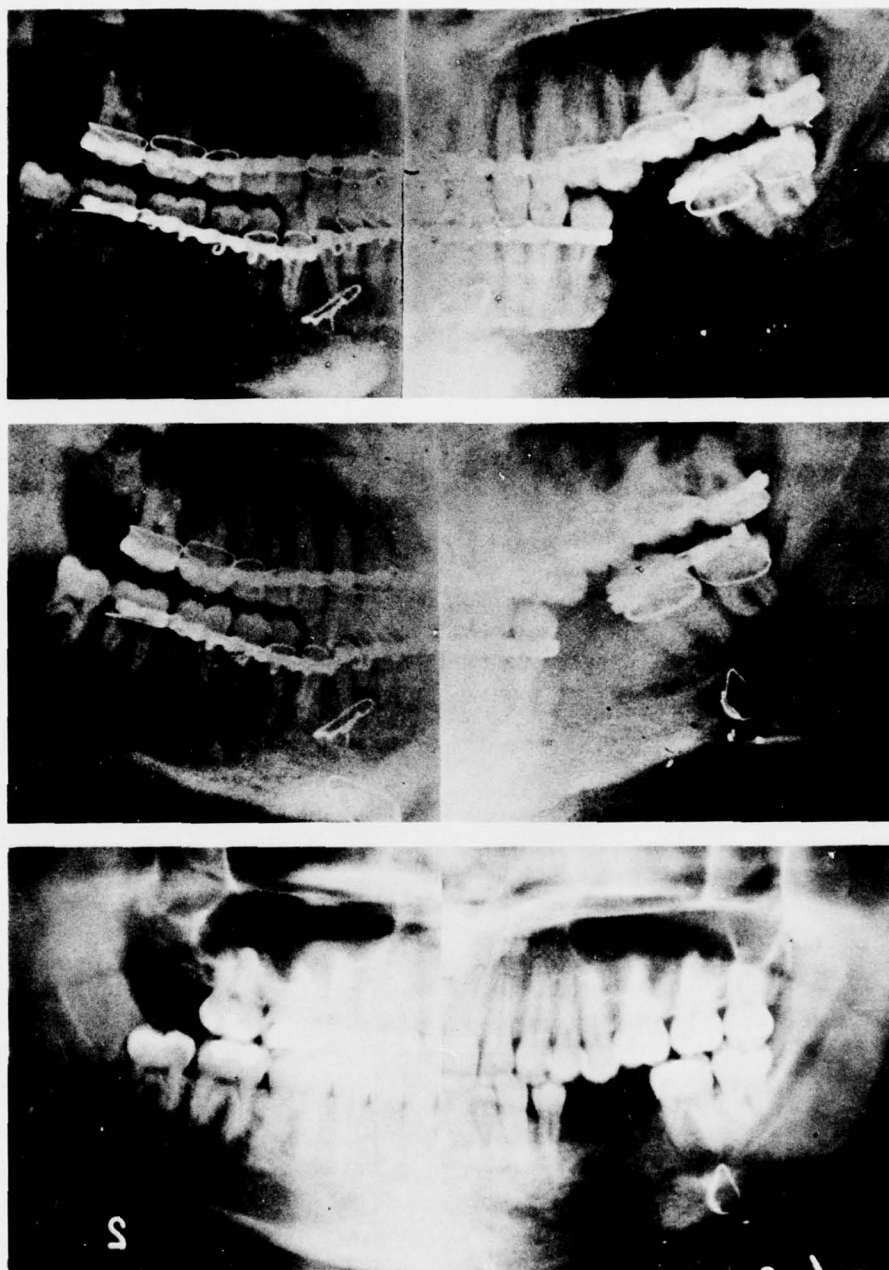


Figure 54.—*Upper*) Panoramic radiograph of a 19-year-old casualty 12 days following a high velocity missile injury to the face and jaw. Discontinuity existed in the left body of the mandible and there had been avulsion of a portion of the inferior border to and including the symphysis. Treatment had consisted of debridement and conservative open reduction (one wire in right parasymphysis area) and fixation by intermaxillary fixation with arch bars. Two molar teeth in the proximal fragment had been brought into occlusion and used for fixation thus aligning the fragment. *Middle*) Panoramic radiograph 5 months post injury and 1 month following autogenous iliac bone graft reconstruction of the mandible. The proximal fragment was still maintained in correct alignment by the occlusion of the molar teeth. No other teeth were lost during the course of healing prior to bone grafting. *Lower*) Panoramic radiograph 62 months post injury and 58 months following bone grafting. The graft was well healed, the molar teeth were still in functional relation with the maxilla and symmetry of the mandible was normal as a result of controlling the proximal fragment during the early healing and in conjunction with bone grafting.

benefit in maintaining the normal anatomic position of the proximal ramus by preventing the anterosuperior malpositioning of this fragment (Figure 54; Case reports 09, 12).

Obviously, canine teeth were advantageous both for splinting and prosthetic restoration and considerable effort was expended to retain them when it was determined they would not unduly compromise grafting.

Sometimes, when there was a limited number of remaining mandibular teeth and they were insufficient for fixation or offered little prosthetic advantage, it was considered expedient to remove them and provide graft stabilization by means other than intermaxillary fixation.

During routine prosthetic treatment, maxillary teeth that opposed an edentulous mandible were removed when necessary to relieve stress on the mandible and minimize resorption and atrophy. This philosophy was *not* considered applicable during mandibular reconstruction because it was necessary to retain all infection-free, functionally capable teeth for as long as possible to provide the greatest potential for mastication.

### Soft Tissue Considerations

**Adequacy of Tissue.** The sequelae of soft tissue injury markedly influenced osseous reconstruction so it was necessary to closely coordinate management of soft tissue problems with the management of related skeletal injury.

Occasionally, in an overzealous attempt to achieve primary closure of avulsive perioral soft tissue wounds, the principle of suturing mucosa to skin was violated at the time of early treatment with resultant *microstomia*. In such cases it was obviously essential to reestablish adequate access to the oral cavity to permit continuing wound and dental care, such as elimination of oral sepsis, definitive care of the dentition, and construction of study casts and splints. This was best accomplished by some type of commissurotomy as soon as possible after injury and unquestionably before the time of bone grafting. The needless delay and increased complexity of management seen in these cases served to strongly reinforce the absolute necessity of proper early surgical wound care (pp. 69–87, Chapter IV).

The *quantity and quality of soft tissue* in the area of the osseous defect were evaluated to ensure that it was ample to provide both cover and lining for an

anatomically positioned bone graft that was of adequate size and contour. When sufficient soft tissue was available bone grafting preceded final soft tissue revisions. If there was insufficient soft tissue for grafting, pedicled or rotational flaps were performed before grafting to correct deficiencies (Converse, 1964; Converse, 1974 [f]; Parsons, 1975). Remaining jaw segments were anatomically reduced *prior to* bringing in additional soft tissue to assure a more accurate appraisal of soft tissue requirements. After additional tissue was transposed it was *essential* to allow sufficient time for revascularization before osseous reconstruction (Case report 04).

In the MFCS series, 48 patients (32.88%) received 110 secondary soft tissue procedures exclusive of those performed for preprosthetic surgery. The greatest number of procedures were required in group I (40%) and group II (34.48%) patients. An average of 2.29 procedures were thus required per patient (Table 32). Of the total procedures, scar revisions (38.18%) and local flaps (25.45%) were most commonly used. The distinction between local flaps and scar revisions was arbitrary since most scar revisions were performed by local-flap methods yet listed in the record only as scar revision. The important point is that 63.63% (local flap and scar revision) of all soft tissue procedures were of the local variety. Distant flaps constituted 11.82% of the total procedures, skin grafts 19.09%, and mucosal grafts 5.45% (Table 33).

**Scar and Malalignment.** When anatomic reduction had been effected and maintained for a reasonable time post injury, *malalignment due to scar-tissue contracture* was minimal and did not pose a management problem. This was the case with most of the patients in the MFCS. However, in situations where appropriate early and intermediate care was not provided, intense scar tissue

TABLE 32.—Incidence of Soft Tissue Procedures

Group	Number of patients	Number of procedures	Procedures per patient
I (N=85)	34[40.00]*	74	2.17
II (N=29)	10[34.48]	25	2.50
III, IV, V (N=32)	4[12.50]	11	2.75
Total (N=146)	48[32.88]	110	2.29

\*Figures in brackets equal percentage of N.



TABLE 33.—Type and Incidence of Soft Tissue Procedures

Group	Flaps		Grafts		Scar revision	Total
	Distant	Local	Skin	Mucosa		
I	8[10.81]*	18[24.32]	13[17.57]	5[6.76]	30[40.54]	74 [100.00]
II	3[12.00]	7[28.00]	5[20.00]	1[4.00]	9[36.00]	25 [100.00]
III, IV, V	2[18.18]	3[27.27]	3[27.27]	0[00.00]	3[27.27]	11 [100.00]
Total	13[11.82]	28[25.45]	21[19.09]	6[5.45]	42[38.18]	110 [100.00]

\*Figures in brackets equal percentage of total procedures performed.

resulting from lack of fixation and chronic infection caused considerable malalignment of jaw segments, which necessitated scar excision and surgical repositioning of segments prior to grafting. Patients with these problems were commonly seen by both military and civilian surgeons involved with reconstruction of civilian casualties. Connoles (1974) described the management of these adverse sequelae in the following way:

Scar contracture in the discontinuity defect prevented anatomic reduction of remaining mandibular fragments until scar release was carried out [well in advance of bone grafting]. The jaws were stabilized anatomically at the same time as scar tissue was excised to prevent recurrence of the collapse as a result of additional cicatrix formation. Three to four weeks were allowed for mucosal healing before bone grafting. The notable exception to preliminary scar release was in instances in which the defect included the angle or vertical ramus of the mandible. In such instances, the proximal fragment is drawn superiorly and medially by unopposed masticatory muscle action [Figures 9 and 10, Chapter III]; the fragment heals in that position. It is best to reposition such fragments at the time of bone grafting.

Such a treatment rationale was appropriate in cases of gross malalignment due to contracture since stable reduction could seldom be achieved in these instances without preliminary release.

*When releasing and reducing a proximal ramus*

*fragment at the time of grafting, it was prudent to remove the coronoid process to permit unrestricted realignment of the ramus. Once the proximal fragment had been returned to its normal anatomic position, it occupied a much more inferior position. For this reason, the incision for the surgical approach was placed much lower in the neck than would ordinarily appear appropriate. This lower incision facilitated identification of tissue planes, enhanced safety of the seventh nerve branches, and assured that the incision closure would fall beneath the border of the mandible in a more esthetic position.*

**Fixation Appliances for Grafting.** *Objectives of Fixation.* The means of obtaining stable fixation of remaining jaw fragments in grafting cases were similar to those methods described in the early and intermediate chapters. *There was no universal method of fixation that was acceptable to all circumstances and, in general, the simplest and least cumbersome technique which provided stability in a given circumstance was selected.* The principal reason that appliance selection did vary from routine maxillofacial fracture treatment was the requirement for extremely long-term positive fixation encompassing both the period from time of injury to graft reconstruction as well as the postgraft interval. The previously noted mean interval from injury to grafting for MFCS patients was 253.16 days (Table 30), whereas the

TABLE 34.—Period of Intermaxillary Fixation in Conjunction with Successful Bone Grafting for Continuity

Type of graft	Mean fixation period (days)	Range of fixation period (days)
A. Iliac (N=21)	69.67	36 - 131
B. Rib (N=4)	77.00	51 - 116
C. PCM (N=22)	47.73	21 - 85
D. Other (N=1)	70.00	-
Total (N=48)	60.23	21 - 131

mean period of intermaxillary fixation following graft reconstruction was 60.23 days (Table 34).

During the pregrafting period emphasis was placed on maintaining reduction with adequate fixation by closed means. Whenever feasible, the use of monoarch fixation was employed to permit more satisfactory dietary intake as well as access to the oral cavity (Figures 50 and 51; Case report 13). This not only allowed improved oral hygiene and wound care, but greatly simplified anesthetic management during treatment of other injuries.

Stabilization appliance requirements were reappraised in the immediate pregrafting phase of treatment. If the case was uncomplicated and the dentition adequate, the only need was to ensure that IMF was still secure and did not have to be readjusted or reapplied.

Table 35 lists the frequency of utilization for the various methods of fixation in conjunction with bone grafting. Intermaxillary fixation with stock arch bars was used in 43.59% of the patients, while custom arch bars were fabricated for 19.23%. Not uncommonly, it was necessary to supplement intermaxillary fixation to provide the positive stability required in grafting. This was usually due to a lack of sufficient dentition or the complex nature of the injury. The inadequacy of simple intermaxillary fixation in these circumstances was overcome with various types of custom fabricated intraoral splints or arch bars, extraoral fixation appliances, and in some cases with internal fixation achieved during reconstructive surgery. In 26.92% of the patients a

combination of fixation methods was utilized. The most common conjoint fixation systems were custom splints in conjunction with stock arch bars in 11 patients [14.10%] followed by biphasic external skeletal fixation and intermaxillary fixation in 7 [8.97%]. (See footnote table 35)

*Oral Splints.* In many respects, the intraoral splints used for graft stabilization resembled conventional fracture splints though the requirements for absolute stability of fragments in conjunction with grafting were more critical. Splint failure during fracture treatment usually necessitates only the inconvenience of reapplication and possible delay in union, whereas failure of a splint during grafting was more serious and frequently resulted in an unsuccessful graft. Whereas monoarch splinting was acceptable in the pregrafting period, it was generally recommended that splinting plus intermaxillary fixation be used in conjunction with grafting to assure positive stability, particularly during the early phase of osseous repair. Once satisfactory graft healing and union were evident, it was possible to return to monoarch splint stabilization while the graft underwent maturation.

*Rigid one-piece splints that spanned the avulsive defect* were used most commonly; they were constructed in either acrylic resin, gold, or chrome-cobalt alloy. *Cast metal splints* had the advantage of providing very positive fixation with a minimum of bulk. However, they were extremely unforgiving of any technical or planning errors and were difficult to modify at surgery. Even a slight alteration in the relation of osseous fragments

TABLE 35.—Frequency of Various Methods of Fixation in Conjunction with Bone Grafting

Type of graft	Arch bars		Custom splint	Other*	Combinations
	Stock	Custom			
Iliac (N=33)	11[33.33]†	6[18.18]	2[06.06]	1[12.50]	12[36.36]
Rib (N=8)	1[12.50]	0[00.00]	2[25.00]	1[12.50]	4[50.00]
PCM (N=34)	20[58.82]	8[23.53]	0[00.00]	1[02.94]	5[14.71]
Other (N=3)	2[66.67]	1[33.33]	0[00.00]	0[00.00]	0[00.00]
Total (N=78)	34[43.59]	15[19.23]	4[05.13]	4[05.13]	21[26.92]

\*Other: Biphasic ..... 2  
K-wire ..... 1  
Ivy Loops ..... 1

Combinations:  
Custom splint + stock  
arch bar [14.10] ..... 11  
Biphasic + IMF [8.97] ..... 7  
Headband + IMF ..... 1  
Other ..... 2

†Figures in brackets equal percentage of N.



was greatly magnified at the dentition-splint interface, thus precluding insertion of the splint without significant adjustment. For this reason, it was often the practice at the time of grafting to utilize *acrylic splints* that could be more easily adjusted to planned or anticipated changes in fragment position. If a metallic splint was desirable but there existed a possibility of fragment repositioning at surgery that might preclude metal splint adjustment, an acrylic splint was also constructed to be used as an alternative and thus eliminate the necessity of abandoning splint stabilization altogether. At an appropriate interval following surgery, the acrylic splint could be replaced with a metallic splint that permitted more satisfactory long-term stabilization including monoarch fixation.

When the teeth to be ligated to the splint were not entirely satisfactory, i.e., short clinical crowns, limited number, the splint tended to loosen during the critical period of immobilization. To prevent this particularly undesirable complication, it was advisable to *enhance splint retention with circummandibular wiring* although these adjunctive wires were not placed too close to the graft site because they could provide a potential source of graft contamination. The oral and extraoral tissues along the wire tracts were carefully observed for signs of inflammation and all wires were removed if infection developed.

**External Skeletal-Pin Fixation.** In the presence of inadequate dentition or edentulous fragments that could not be appropriately controlled by intraoral splints, external skeletal-pin fixation was used to control jaw fragments. In the past the Roger Anderson appliance was used in this country; however, its use has become less popular, partially because of inexpert utilization but also because of intrinsic disadvantages with the system itself.

The majority of Vietnam casualties requiring external pin fixation were treated with the *biphasic appliance* (Morris, 1949) (Case reports 05, 14, and 17). The advantages of the biphasic appliance were: 1) The pin-screw design provided positive bony engagement and thus ensured long-term stability; 2) the acrylic stabilization bar was light, strong, and contoured readily to facial form; 3) the appliance could be released and reapplied as necessary; 4) the appliance was applicable in a variety of anatomic locations and clinical situations (Kelly, 1971).

When the biphasic pins were placed it was essential to engage both the inner and outer complex of the mandible to ensure firm engagement and long-term stability. Two pins were placed in the proximal and distal segments, a sufficient distance from the graft margin to reduce contamination via the pin tract. Because the external pins penetrated the cutaneous barrier, they represented a potential pathway for introduction of infection and it was *essential to maintain scrupulous cleanliness around the pins*. Inadequate seating of pins and pin-tract infection were the most common causes of appliance failure.

**Internal Stabilization.** Various methods of internal fixation were used for graft stabilization such as *wires, pins, plates, or metal cribs*. Specific applications of internal fixation will be presented in association with discussion of the various grafting methods.

## METHODS OF GRAFTING

### Introduction

As previously stated, there are numerous grafting systems available and *no one system has as yet demonstrated universal applicability* for mandibular grafting. However, individual characteristics of the various systems may be of relative advantage in particular clinical situations. A discussion of the characteristics of the more commonly employed grafting methods follows.

### Iliac Crest Grafts

**Techniques of Graft Recovery.** The various approaches to the iliac crest for obtaining bone graft material are well documented in the surgical literature and only a brief summary of the most commonly used methods, the rationale for their use, and complications that might develop are presented.

The iliac crest may be approached anterolaterally or posteriorly to obtain either solid or particulate graft material. The anterolateral approach was employed in the majority of MFCS patients receiving solid iliac grafts as well as those cases where cancellous bone and marrow were recovered for particulate grafts.

When the *anterolateral approach* was employed, the patient was placed in a supine position and the



donor hip elevated. If the incision was placed directly over the crest and continued directly to bone in a single plane, there was a tendency for postoperative scar contracture along the belt line which caused discomfort to the patient. This was avoided by utilization of a stepwise approach to the crest. The skin incision was initiated approximately 1 inch below and parallel to the crest while the rest of the dissection was carried down to bone directly over the crest. This stepwise approach prevented development of a direct scar band from bone to the skin surface and also placed the incision line well below the crest. Dissection in the inferior portion of the incision was carried out with caution because the lateral femoral cutaneous nerve passes over the inferior portion of the anterior crest and its severance produces a rather annoying anesthesia on the ventral surface of the thigh. Retraction of tissues medial to the ilium was judicious since herniation of abdominal contents from this location was a reported complication of iliac osteotomy (Reid, 1968).

Either *full- or half-thickness grafts* could be obtained from the anterolateral approach though, in general, full-thickness grafts of the iliac crest were avoided if possible since their removal created a distinct deformity of the hip. Half-thickness grafts were most commonly employed because they had the advantage of maintaining the overall morphology of the iliac crest while providing sufficient bone for reconstruction. The *unique curvature of the ilium* allowed selection of a portion of the crest which best conformed to specific requirements for mandibular contour (Mohnac, 1969). More discomfort was noted when a block graft was removed from the lateral aspect of the crest since this is the origin of the abductor muscles of the leg (Crenshaw, 1971[a]). Half-thickness grafts taken from the medial aspect caused less discomfort during early postoperative ambulation. Although some degree of remodeling takes place in the iliac crest following removal of a block graft, it was generally not possible to use this same donor area for future grafts.

*Chip grafts of cancellous bone and marrow* have the distinct advantage that they could be obtained in such a way that essentially no deformity of the hip occurred. Most frequently bone was removed by curettage of the marrow space through an osteotomy window in the cortical plate, either by raising and then replacing an osteoperiosteal flap

or removal of a cortical bone plug.

Although the *posterior approach* to the crest required a larger incision and a greater depth of dissection through soft tissue, a large portion of the crest could be removed with less deformity and minimal discomfort upon ambulation in the early postoperative phase. The posterior approach was used primarily when a large block graft was required. The patient was positioned in either the lateral decubitus or prone position and a 6- to 8-inch curvilinear incision was made along the palpable outline of the posterior iliac crest. Because of the greater mass of soft tissue involved in dissection and the generally larger size of the grafts when this approach was used, drainage of the wound was routinely employed to prevent formation of a hematoma. This was in contradistinction to the anterior approach where the use of a drain was more of an elective decision based on intraoperative findings.

**Block Grafting to the Mandible.** Iliac crest block grafts were used in a variety of ways to restore mandibular discontinuity defects. Thirty-five MFCS patients received this type of graft (Table 24). Block grafting was accomplished by different techniques such as inlay, onlay, or inlay-onlay combination.

*Inlay grafts* restored just the defect with no overlay of proximal or distal host bone (Crenshaw, 1971[b]). Prior to placement of the graft, the mandibular bone ends were cut back to a bleeding surface to encourage vascularization and to provide a smooth interface for abutment of the graft. The grafts were usually secured with interosseous wiring though bone plates or metal mesh also were occasionally used (Figure 55). Augmentation of these grafts with cancellous chips to enhance healing was found effective, particularly at the graft-host junction (Obwegeser, 1966). Inlay grafting is essentially gap filling and does not afford primary stability to the reconstructed jaw; therefore, it was used when graft stability could be achieved by firm jaw immobilization or other positive means of fixation.

Although *onlay grafting* was used to restore all areas of the mandible, these grafts were considered most appropriate in areas subject to considerable stress. The onlay graft overlaid the host bone adjacent to the defect thus providing additional stability. They were placed on either the lateral or medial surface of the mandible and secured with interosseous wiring—they bridged

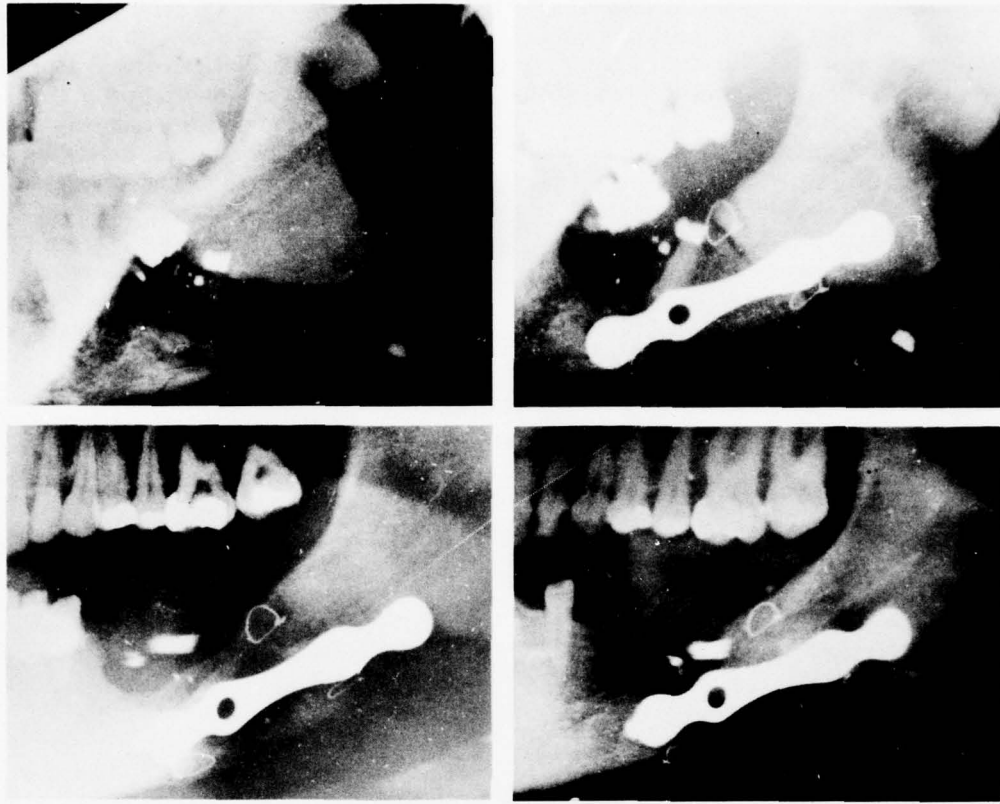


Figure 55.—*Upper left*) Lateral radiograph of mandible of a 22-year-old casualty 6 months following multiple fragmentation wounds that included mandibular injury. Early, intermediate, and initial phase of late care had been complicated by the severity of the thoracic, abdominal, and extremity injuries. He had been admitted to a late care facility for mandibular reconstruction 5 months after injury at which time the edentulous proximal fragment was markedly distracted and a discontinuity defect existed. *Upper right*) Lateral radiograph of mandible 3 weeks following mandibular reconstruction with a solid, autogenous, iliac, inlay bone graft that had been placed 6 months post injury. The proximal fragment had been repositioned with difficulty and internal fixation was provided by a Sherman bone plate. *Lower left*) Lateral radiograph of mandible 7 months post grafting. The graft was well incorporated. Note the presence of several metallic missile fragments that had been allowed to remain in the soft tissues as they were asymptomatic. *Lower right*) Lateral radiograph of mandible 8 years and 6 months post grafting. The graft had remodeled to a lesser dimension as the metal plate was accepting the major portion of the vector forces within the mandible.

rather than filled the discontinuity defect and thus did not always provide sufficient bulk or accurately restore desired contour.

The *inlay-onlay* graft, which was prepared to both overlay and fill the defect, did conform more accurately to mandibular morphology and produced sufficient bulk of osseous tissue, but its preparation was tedious and very time consuming.

In a number of cases a grafting system was employed in which an onlay portion, a section of corticocancellous bone, was overlaid on the lingual surface of the mandible and the discontinuity defect was overfilled with cancellous chips. Stabil-

ity was provided by the onlay section, and the cancellous chips not only restored morphology but also assured active, early osteogenesis at the graft site (Mowlem 1944; Burwell, 1964). The early healing and ultimate maturation of such grafts were excellent and, in addition, the amount of metal required in the system was minimal, thus improving the opportunity for uncomplicated secondary preprosthetic surgery when required (Figure 56; Case report 15).

*Partial decortication of solid grafts*, which was consistent with strength requirements, was frequently employed since it theoretically increased exposure of the osteogenic marrow tissue. Such

exposure was thought to improve vascularization of the graft and promote earlier and more extensive osteogenesis while at the same time enhancing the ability of the graft tissue to survive infection (Obwegeser, 1966).

When successful, block grafts had the advantage of providing sufficient bone for long-term requirements for strength as well as continuity. In addition, they could be performed with a minimum of sophisticated instruments, materials, and laboratory support; a distinct advantage with any type of surgery.

A number of disadvantages were observed in association with block grafting. It was sometimes difficult to obtain adequate bone to restore large mandibular defects without significant mutilation of the iliac crest, a situation that often precluded subsequent use of the crest as a source for additional grafts. *Infection of block grafts created a precarious situation* since they contained a high percentage of cortical bone which was slowly replaced with viable tissue and tended to resist infection poorly. Once they became infected there was often sloughing of the entire graft unit as compared to the situation in the more viable corticocancellous grafts where at least partial survival of osseous tissue occurred. Despite excellent graft preparation and stabilization at the time of operation, *block grafts were slow to remineralize* and required relatively long periods of rigid immobilization (Table 34). When these grafts were prematurely placed into function before sufficient remineralization had occurred, a degree of collapse or malalignment resulted.

### Rib Grafts

The procedure for removal of autogenous ribs was accomplished by a surgical consultant experienced with rib resection. A *lateral approach* was most commonly employed and an appropriate length of the sixth, seventh, or eighth ribs was recovered. Anteriorly the amount of rib available for resection is limited by the costochondral junction, thus when long spans of rib were required it was necessary to extend the dissection more posteriorly. This posterior dissection was necessarily carried through the heavy back musculature which finds its insertion on the humerus and as a result greater postoperative morbidity was experienced including temporary, painful limitation of arm movement.

As shown in Table 24, *eight rib grafts were used to reconstruct discontinuity defects in MFCS patients*. They were generally performed as onlay grafts, that is with the rib overlapping the medial or lateral aspect of host bone adjacent to the graft. Although the rib has been used to restore the mandibular deficits in all locations, it was particularly advantageous for restoration of the curved region of the symphysis. Six of the eight rib grafts placed in MFCS patients were used to restore this area (Table 25), and this perhaps explains the slightly longer mean period of fixation for these patients (Table 34).

To facilitate bending the rib to the desired contour, it was usually grooved at intervals along the medial aspect and gently fractured in an incomplete or "green stick" manner (Figure 57). An alternative method involves the use of split rib, as described by Longacre (1957).

The major drawback of autogenous ribs for restoring mandibular discontinuity is their lack of bulk. The superior-inferior height of most adult ribs is only 1–1.5 cm, whereas the width is less than 1 cm. Ribs, like other osseous grafts, undergo resorption and remodeling during healing and occasionally the amount of bone remaining was insufficient to provide adequate strength and/or alveolar bulk to the restored mandible. In these cases, secondary bony augmentation, principally for preprosthetic purposes, was performed prior to construction of a prosthesis and restoration of normal masticatory function. It should be noted that lack of alveolar bulk for prosthetic restoration following grafting was seen with solid iliac and PCM grafts as well.

### PCM Grafts

Boyne (1970) developed a modification of Mowlem's chip grafting involving the use of a metallic crib lined with a microporous filter into which cancellous marrow material was placed, to effect restoration of osseous defects. This grafting system took advantage of the superior osteogenic potential of cancellous bone and allowed removal of adequate graft material from the ilium without mutilation of the donor site. Additionally, the metal crib provided intrinsic support to the graft system. The mean period of IMF following PCM grafting was considerably less than for rib, ilium, or composite grafts (Table 34), although a relatively high percentage of



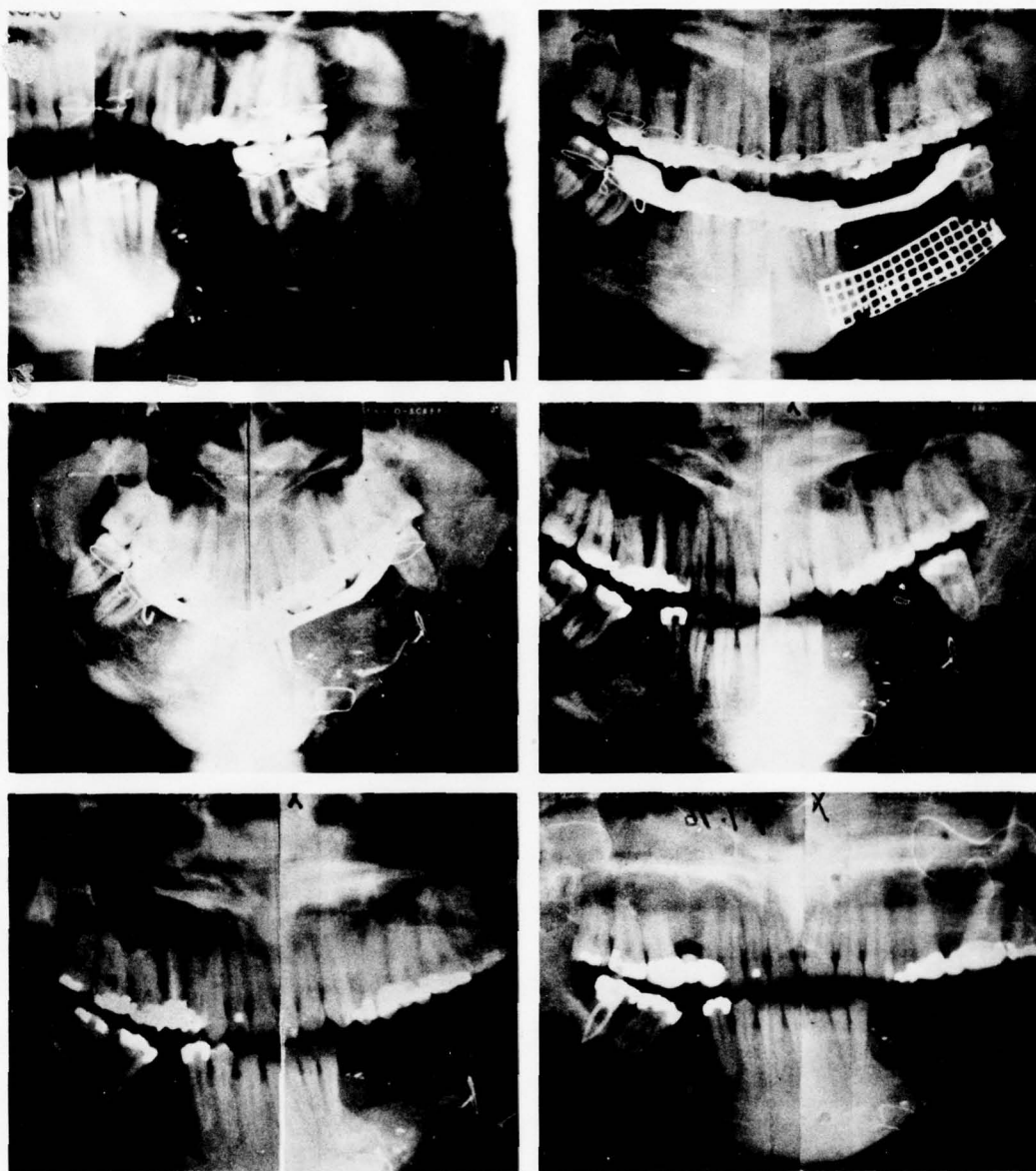


Figure 56.—*Upper left*) Left panoramic radiograph 6 weeks post injury of a 20-year-old casualty who had sustained multiple fragmentation wounds including the orofacial area. The mandibular wound had been debrided and the jaw placed in IMF with Ivy loops; the wound had healed without complications. The proximal ramus fragment had been maintained in position by the mandibular second and third molars. The roots of the second molar projecting into the discontinuity defect were not adequately supported by bone and the tooth was removed prior to bone grafting. *Upper right*) Left panoramic radiograph 15 weeks following a PCM graft to the mandible. No osseous regeneration had occurred at the graft site and the mandible was unstable when the monoarch splint was removed. *Middle left*) Left panoramic radiograph 20 days following a second bone graft to the mandible. The graft consisted of a single table sheet of autogenous corticocancellous iliac bone that was secured to the medial aspect of the mandible and augmented with particles of cancellous marrow. *Middle right*) Left panoramic radiograph 5 months following the second bone graft showing satisfactory consolidation of the graft at this interval. *Lower left*) Left panoramic radiograph 24 months post grafting. Unfortunately, the mandibular third molar had been lost thus creating an edentulous space with no distal abutment. *Lower right*) Left panoramic radiograph 8 years following the second bone graft. The graft is mature and has remodeled to conform with the functional axis of the mandible.



Figure 57. — *Upper*) Cortical cuts being made in autogenous rib graft to permit bending of the bone to conform to the "U" shape of the mandible. *Middle*) Spine of the rib being removed to facilitate bending to desirable shape. *Lower*) Autogenous rib graft contoured to the shape of the mandible.

PCM grafts was placed in short-span body defects (Table 25).

**The Metallic Crib.** A variety of metal cribs was employed with this system including individually cast cribs of chrome-cobalt alloy as well as swaged or adapted cribs from panels of titanium or Vitallium®. The type of crib was selected on the basis of the technologic laboratory support available to the surgeon as well as the crib characteristics which offered relative advantage in the particular grafting situation. The cribs were usually secured to bone by compatible metal screws.

*Custom cast cribs* of surgical chrome-cobalt alloy offered the greatest degree of rigidity. They were employed infrequently for avulsive defects of modest size, because they required time-consuming fabrication and when used were most advantageous where extremely large segments of the mandible were to be restored. A pattern for the crib was usually developed with the use of a mandible from a dry skull which approximated the size and shape desired for the particular patient; the preliminary pattern could be modified to more accurately conform to the actual contour. Determination of crib contour that would best approximate the desired mandibular morphology was aided with the use of lateral cephalometric radiographs, preinjury photographs, if available, and appraisal of the quantity and quality of soft tissue overlying the defect. It was desirable that the design of the crib assure at least 1.5 cm of overlay onto the proximal and distal fragments to provide sufficient stabilization. The enhancement of stabilization by broad crib overlap was due not only to the larger area of crib in contact with host bone but also to wider placement of the fixation screws, which was possible in these instances. Screws used for securing the crib to the bone were preferably cast in the same metal as the crib to prevent electrolysis induced by dissimilar metals.

*Titanium and Vitallium® implants* were commercially available either as flat panels that could be contoured to the desired shape or as preformed contoured cribs that could be modified at surgery. Vitallium® is an alloy whereas titanium is a pure metal, and each material has been found clinically acceptable. Of significance, however, is the relative difference in malleability and plasticity of the two metals. Titanium is much more plastic, and a given thickness must be very nearly twice that of Vitallium® to achieve the same resist-

ance to deformation with a given stress (Steinmann, 1973). This point is probably most pertinent in weighing the advantage of the malleability versus stability required in a particular grafting situation.

During the era of the Vietnam conflict, most PCM grafts were supported with contoured Vitalium® panel cribs since this was the material most readily available at the time. Panels were supplied in various thicknesses, and the most commonly used gauges ran from 12 to 25 thousandths of an inch (0.3–0.6 mm). The heavier gauges were employed for grafts in the posterior body region of the mandible, especially when the crib provided stabilization to the proximal fragment. Normally the heavier gauges of the panel were precontoured before surgery and slight modifications were carried out during the operation. The use of malleable panels, which could be cut and contoured to size in the operating room, was of distinct advantage in cases where the size of the discontinuity defect could not be determined until final reduction of segments was accomplished during surgery. In areas of acute curvature, as in the symphysis region, contour could be achieved with multiple partial sections on the medial aspect, which allowed overlap of the contoured panel. This technique had the advantage of achieving the desired contour and curvature, but much of the rigidity of the crib was sacrificed.

Selection of the crib material and thickness depended upon availability and the situation in which it was being utilized. A more malleable, lighter crib could be used if it was only supplementing other fixation schemes such as intermaxillary fixation, biphase pins, and monoarch splints. The more stable and thicker crib material was used when a major portion of the fixation was provided by the crib itself. In any event, every effort was made to reduce the bulk of the crib to the absolute minimum required to accomplish its intended purpose.

**Technique of Application.** When PCM grafts were used, it was not as critical to identify the exact size of the defect before removal of donor bone as it was with block grafting, because it was much easier to estimate the quantity of particulate cancellous marrow required to fill the defect than it was to select the exact size of a block section of bone that would be needed. Thus, donor material could be obtained before graft-site surgery or

the two procedures could be carried out simultaneously, which reduced operation time. Additionally, there was less need for modification of mandibular host bone unless considerable eburnation was present. This was in contrast to block grafting where considerable time and effort were consumed in placing the graft and making precise butt or morticed joints to provide local fixation and stability between the host-graft segments.

When the metal crib was placed, a 1.5 cm or more overlap on both host bone ends was desired, with at least two screws in each of these overlapped areas to secure the crib to the adjacent bone. It was found that only a light lateral-medial curve at the inferior aspect was required to give inherent strength to the crib. The vertical dimension was adjusted so that the portion bridging the edentulous space was of just sufficient height to provide the support needed.

Careful control of this vertical crib height dimension was important in reducing late complications caused by the superior edges of the crib being exposed to the oral cavity in response to pressure by denture flanges or subsequent preprosthetic surgical procedures. When the crib eroded through the mucosa it usually had to be removed.

When the metal crib was placed, it was highly desirable that the *flange not be palpable through the overlay mucosa*. This became significant at the time of denture fabrication because when the crib flange was distinctly palpable intraorally it presented a location for pressure ulceration, and removal of the crib was required before a denture was constructed. Crib placement will be discussed further in the section on preprosthetic surgery.

Regeneration of bone above the level of the crib was essentially undirected and uncontrolled. To assist the establishment of vertical graft height, particularly when a low crib was used, it was necessary to *overpack the crib* in an effort to encourage osseous proliferation that would provide vertical height and establish alveolar bulk for subsequent denture requirements.

**Long-Span PCM Grafts.** Although complications associated with grafts will be subsequently discussed, it is pertinent to mention at this time a common observation concerning long-span PCM grafts. There was a *tendency for inadequate graft proliferation in the very long spans, particularly in the midgraft area* (Case report 16). Whether this was



due to a lack of vascularity for graft nutrition is only a matter of speculation. Whatever the cause of this lack of proliferation, it perhaps should influence the selection of grafting system for this type of situation. A crib-supported block graft augmented with particulate cancellous marrow could be postulated as probably the most acceptable method in these circumstances.

## COMPLICATIONS OF BONE GRAFT RECONSTRUCTION

Recurring problems with both recipient and donor sites were encountered in bone graft reconstruction. These complications were sometimes unavoidable, but their sequelae were minimized and their incidence was reduced by recognition of the potential for their development and institution of measures to avoid them. With the understanding that occasional complications will occur, particularly in the management of complex war trauma cases, this section identifies what these complications are rather than pontificates with clarity of hindsight concerning errors in management.

### Donor Site Complications

**Iliac Crest.** In addition to *almost universal difficulty on early ambulation*, a number of other complications were associated with iliac crest osteotomy. Most commonly a *postoperative hematoma* was found. Although these usually resolved innocuously, they represented a potential for infection and if significant fluid was present aspiration and culture under aseptic conditions were performed. Infections usually arose from surgical contamination alone or in conjunction with devitalized bone. They were treated with local wound care such as irrigation, debridement, and appropriate antibiotic therapy.

Infrequently a *postoperative ileus* developed secondary to retroperitoneal hematoma and for this reason it was well to confirm the presence of bowel sounds and remain carefully alert for abdominal distention. Herniation was reported after removal of large full-thickness grafts (Reid, 1968) and, although a rare complication, it should be considered when prolonged ileus or a palpable soft-tissue mass appear in the area of surgery. Obviously, such complications are man-

aged by an appropriate surgical specialist.

**Rib Resection.** Pneumothorax is the most commonly encountered complication of rib resection and, although it was not reported in the MFCS group, this is not viewed as representative because of the small number of patients. Davis (1976) and Baker and Connole (1976[a]) reported an incidence of pneumothorax of 25% in a combined group of 58 patients who underwent rib resection in association with bone graft augmentation of the jaws for preprosthetic purposes. All the patients who experienced pneumothorax were treated with a chest tube without serious sequelae. The relatively high incidence of pneumothorax does not preclude rib grafting when indicated, because the condition is temporary when properly treated. There is, however, a definite need for careful patient management by members of both surgical teams to assure early diagnosis and treatment of pulmonary dysfunction. Normal lung expansion was routinely confirmed in the recovery room by chest radiographs and auscultation.

Even in the absence of pneumothorax there is a tendency toward restricted lung expansion during the early postoperative period; therefore aggressive pulmonary care was routinely employed, particularly the encouragement of deep breathing and maintenance of meticulous pulmonary toilet. When longer sections of rib were required, the patients frequently experienced aggravating symptoms associated with the donor site that included tenderness over the incision area and discomfort on deep breathing (Baker and Connole, 1976[b]).

### Recipient Site Complications

The *majority of recipient site complications were infectious in nature*. The incidence of postoperative infections for all MFCS bone graft patients was 33.66%. Interestingly, the incidence for continuity grafts (33.73%) was almost identical to that for augmentation grafts (33.33%) (Table 36). When wound infection developed in cases of grafting for continuity, it was of considerable concern because in 12 of 28 instances (43%) there was failure to achieve continuity. Connole (1974) reported an infection/graft failure ratio of 50% in a series of PCM grafts.

A resume of factors that contributed to graft

infection, as well as comments concerning their prevention and/or management, follows.

TABLE 36.—*Bone Grafting—Postoperative Infection*

Grafts for:	Number of infections*
A. <i>Continuity</i>	
Iliac (N=35)	10
Rib (N=8)	5
PCM (N=37)	10
Other (N=3)	3
Total (N=83)	28{33.73}
B. <i>Augmentation</i>	
Iliac (N=11)	3
Rib (N=4)	2
PCM (N=3)	1
Other (N=0)	0
Total (N=18)	6{33.33}
C. <i>Total, all grafts</i> (N=101)	34{33.66}

\*Figures in brackets equal percentage of N.

**Nonvital Teeth or Foreign Bodies.** The presence of nonvital teeth adjacent to the graft site was frequently implicated in the development of graft infection and resulting failure (Figures 58 and 59). Previously quiescent foreign material, in close proximity to the graft site, was recontaminated at surgery and infection ensued complicating the entire procedure. It was therefore necessary to conduct a careful clinical and radiographic preoperative evaluation and if these sources of infection were present, redebridement was necessary prior to final graft preparation. Additionally, previously sound teeth were occasionally inadvertently devitalized during the graft procedure when the surgeon was recontouring host bone, placing fixation wires, or inserting bone screws. To obviate these iatrogenically created sources of infection meticulous surgery with full knowledge of pertinent anatomic detail was necessary.

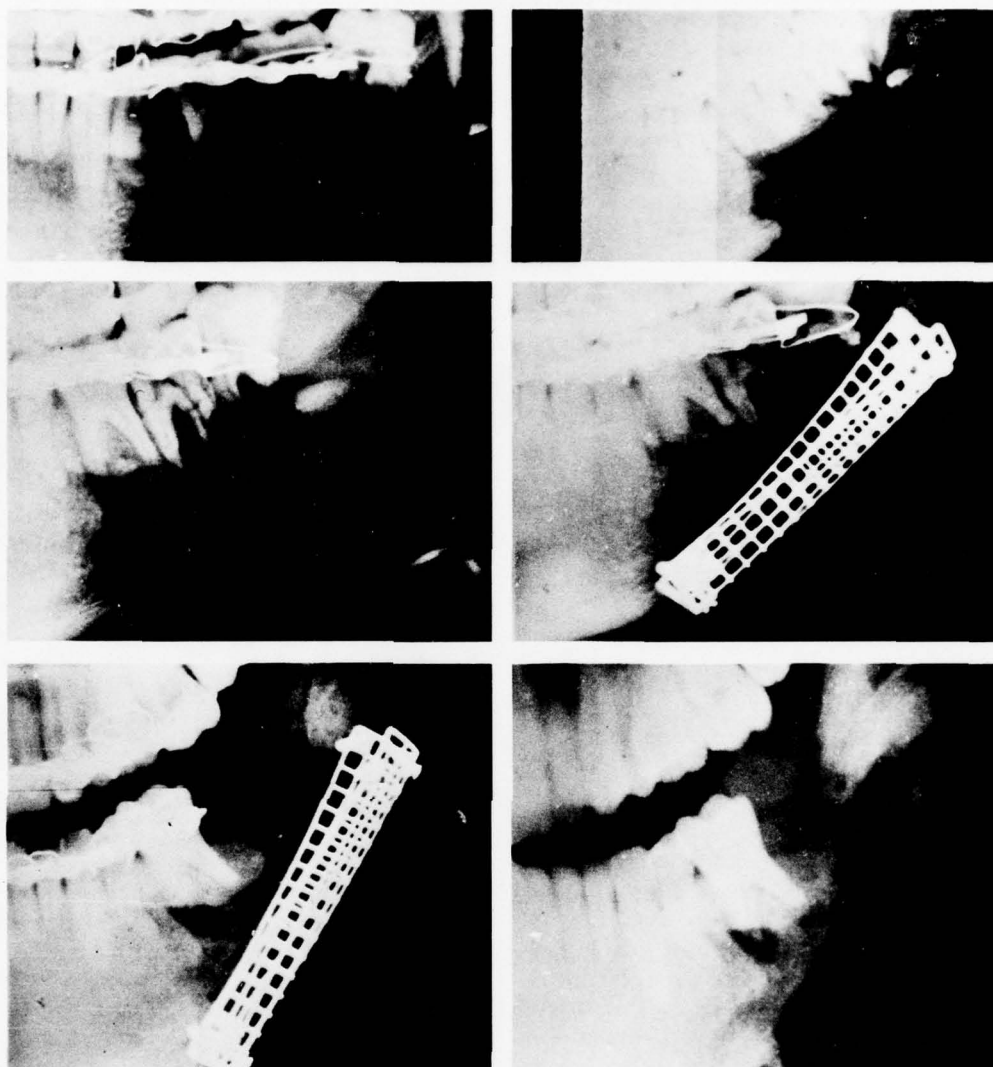
**Hematoma Formation.** Occasionally, despite correct wound management, hematoma developed. This served as a potential culture media for bacteria that might be in the wound as a result of surgical contamination. The accumulation of such fluid also prevented the adaptation and revascularization of tissues, thus compromising

early graft nutrition. Large hematomas that had widely dissected tissue planes were evacuated aseptically and cultured; a drain was placed and a pressure dressing reapplied in an attempt to prevent reaccumulation of fluid. If pus was present or C&S studies confirmed pathologic organisms, wound irrigation with saline or an appropriate antiinfective solution was instituted to prevent accumulation of contaminated exudate around the graft. Early, aggressive treatment with irrigations, and of course, proper systemic antibiotics, often prevented graft failure.

**Violation of Oral Mucosa and Wound Dehiscence.** Inadvertent intraoral perforation with resultant break in aseptic technique sometimes occurred even after careful dissection. It was difficult to establish the precise depth of the plane for the graft bed in the scar tissue present in the defect. If the perforation was recognized at surgery, it was carefully closed to reestablish a water-tight seal and the wound was copiously irrigated. If antibiotics were not being used, they were instituted intravenously during surgery and continued by the appropriate route for at least 7 days postoperatively to treat the now contaminated wound.

Intraoral perforation during surgery could occur without recognition, thus it was necessary to rule out this violation whenever postgrafting infection occurred. This was accomplished by release of IMF and examination of the floor of the mouth for a mucosal rent and/or the presence of purulent exudate. In instances of suspected through-and-through drainage, the patient was asked to rinse orally with a dye solution and the extraoral drainage examined for the dye. Through-and-through drainage (oral and extraoral) was associated with a high incidence of graft failure, therefore vigorous wound treatment and high dosages of antibiotics, selected on the basis of C&S studies, were essential if the graft was to survive in those difficult circumstances.

If a PCM graft had been used and oral perforation noted at the time of infection, prognosis for long-term retention of the crib was poor since the crib and its filter acted not only as a foreign body but also as a trough in which pathogenic organisms sequestered. Despite these adverse conditions, removal of the crib was sometimes deferred for a reasonable time in the hope that there was a chance for consolidation of the graft.



*Figure 58.*—*Upper left*) Left panoramic radiograph 15 days after injury showing avulsive injury to the mandible with retained molar teeth projecting into the osseous defect. *Upper right*) Left panoramic radiograph 9 weeks after injury. The teeth are still present and the extent of the osseous defect is well delineated. *Middle left*) Left panoramic radiograph 7 months after injury and 1 day prior to bone grafting showing minimal to absent osseous support for the retained molar teeth which were projecting into the future graft bed. There was considerable root resorption on the retained molars. *Middle right*) Left panoramic radiograph 3 days post grafting showing a metal crib supported graft (PCM) bridging the osseous defect. The molar teeth were still in place. *Lower left*) Left panoramic radiograph 2 months post grafting. The second and third molar teeth had been removed in the face of chronic infection at the graft site but the metal crib was still in place. There was some evidence of increased opacification in the graft area although the mandible was unstable at the graft site. *Lower right*) Left panoramic radiograph 3 months post grafting. The metal crib had been removed and the first molar tooth was extracted the following day. There was non-union at the graft site. Subsequent to this the infection at the graft site was soon resolved. *Continued in Figure 59.*

Deferral was justified only in infected cases where symptoms were minimal and aggressive local wound care could be maintained. In these instances, careful radiographic scrutiny was essential to monitor the progress of healing and to

identify potential destructive extension of infection of host bone. The objective of prolonged crib retention was to gain consolidation at the graft site prior to crib removal and thus establish at least some bridging of the discontinuity defect to



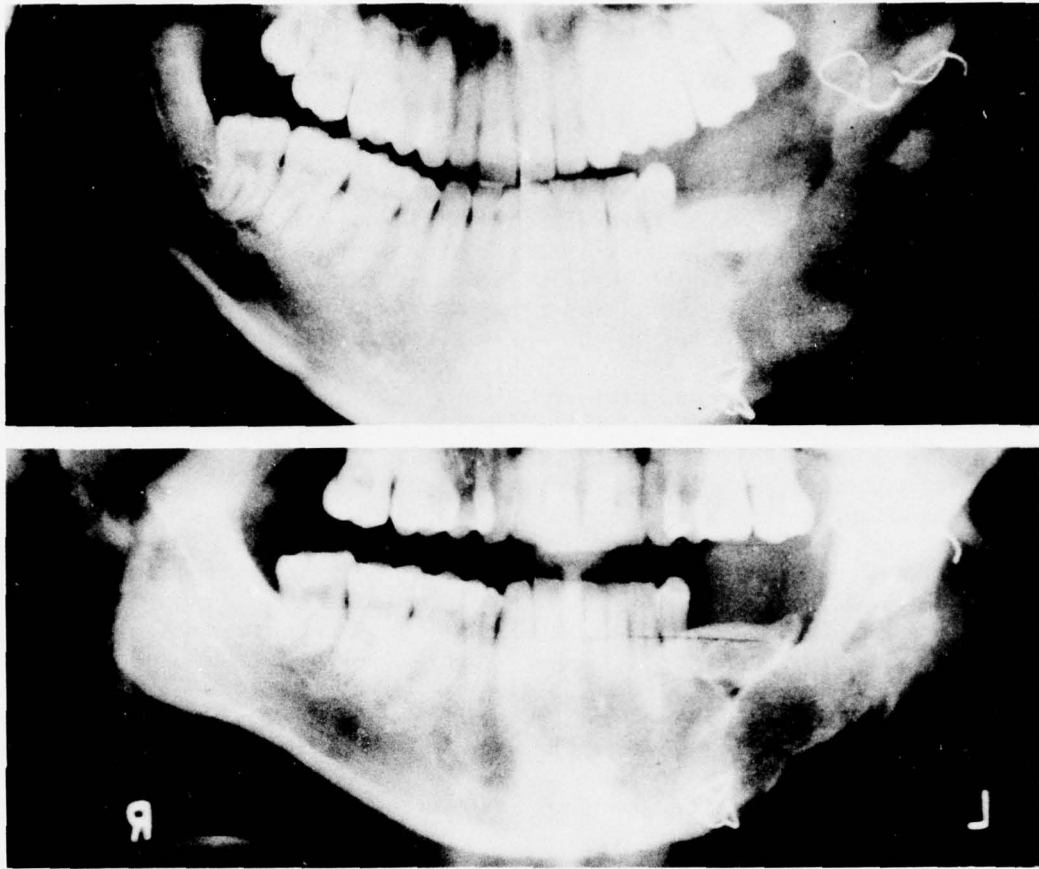


Figure 59. Continuation of Figure 58—Upper) Panoramic radiograph 16 months after removal of the crib and first molar and 2 months following a second bone graft (autogenous solid iliac) to the mandible. The proximal ramus fragment was distracted anterosuperiorly and the graft had been placed outside the functional vector of the mandible apparently to fill out the angle region. No attempt was made to section the coronoid process and reposition the ramus. Lower) Left panoramic radiograph 52 months following the second bone graft showing the remodeling of the graft that had occurred particularly where the angle had been augmented outside the functional vector of the mandible. Continuity had been successfully restored although symmetry and the proximal ramus fragment position could have been improved at the time of bone grafting by release of the coronoid process.

facilitate continued management.

Extraoral wound dehiscence also offered a poor prognosis for a graft. The wound and exposed crib material were kept clean with daily irrigation and dressing changes. The decision for the crib removal was predicated on the considerations just described. Once an extraoral dehiscence developed, no attempt was made to surgically cover over the crib.

**Inflammatory Conditions.** In addition to the above factors, which were directly associated with an infectious process, other complications developed that presented clinically as aseptic inflammation rather than overt infection. The po-

tential for infection existed; however, it did not ordinarily occur unless the inflammation became quite intense and/or a secondary source of contamination was introduced. In this category were galvanism caused by dissimilar metals, sialoceles near the graft, and the disruption of healing produced by instability at the graft site.

In summary, it was necessary to carefully differentiate between inflammation and infection in the face of postoperative graft complications with the understanding that there was a wide range of factors that contributed to their development. Early, vigorous treatment directed toward an accurately established diagnosis was mandatory if

graft failure was to be avoided.

### Assessment of Unsuccessful Grafts

Table 24 indicated the rate of success with the various types of grafting systems used for continuity restoration. Although it was not always possible to precisely identify why a particular graft failed, it was nonetheless possible to derive certain conclusions concerning graft failure in general. These conclusions have been distilled from an analysis of the MFCS cases in which grafts were unsuccessful.

**Insufficient Time Between Injury and Grafting.** Time is essential to reconstruction of a surgically resected area and especially to reconstruction of a war wound. Whereas immediate reconstruction has been advocated and successfully performed following tumor resection, it should be recognized that the remaining graft bed in cases of tumor resection is often previously uninfected normal tissue with adequate vascularity. Soft tissue and vascular damage in war injuries extended far beyond the avulsive defect itself and the wounds were universally contaminated—healing was prolonged and associated with considerable scarring. In such cases it was essential before grafting to allow time for recovery of vascularity, ensure asepsis, and await development of suppleness in the tissues overlying the defect. Better patient acceptance of necessarily protracted treatment was gained if the treatment objectives and the anticipated sequence of therapy were adequately explained.

**Inadequate Stabilization.** Loss of stability was a major cause of graft failure. If means of positive fixation had not been assured prior to placement of the graft, attempts to recover stability after graft placement were frequently inadequate or ineffective and graft failure resulted.

**Inadequate Debridement.** Debridement accomplished less than 4 weeks prior to grafting was characterized by wound infection, dehiscence, and graft failure.

**Intraoral PCM Grafting.** PCM grafts for restoration of continuity, which were placed via an intraoral route, were associated with a high incidence of complications and failure. Such an approach was not advisable for war casualty reconstruction.

**Adherence to Basic Principles.** In almost every unsuccessful graft, failure was attributable to violation of basic principles of bone grafting that were recognized and stated as early as World War I (Hayes, 1920; Ivy and Eby, 1924) as noted in chapter I (p. 6) and restated in this chapter. *Violation of these principles was never justified.* Although it was possible, via contemporary reconstruction techniques, to more consistently achieve restoration of form and function, the percentage of successful grafts for continuity was not markedly improved in comparison to World War II. Improvement in this percentage in the future to a great extent will depend on how assiduously surgeons follow recognized principles rather than on development of newer techniques or therapeutic protocols.

## PREPROSTHETIC SURGERY

### INTRODUCTION

*The majority of maxillofacial casualties required dental prostheses to complete their rehabilitation* but loss of bone, soft tissue, and dentoalveolar structures often compromised the adequacy of the prosthetic treatment that could be provided. Although dentures could be constructed in most instances, they were not optimally efficient when placed in areas of deficiency without the aid of preprosthetic surgery. Even with preprosthetic surgery ideal conditions for prosthetic treatment were seldom achieved; however, creation of a stable

denture-bearing area did improve the efficiency of the prosthetic appliance and also greatly reduced adverse stress on remaining dentoalveolar tissue. In this section we will define the problems of prosthetic rehabilitation that lent themselves to surgical correction and discuss solutions using selected cases to illustrate satisfactory long-term results.

Although many patients in the MFCS, other than those who received bone grafts, required some type of preprosthetic surgery, *particular attention is focused on 51 patients who were grafted for mandibular discontinuity defects and who required den-*

TABLE 37.—*Prosthetic Status of Patients Who Received Successful Bone Grafts for Continuity Relative to Their Preprosthetic Surgery Requirements*

Type of graft	Denture constructed	PPS performed before denture construction	
		Bone aug.	Soft tissue
Iliac *(N = 23)	15[65.22]†	2[08.70]	8[34.78]
Rib (N = 5)	4[80.00]	2[40.00]	3[60.00]
PCM (N = 22)	13[59.09]	2[09.09]	3[13.64]
Other (N = 1)	0[00.00]	0[00.00]	0[00.00]
Total (N = 51)	32[62.75]	6[11.76]	14[27.45]

\*N = number of patients requiring a denture following successful bone grafting for continuity (from Table 29).

†Figures in brackets equal percentage of N.

*tal prosthetic appliances.* Thirty-two of these patients had dentures constructed and of this group, 6 underwent bone graft augmentation and 14 had vestibuloplasty procedures prior to denture construction. Of the 19 patients who did not have dentures constructed the reasons were variable: patients either felt they could "get along" without a denture, refused further treat-

ment, or found it inconvenient to have further treatment because of geographic location, business commitment, etc. (Table 37).

Because of the complicated nature of prosthetic rehabilitation not all dentures were satisfactory for the long term, and preprosthetic surgery was still considered necessary at the time of last examination for 23 of the bone graft patients who had required dentures. Vestibuloplasty was required for all 23 patients, whereas bone graft augmentation was required for 13. There were no plans for preprosthetic surgery in 18 of the 23 patients. Of these 18 patients, 8 refused treatment, but in 6 instances the evaluating clinicians did not recommend surgery although it was indicated in light of the criteria discussed in this chapter. In the remaining 4 patients the reasons for failure to plan preprosthetic surgery were unclear (Table 38).

It should be noted that in the past many of the conditions that could have been corrected by contemporary preprosthetic surgery were not treated and prosthetic rehabilitation was either compromised or not attempted. Even today, all clinicians are not adequately familiar with the treatment opportunities provided by preprosthetic surgery and for this reason some of the casualties have been incompletely rehabilitated. *In fact, one of the major objectives of this section is to review the indications for preprosthetic surgical therapy so that all clinicians who will be responsible for casualty management, either now or in the future, will*

TABLE 38.—*Status of Patients Who Required a Denture Following Bone Grafting for Continuity Relative to Their Requirement for Preprosthetic Surgery at Last Follow-Up Examination*

Type of graft	PPS required at time of last examination		No plans for PPS	Patient refused	Clinician did not recommend PPS	Reason PPS not accomplished unknown
	Soft tissue	Bone aug.				
Iliac *(N = 23)	10[43.48]	3[13.04]†	10[43.48]	5[21.74]	3[13.04]	3[13.04]
Rib (N = 5)	2[40.00]	2[40.00]	1[20.00]	—	—	—
PCM (N = 22)	10[45.45]	7[31.82]	7[31.82]	3[13.64]	3[13.64]	1[04.55]
Other (N = 1)	1[100]	1[100]	1[100]	—	—	—
Total (N = 51)	23[45.10]	13[25.49]	18[35.29]	8[15.69]	6[11.76]	4[07.84]

\*N = number of patients requiring denture following successful bone grafting for continuity.

†Figures in brackets equal percentage of N.



*be fully appreciative of what can be achieved for these patients.*

## DEFINITION AND PURPOSE

*Preprosthetic surgery can be defined as surgery of the hard and soft tissues of the jaws which makes successful prosthetic treatment possible.* Specifically, the goal of these procedures was to provide a suitable foundation for the construction of a prosthesis which would be stable and retentive under functional stresses, preserve the associated structures, and satisfy esthetics. The extent of injury and other uncontrollable circumstances made it impossible to provide ideal conditions for prosthetic treatment in every instance, therefore, compromise in final management was sometimes required.

To obtain satisfactory prosthetic rehabilitation and to avoid both unnecessary compromise in prosthetic care and inappropriate preprosthetic surgery, it was essential to assure complete cooperation and understanding between the prosthodontist and surgeon. Only when the patient's requirements were clearly identified and there was a mutual understanding of each therapist's capabilities could these needs be resolved in an optimal manner. Effective cooperative therapy encompassed not only planning and treatment but also a comprehension of what could be realistically accomplished and what long-range complications might be anticipated relative to the patient's injury and rehabilitation.

*It is anticipated that war casualties, with their compromised dental and orofacial conditions, will be especially susceptible to dental disease as they experience the usual physiologic alterations of aging.* Further adverse conditions resulting from early loss of teeth, resorption of supporting bone, and deteriorating soft tissues will result in additional functional impairment that must be recognized and treated early. For this reason, it is essential that these patients be impressed with the need to accept a responsible role in maintaining their oral health and to present for follow-up examination and required treatment on a regular basis. The need for continuing prosthetic care supplemented by appropriate surgery is especially important and cannot be overemphasized.

## RATIONALE FOR PREPROSTHETIC SURGERY

MacIntosh and Obwegeser (1967) have presented an excellent resume of preprosthetic surgery and although the procedures they described were not specifically designed for treatment of war casualty sequelae, they have been found to be readily adaptable to this purpose. The sound biomechanical principles upon which these procedures were based permitted the development of specific diagnostic criteria for evaluating trauma sequelae and selecting appropriate soft and hard tissue corrective procedures. Acceptable functional results were obtained with these newer treatment approaches, whereas previously employed ridge modifying procedures (Kazanjian, 1935; Trauner, 1952; Clark, 1953) were generally unpredictable and had gained acceptance by neither the surgical nor prosthetic communities even for more conventional non-traumatic conditions.

## Vestibuloplasty

In accomplishing these procedures soft tissues were modified to provide a primary denture support base consisting of firm, attached, immobile tissue overlying the edentulous alveolar area. Lateral stability was gained by providing as much buccal-labial and lingual vestibule as possible. For optimal denture support and stability it was desirable to have fixed tissues extending over one half the distance from the alveolar crest to the depth of the vestibule.

As a general rule, *vestibuloplasty procedures were deferred until all other corrective hard and soft tissue surgery had been accomplished and sufficient time had elapsed for tissue healing and maturation.* The preliminary corrective procedures included: providing additional soft tissue when required; establishing bony continuity with satisfactory alignment, contour, and intermaxillary relationship; osseous alveolar augmentation; and restoration of acceptable mandibular function. Another important consideration was removal of previously placed wires and metal plates that could complicate either the vestibuloplasty or subsequent

prosthetic rehabilitation (Case report 16). Since vestibular surgery was considered the final step prior to prosthetic rehabilitation it was therefore important to ensure that all preliminary measures were accomplished before undertaking these procedures.

**Indications.** Problematic conditions requiring corrective vestibuloplasty included: 1) Mobile tissue over the crest of the remaining bony ridge without associated keratinized mucosa; 2) insufficient vestibular depth; 3) scar tissue that either partially or completely obliterated the vestibule; and 4) buccal-labial tissues continuous with the lingual or palatal mucosa.

Although the presence of sound "strategically" located teeth usually enhanced prosthetic rehabilitation by providing primary retention and support for a fixed or removable prosthesis, additional vestibuloplasty procedures were often required to provide optimal long-term results.

**Mandibular Procedures.** The primary goal of mandibular soft tissue procedures was establishing an area of fixed tissue over the remaining alveolar crest and creating an adequate buccal-labial and lingual vestibule. This was accomplished by placement of either a split-thickness skin or mucosal graft over the exposed periosteum following excision of scar tissue and repositioning of muscle attachments and mucosa (Rehrmann, 1959; MacIntosh and Obwegeser, 1967; Steinhäuser, 1969; Hall, 1970; Davis et al., 1974).

An important point of emphasis concerns the placement of a denture over the surgical area. In most instances an interim denture was inserted shortly after stent removal. It was important to ensure that the flange of the interim prosthesis did not extend beyond the grafted tissue-repositioned mucosa junction because such extension at this time caused an inflammatory response that ultimately resulted in a loss of vestibular depth thus reducing the amount of fixed tissue covering the remaining alveolar ridge. To assure that the level of the flange was correct, the prosthodontist was requested to relieve the interim denture so that a margin of the skin or mucosa graft was exposed and visible around the entire buccal-labial border (Figure 60 and Case report 17). After an interval of about 6 weeks, it was permis-

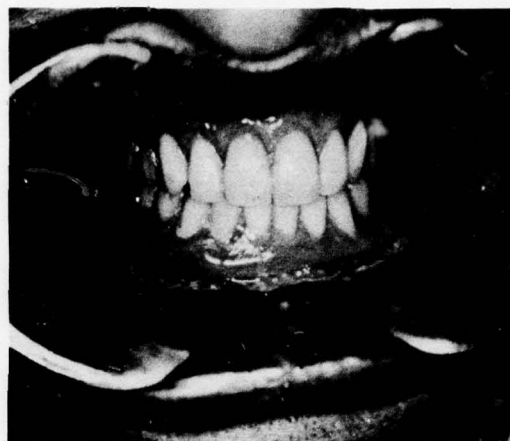


Figure 60.—Interim denture in place over mandibular alveolar process that had been reconstructed by means of a vestibuloplasty and skin graft several weeks previously. The flange of the denture is intentionally relieved to a level that is well above the junction of the skin graft-vestibular mucosa.

sible to extend the interim denture to whatever level was necessary for optimum support and retention. A permanent prosthesis was placed when, in the opinion of the clinicians, the reconstructed tissues overlying the alveolar ridge were sufficiently mature.

When a vestibuloplasty was planned in a patient whose discontinuity defect had been reconstructed with a PCM graft, a decision was necessary regarding retention or removal of the metallic crib. The criterion that evolved was to remove the metallic crib if there was any possibility that a portion of the crib would be exposed by the surgery or impinged upon by the subsequent prosthesis (see Figures 62 and 63 and Case report 05).

*In the casualty patients there were two major reasons that made it necessary to modify the usual vestibuloplasty techniques—when the vestibule was obliterated by extensive scarring or when there was continuous buccal to lingual mucosal bridging by unattached tissue.* In these instances it was very difficult to get an impression that could accurately reflect the underlying bony contours (Case report 17). One method for solving this problem was to place wire loop extensions from the periphery of the stent (Figure 61). These loops permitted controlled direction of the thermoplastic impression ma-





Figure 61.—Modified impression stent for mandibular vestibuloplasty procedure. Wire loop extensions have been incorporated on the buccal aspect of the stent to control the direction of the impression material into the extent of the defect and also on the lingual not only to direct the impression material, but also to secure the circummandibular sutures from the opposite flap.

terial into the extent of the defect thus assuring an accurate adaptation of the soft tissue graft. These wire loop additions were also used to support and secure circummandibular sutures on the side opposite the flap when only one side of the vestibule was being grafted. This assured positive flap control and fixation in the preplanned position.

**Maxillary Procedures.** In the maxilla, as in the mandible, corrective surgery was recommended when the vestibule was partially or completely obliterated by scar tissue or abnormal mucosa-muscle attachments which interfered with denture placement. The techniques usually included grafts of split-thickness skin or mucosa although secondary epithelialization techniques were utilized when there was a limited area of involvement. Other types of vestibuloplasty were rarely used.

Grafts of split-thickness skin or mucosa were used in the maxilla where there was extensive scar tissue that required excision and it was important to retain as much of the surgically acquired vestibular depth as possible. Displacement of scar tissue to obtain an impression that accurately represented the underlying bony contour was often difficult and stent modifications similar to those in the mandible were required. Interim and permanent denture construction was similar to that for the mandible (Case report 18).

*Because secondary epithelialization was known to be*

*associated with a 50% loss of the vestibular depth gained at surgery (MacIntosh and Obwegeser, 1967), it was necessary that the projected ridge height be sufficient for support and retention of a prosthesis. If it was apparent that with the anticipated relapse there would be insufficient ridge height and vestibule, then a vestibuloplasty with less relapse potential was selected.*

A stent was not ordinarily utilized when secondary epithelialization techniques were employed because the inflammatory response elicited by the stent contributed to delay in healing and additional relapse. As in the mandible, an interim prosthesis could be placed immediately provided that the flange did not extend beyond the repositioned mucosal edge. After the secondary epithelialization was complete, the final prosthesis could be extended as desired by the prosthodontist.

**Additional Considerations.** In some cases specially designed unconventional prostheses were constructed to restore areas of damaged and deficient tissue without benefit of preprosthetic surgery (Case report 13). It should be recognized that in many of these instances such appliances were constructed before preprosthetic surgery was widely applied to the reconstruction of these deformities. Although these prostheses were initially quite functional, they were prone to eventual failure as a result of the additional stress that was placed on the remaining teeth and supporting structures. In retrospect, preprosthetic surgery would have created a more favorable denture base and permitted construction of a denture with more evenly distributed stress thus preserving the teeth and supporting bone and enhancing long-term success.

### Bone Graft Augmentation

**Indications and Types of Grafts.** Bone graft reconstruction for alveolar ridge augmentation was necessary in both the maxilla and mandible to restore substantial osseous loss in the denture support area. Specific indications for these procedures varied according to the anatomic location of the deficiencies and the suitability of underlying osseous structure for complete support of the prosthesis. When the amount of remaining bone in the denture-bearing area was so minimal that vestibuloplasty alone would not provide a sufficient base for the construction and support of a satisfactory den-



ture, bone graft augmentation was considered (Celesnik, 1963; Steinhauser and Obwegeser, 1965; Davis et al., 1970, 1975; Terry et al., 1974).

An additional reason for augmenting the mandibular alveolar ridge was the need to correct the problem of flexion that occurred when the bony defect was so great that the mandible was unstable during functional movements. This was especially annoying in the partially edentulous patient and was often initially manifested by dislodgment and/or distortion of a prosthesis during mastication (Figures 62 and 63). When a fixed appliance spanned an area of flexion either unseating of the bridge occurred and/or periodontal pathosis developed that caused loosening of the abutment teeth.

Isolated areas of bony deficiency in the edentulous maxilla usually presented no serious prosthetic problems and could ordinarily be managed with local soft tissue procedures.

In the MFCS 18 of 101 bone grafts were performed for augmentation in patients with mandibular continuity. Thirteen of these grafts were performed for functional augmentation of the alveolar ridge to enhance prosthetic rehabilitation whereas 5 were performed for cosmetic augmentation (Table 28). The types of grafts used and their incidence were reported in Table 23. Six of the functional augmentation grafts were accomplished after a previous bone graft for continuity restoration and 7 were performed in patients where a discontinuity defect had never existed.

Bone graft systems previously discussed for management of mandibular discontinuity defects were also used for alveolar ridge augmentation. In the MFCS patients these included rib (4), solid iliac (6), and PCM grafts (3). The type of rib graft described by Davis et al. (1970) was well suited for augmentation procedures. The particulate cancellous marrow grafting system was also considered satisfactory but its use did require metallic crib adaptation and the necessity of a second surgical procedure for removal and for this reason it was only recommended for isolated alveolar ridge defects (Case report 17). An advantage of the PCM system was the greater osteogenic potential of the cancellous marrow, as well as its earlier vascularization.

**Technical Procedure and Complications.** Regardless of the system used, it was necessary to adhere to the following basic surgical principles if the augmentation was to be successful.

- 1) The primary incision for development of mucoperiosteal flaps was placed in the center of the residual scar tissue overlying the alveolar crest. This insured maximum blood supply to both sides of the flap.
- 2) The flaps were mobilized at the expense of vestibular depth so that adequate graft cover and tension-free closure could be achieved.
- 3) Periosteal relaxing incisions when necessary were placed well away from the flap margins to protect the blood supply.
- 4) The graft was stabilized against the host bone and potential dead space eliminated by

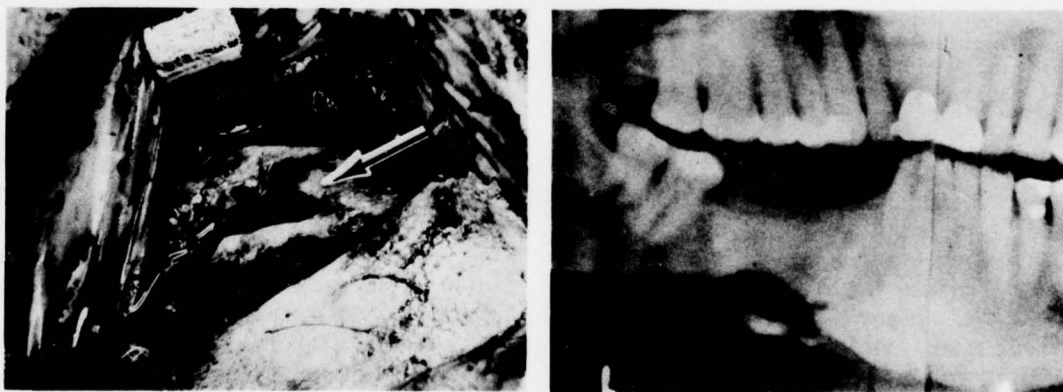


Figure 62.—(Left). Panoramic radiograph 19 years following a missile injury to the face and jaw that had been treated by IMF and external skeletal fixation. The residual osseous defect (arrow) caused weakening of the mandible with flexion of the jaw during function and dislodgement of the partial denture. (Right) Appearance of osseous mandibular defect at time of PCM bone grafting for strength augmentation 19 years following injury.

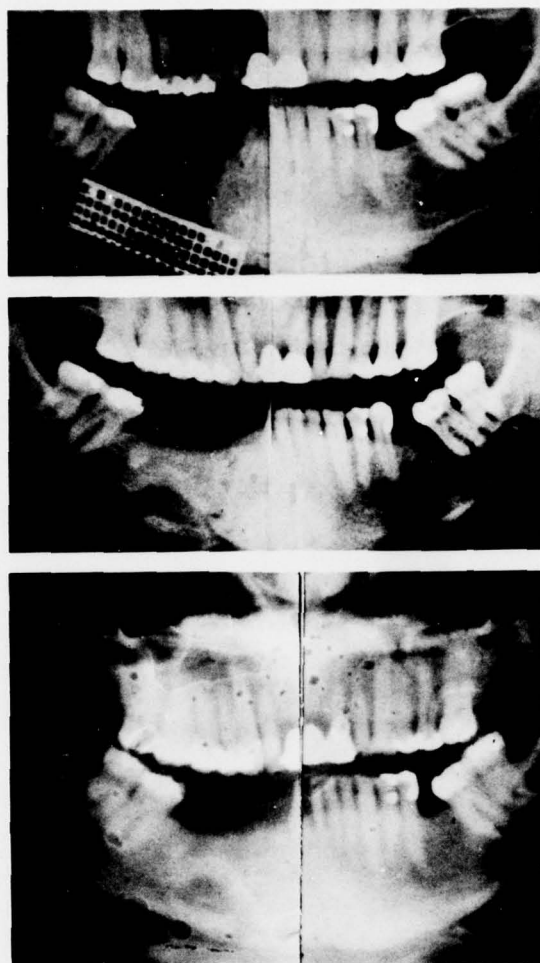


Figure 63.—Upper and Middle) Panoramic radiographs 2.5 months post bone grafting before and after removal of the metallic crib that was placed at the time of PCM grafting. The crib was removed because it encroached on the area of the denture flange. Lower) Panoramic radiograph 6 years following bone grafting and 25 years following missile injury. The mandible was stable at this time and the patient was wearing a satisfactory partial denture.

placement of bone chips about the graft which also had the advantage of providing final osseous contour.

- 5) Water-tight closure was accomplished with a monofilament nonwicking-type suture material (Lilly et al., 1969; Kelly, 1973).

In order to minimize the opportunity for infection, meticulous aseptic technique was observed during the surgical procedure and appropriate antibiotic coverage was instituted and continued for at least 7–10 days postoperatively.

The quality and vascularity of overlying soft tissue had an important bearing on the outcome of augmentation. With bony augmentation procedures, the incidence of complications such as wound dehiscence and partial sequestration of the graft was usually higher than in patients with uncompromised soft tissues (Baker and Connole, 1976 [a]). In the MFCS there were 6 cases of postsurgical infection (33.33%) involving augmentation grafts. Infection occurred in conjunction with 3 of 11 solid iliac grafts, 2 of 4 rib grafts, and 1 of 3 PCM grafts (Table 36).

Postoperative wound dehiscence or infection occurring in association with solid autografts did not necessarily herald complete loss of the graft providing timely and appropriate treatment was instituted. This included culture and sensitivity testing of any exudate to guide selection of antibiotic therapy, daily irrigations of the exposed graft with an antibacterial solution, protection of the area with a petrolatum gauze dressing, reduction of obviously devital bone without disturbing the surrounding soft tissue, and removal of bony sequestra only when they had become completely separated and could be lifted from the wound with minimal force. *More vigorous surgical management including flaps to reestablish primary closure over exposed grafted bone was not successful and therefore not advocated.*

When the PCM grafting system was employed the microporous filter because of its position provided some protection against the oral environment when wound dehiscence occurred. In the presence of dehiscence the area was kept clean by local hygiene and daily irrigations with a selected antibacterial solution. In all cases, the crib and microporous filter were removed at 8–14 weeks post grafting. The wound was again closed primarily and the vestibular surgery planned at about 6 months post grafting (Case report 17).

**Vestibuloplasty Following Bone Graft Augmentation.** Vestibuloplasty following bone graft augmentation was very frequently indicated in order to provide optimum denture support and function because at the time of grafting flaps had been mobilized and vestibular tissue displaced to obtain adequate graft cover (Case reports 03, 05, and 17). At the last follow-up examination, 11 of the 13 patients who underwent functional augmentation grafts were wearing a denture, one was unable to wear a denture, and one patient planned to have a denture constructed in the fu-

ture. Seven of the 13 patients had vestibuloplasty prior to denture fabrication and the procedure was planned for the one patient not able to wear a denture. Of the remaining 5 patients who had not had vestibuloplasty, it was considered desirable in 3 instances, although denture construction had been possible, whereas in 2 patients optimum dentures could be fabricated without additional surgery.

It was found best to wait at least 6 months after bony augmentation for the soft tissue alterations. This allowed time for the graft to mature and develop a periosteal-like tissue sheath. Ideally, all soft tissue vestibular procedures were deferred until the greatest proportion of the remodeling-

recontouring had occurred. Although such changes can continue for up to 2 years post grafting, the major modification has been shown to be complete by 6 months (Davis et al., 1974; Terry 1974; Baker and Connole, 1977 [b]).

**Summary.** In summary, predictable surgical techniques were available for correction of osseous alveolar ridge deficiencies in the maxilla or mandible. On the basis of experience with war casualty reconstruction a high degree of success can be anticipated with these procedures in both the mandible and maxilla, but because of differing anatomy and prosthetic requirements, bone graft augmentation was more frequently indicated in the mandible.

## CONCLUSION

The late care period was characterized by a constant review of treatment goals and coordination of the efforts of all clinicians involved with accomplishing these goals. The needs of each patient were determined and therapy predicated on their individual requirements. The treatment afforded many of these patients was complex and prolonged and of such nature that they will ideally require follow-up care for the remainder of their lives in order to assure a stable functional and esthetic result. No definite system that provides for coordination of this extended care for the individual patient has yet been designed or

planned. The need for such a system was made readily apparent as patients in the MFCS were recalled and examined. Problems were identified that had gone unnoticed and instances of delayed or omitted therapy were observed. When treatment was instituted for these long-term deficiencies it was usually not simple and often involved a broad range of surgical and dental care.

It has been made clearly evident that the long-term needs of oral and maxillofacial casualties should not be overlooked and formal provisions should be made for their continued care.

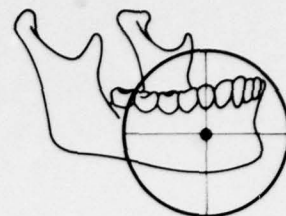
## BIBLIOGRAPHY

- Alexander, R. E., Taylor, C. G., Cinquemani, N. F., and Kramer, H. S.: Use of physical therapy in oral surgery practice. *J Oral Surg* 28:671, 1970.
- Arpin, E. J., and Downs, A. R.: Two false aneurysms of the common carotid artery—a delayed complication of penetrating cervical trauma. *J Trauma* 15:976, 1975.
- Baker, R. D., and Connole, P. W.: Unpublished data. 1976[a].
- Baker, R. D., and Connole, P. W.: Preprosthetic augmentation bone grafts—autogenous bone. *J Oral Surg* 35:541-545, 1977 [b]. 1976[b].
- Bell, W. H.: Revascularization and bone healing for anterior maxillary osteotomy. *J Oral Surg* 27:249, 1969.
- Bell, W. H.: Revascularization and bone healing after posterior maxillary osteotomy. *J Oral Surg* 29:313, 1971.
- Bell, W. H.: Biologic basis for maxillary osteotomies. *Am J Phys Anthropol* 38:279, 1973.
- Bell, W. H.: Bone healing and revascularization after total maxillary osteotomy. *J Oral Surg* 33:253, 1976.
- Biron, P. E., Howard, J., and Valeri, C. R.: Chronic deficits in red-cell mass in patients with orthopaedic injuries (stress anemia). *J Bone Joint Surg [Am]* 54-A:1001, 1972.
- Blocker, T. G., and Stout, R. A.: Mandibular reconstruction, World War II. *Plast Reconstr Surg* 4:153, 1949.
- Boyne, P. J.: Autogenous cancellous bone and marrow transplants. *Clin Orthop* 73:199, 1970.
- Brown, J. B., Peterson, R. L., Connon, B., and Lecher, C.: Ankylosis of coronoid process of the mandible. *Plast Reconstr Surg* 1:277, 1946.
- Burwell, R. G.: Studies in the transplantation of bone. VIII The fresh composite homograft-autograft of cancellous bone. *J Bone Joint Surg [Am]* 46-B:110, 1964.
- Burwell, R. G.: The fate of bone grafts. In *Recent Advances in Orthopaedics*. Baltimore, Williams and Wilkins, 1969, pp. 116-207.
- Burwell, R. G.: The fate of freeze-dried bone allografts. *Transplant Proc (Suppl 1)* 8:95, 1976.



- Celesnik, F.: Intraoral osteoplastic operations. *Acta Chir Plast* 5:266, 1963.
- Clark, H. B., Jr.: Deepening the labial sulcus by mucosa flap advancement: Report of a case. *J Oral Surg* 11:165, 1953.
- Connole, P. W.: Unpublished data.
- Connole, P. W.: Mandibular cancellous bone grafts: Discussion of 25 cases. *J Oral Surg* 32:745, 1974.
- Converse, J. M.: *Reconstructive Plastic Surgery*. Philadelphia, W. B. Saunders, 1964, [a] 433-439 and [b] 21-80.
- Converse, J. M.: *Surgical Treatment of Facial Injuries*. Baltimore, Williams and Wilkins, 1974, pp [a] 130, [b] 1198, [c] 1201, [d] 1192-1201, [e] 115-119 and [f] 949-1012.
- Crenshaw, A. H., ed.: *Campbell's Operative Orthopaedics*. St. Louis, C. B. Mosby, vol 1, 5th ed., 1971, pp [a] 802 and [b] 103.
- Crockett, D. J.: Reconstructive surgery of the face after cancrum oris. *East Afr Med J* 40:552, 1963.
- Davis, N. J.: A new fiberoptic laryngoscope for nasal intubation. *Anesth Analg (Cleve)* 52:808, 1973.
- Davis, W. H., Delo, R. I., Weiner, J. R., and Terry, B.: Transoral bone graft for atrophy of the mandible. *J Oral Surg* 28:760, 1970.
- Davis, W. H., Delo, R. I., and Weiner, J. R.: *Mandibular Vestibuloplasty with Skin Grafting*, 2nd ed. Inglewood, Southern California Oral Surgery Foundation, 1974.
- Davis, W. H., Delo, R. I., Ward, W. B., Terry, B., and Patakas, B.: Long-term ridge augmentation with bone graft. *J Maxillofac Surg* 3:103, 1975.
- Davis, W. H.: Personal communication, 1976.
- Doneker, T. G., and Hiatt, W. R.: Buccal airway device: An aid in the postoperative management of patients with wire fixation of the jaw. *J Oral Surg* 24:318, 1966.
- Dorland: *The American Illustrated Medical Dictionary*, 25th ed. Philadelphia, W. B. Saunders, 1974, p 46.
- Findley, I. A.: Ankylosis of the coronoid to the zygomatic bone. *Br J Oral Surg* 10:30, 1972.
- Friedlaender, G. E.: The antigenicity of preserved bone allografts. *Transplant Proc (Suppl 1)* 8:195, 1976.
- Gray, R. L. M.: Corono-condylar ankylosis in childhood due to infection. *Br J Oral Surg* 7:40, 1969.
- Hall, H. D., and Osteen, A.: Free grafts of palatal mucosa in mandibular vestibuloplasty. *J Oral Surg* 28:565, 1970.
- Hayes, G. B., ed.: *Maxillofacial Surgery: Histories of 146 Selected Cases of Facial Wounds Treated at the American Ambulance, Paris, France, (1914-1917) 1920*. Unpublished.
- Ivy, R. H.: Late results of treatment of gunshot fractures of the mandible. *JAMA* 75:1316, 1920.
- Ivy, R. H., and Eby, J. D.: *Maxillofacial Surgery*. The Medical Department of the U.S. Army in the World War (Surgery), part 2, vol 110. Washington, D.C., U.S. Govt Print Off, 1924, p 462.
- Jones, J. C., Lilly, G. E., Hackett, P. B., and Osbon, D. B.: Mandibular bone grafts with surface decalcified bone. *J Oral Surg* 30:269, 1972.
- Kazanjian, V. H.: Surgery as an aid to more efficient service with prosthetic dentures. *J Am Dent Assoc* 22:566, 1935.
- Kelly, J. F.: Treatment of maxillofacial casualties. Proceedings of Tenth Central Treaty Organization, Ankara, Turkey, October, 1971.
- Kelly, J. F.: Maxillofacial missile wounds: Evaluation of long-term results of rehabilitation and reconstruction. *J Oral Surg* 31:438, 1973.
- Kelly, J. F.: Radionuclide study of bone allografts. *Transplant Proc (Suppl 1)* 8:99, 1976.
- Khosla, V. M.: Pseudoankylosis of mandible produced by temporal muscle fibrosis: Report of case. *J Oral Surg* 28:521, 1970.
- Kirk, N. T.: End results of 150 consecutive autogenous bone grafts for non union of long bones. *J Bone Joint Surg* 6:670, 1924.
- Kuttner: Plastik des ductus parotideus aus der mundescheimhaut mucuen. *Med Wchnschr*, 1906, p 100.
- Kwapis, B. W., and Dyer, M. H.: Pseudoankylosis following a temporoparietal craniotomy and its surgical correction. *J Oral Surg* 32:912, 1974.
- Lilly, G. E., Salem, J. E., Armstrong, J. H., and Cutcher, J. L.: Reaction of oral tissues to suture materials. *Oral Surg* 28:432, 1969.
- Longacre, J. J., and Destefano, G. A.: Reconstruction of extensive defects of the skull with split rib grafts. *Plast Reconstr Surg* 19:186, 1957.
- MacIntosh, R. B., and Obwegeser, H. L.: Preprosthetic surgery: A scheme for its effective employment. *J Oral Surg* 25:397, 1967.
- Mainous, E. G., and Terry B. C.: *Current Advances in Oral Surgery. Clinical Management of Osteomyelitis and Osteoradionecrosis*. St. Louis, C. V. Mosby, 1974, pp 242-263.
- Mincey, D. L., Barnhart, G. W., and Olson, R. E.: Simplified exerciser for the temporomandibular joint following condylotomy. *J Oral Surg* 39:844, 1975.
- Mohnac, A. M.: Gross loss of hard structure. *J Oral Surg* 27:512, 1969.
- Morris, J. H.: Biphase connector, external skeletal splint for reduction and fixation of mandibular fractures. *Oral Surg* 2:1382, 1949.
- Mowlem, R.: Cancellous chip bone grafts. *Lancet* 2:746, 1944.
- Musgrave, R. H.: *Special Problems of Soft Tissue Repair of the Eyelids, Nose, Lips, Parotid Gland, and Facial Nerve and Ears*. (Plastic and Maxillofacial Trauma Symposium). St. Louis, Mosby, 1969, pp 168-170.
- Najarian, J. S., and Simmons, P. L.: *Transplantation*. Philadelphia, Lea & Febiger, 1972.
- Obwegeser, H. L.: Simultaneous resection and reconstruction of parts of the mandible via the intraoral route in patients with and without gross infections. *Oral Surg* 21:703, 1966.
- Parsons, R. W.: Reconstruction of the lower face and lips. *Clin Plast Surg* 2:551, 1975.
- Randall, H. T.: Surgical nutrition: Parenteral and oral. In *Manual of Preoperative and Postoperative Care* (Kinney et al., ed.). Philadelphia, W. B. Saunders, 1971, pp 91-92.
- Rehrmann, A.: Creation of an alveolar ridge after bone transplantation. *J Plast Reconstr Surg* 24:183, 1959.
- Reid, R. L.: Hernia through an iliac bone-graft donor site. *J Bone Joint Surg* 50-A:757, 1968.
- Richter, K. J.: Tetanus after dental procedures: Review of literature and report of case. *J Oral Surg* 29:589, 1971.
- Rowe, N. L., and Killey, H. C.: *Fractures of the Facial Skeleton*, 2nd ed. Baltimore, Williams and Wilkins, 1970, pp 796-801.
- Rowe, N. L., and Sowray, J. H.: Extra-articular ankylosis as a complication of dystrophic epidermolysis bullosa. *Br J Oral Surg* 3:136, 1965.
- Salmon, T. N., Tracy, N. H., Jr., and Hiatt, W. R.: Hysterical trismus (conversion reaction). *Oral Surg* 34:187, 1972.
- Sperling, A. L.: Limitation of mandibular movement secondary to coronoid impingement. *J Oral Surg* 31:780, 1973.
- Steinemann, S. G.: Metallkundliches der implantate. 23rd Congress of German Society of Maxillofacial Surgery. Basel, Switzerland, June 1973.
- Steinhauser, E. W.: Free transplantation of oral mucosa for improvement of denture retention. *J Oral Surg* 27:955, 1969.
- Steinhauser, E. W., and Obwegeser, H. L.: *Second International Conference on Oral Surgery*. Copenhagen, Munksgaard, 1965, pp 203-208.
- Taylor, P. A., and Towey, R. M.: The broncho-fiberscope as an aid to endotracheal intubation. *Br J Anaesth* 44:611, 1972.
- Tempest, M.: Concrum Oris. *Br J Surg* 53:949, 1966.
- Terry, B. C.: Bone grafting for correction of deficient mandibular and maxillary alveolar ridges. Abstracts—2nd Congress European Association for Maxillo-facial Surgery. Zurich, Switzerland, 1974.
- Terry, B. C., Albright, J. E., and Baker, R. D.: Alveolar ridge augmentation in the edentulous maxilla with use of autogen-

- ous ribs. J Oral Surg 32:429, 1974.
- Thoma, K. H.: *Oral Surgery*, 3rd ed. St. Louis, Mosby, 1958, pp [a] 714 and [b] 732.
- Trauner, R.: Alveoloplasty with ridge extension on lingual side of the lower jaw to solve the problem of a lower dental prosthesis. J Oral Surg 5:340, 1952.
- Warsow, R. W.: Pseudoankylosis of the mandible after fracture of the zygomaticomaxillary complex: Report of case. J Oral Surg 29:223, 1971.



## *Case Reports*

---

By JAMES F. KELLY  
ROBERT G. TRIPLET

Previous sections of this text have identified the continuum of casualty care from the initial injury through late reconstructive treatment. Emphasis has been placed on the application of those principles of management that best assure the long term success. The following case reports are presented as a means of further accentuating the necessity of understanding the long term responsibility which is intrinsic to oral and maxillofacial casualty care.

The reader is asked to review the material that is presented in an objective manner and to recognize that the results obtained have been achieved

in the face of many variables and complexities which exist in casualty management. A retrospective view of treatment results invariably imparts a degree of perceptiveness that is seldom achieved prior to the initiation of patient care, particularly when faced with the complications innate to war injuries. These case reports have been selected, therefore, to serve as a prospective guide to future oral and maxillofacial casualty management and thus to help further assure optimal long term treatment success that meets both esthetic and functional criteria.



## CASE NUMBER 01

---

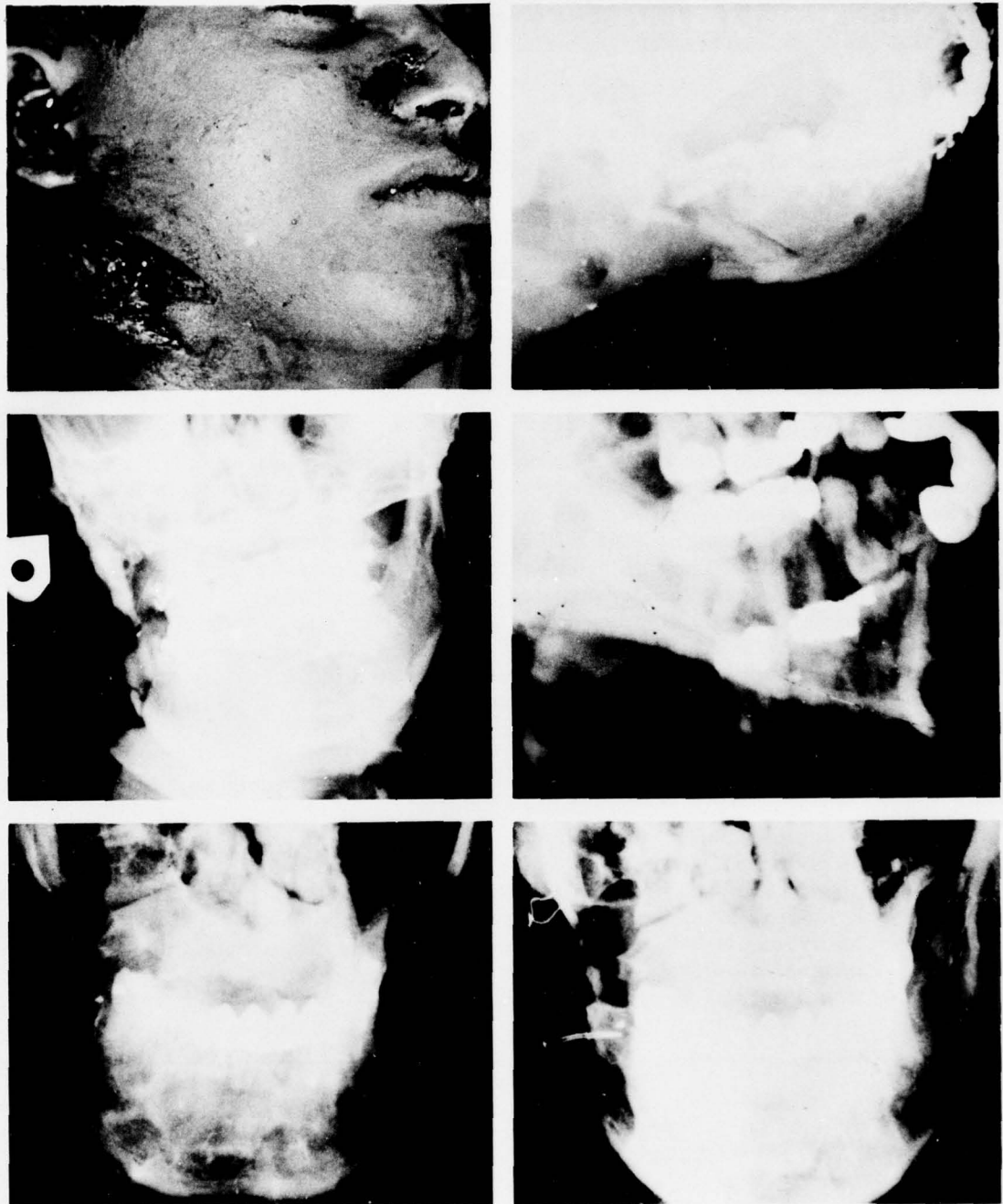
**Description of Injuries:** This 21-year-old casualty sustained a high-velocity gunshot wound to the mid and lower face and extremities. A missile entered the right side of the face on the lateral aspect of the nose and traversed inferiorly, shattered the right maxilla and mandible, and produced a large avulsive exit wound in the right neck. There was avulsion of part of the right mandibular ramus.

**Early Care:** The patient was medically evacuated to a 4th-echelon medical facility (hospital ship) where his maxillofacial wounds were treated by debridement of fragmented bone and teeth as well as a Caldwell-Luc procedure of the right antrum. The mandibular fracture was reduced manually and a closed reduction accomplished. The right neck wound was debrided and closed, and dependent drains were placed. The patient was medically evacuated 3 days following injury.

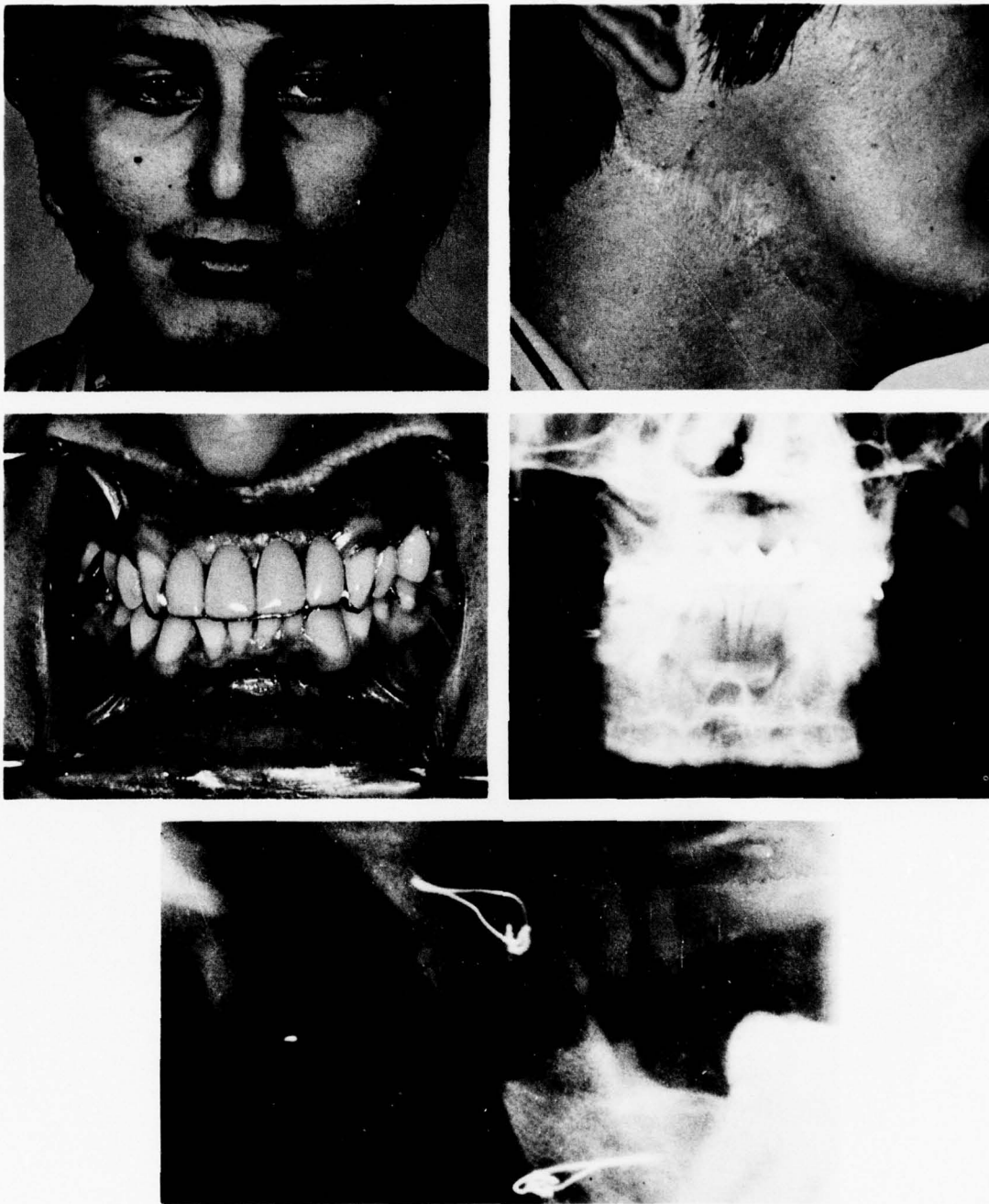
**Intermediate Care:** The patient entered an intermediate care facility the day he was discharged from the early care facility. His facial wounds were irrigated and drainage was maintained. He was provided supportive care until medical evacuation to CONUS 3 days after admission.

**Late Care:** The patient was admitted to the late care hospital after 6 days in transit. At admission, the wound of the right mandible was septic and draining and was treated with local wound care and systemic antibiotics. The infection responded to this regimen, and within 21 days following admission the wound was closed and healing satisfactorily. The patient was provided continuous supportive care and was allowed mandibular function 2 months after his initial injury. At that time there was a discontinuity defect in the region of the right mandibular ramus-angle. Eleven months following injury the patient received an autogenous bone graft from the right iliac crest to the right angle and ramus of the mandible. He was maintained in intermaxillary fixation for 6 weeks. At discontinuance of fixation there was clinical and radiographic alignment of the mandibular fragments, graft stability, and satisfactory occlusion. The patient was subsequently discharged with acceptable function and normal mandibular range of motion. At last follow (8 years and 5 months post injury) the patient continued to do well. There was only slight facial disfigurement and normal masticatory function.

---



*Upper left:* Appearance of a 21-year-old casualty at triage at an early care hospital showing the small entrance wound at the right nasolabial fold and the much larger exit wound in the right neck beneath the right mandibular angle. *Upper right and middle left:* Lateral oblique and posteroanterior radiographs, 1 day following wound treatment, showing the position of the reduced mandibular fragments and the deficit of the right mandibular ramus. *Middle right and lower left:* Lateral oblique and posteroanterior radiographs 11 months following injury just prior to bone grafting. Discontinuity and asymmetry were evident as well as the distracted position of the ramus. *Lower right:* Posteroanterior radiograph, 7 weeks post bone grafting. The graft was onlaid to the fragments and the ramus was not repositioned.



*Upper left and upper right:* Appearance of patient 7 years post injury. There was minimal cosmetic deficit although some mandibular asymmetry existed because the coronoid process had not been realigned at the time of grafting. *Middle left:* Appearance of the occlusion 7 years after injury. The patient had normal range of mandibular motion. *Middle right:* Posteroanterior radiographs 8 years following injury and 7 years following bone grafting. *Lower:* Panoramic radiograph 7 years after bone grafting showing the mature architectural appearance of the bone graft region. The graft had remodeled to the functional vector of the mandible.



## CASE NUMBER 02

---

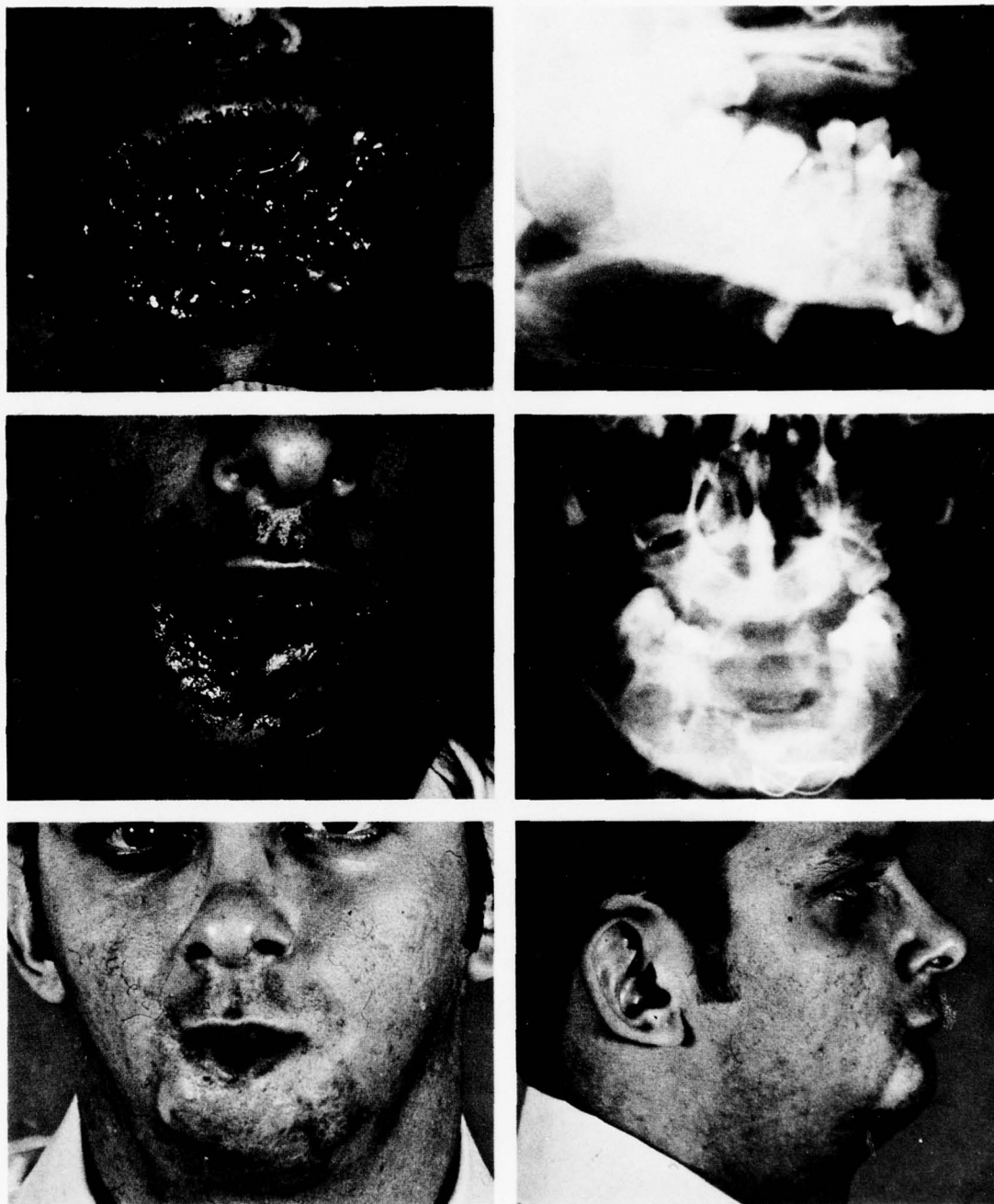
**Description of Injuries:** This 19-year-old casualty was injured by helicopter rotor blades during refueling, resulting in injuries to the left shoulder and right lower face. His maxillofacial injuries included a compound, comminuted, avulsive fracture of the mandibular symphysis and soft tissue avulsion of a portion of the lower right lip. There was also avulsion of the mandibular left first bicuspid through the right cuspid teeth (#21-27).

**Early Care:** The patient was immediately evacuated to a 4th-echelon facility (hospital ship). Following triage he was taken directly to the operating room where he received an emergency tracheostomy. His wounds were then debrided, chest tubes were placed, and an open reduction of the mandibular symphysis was performed. The mandible was immobilized with arch bars and intermaxillary fixation. The patient was admitted to the medical evacuation system 27 days after injury.

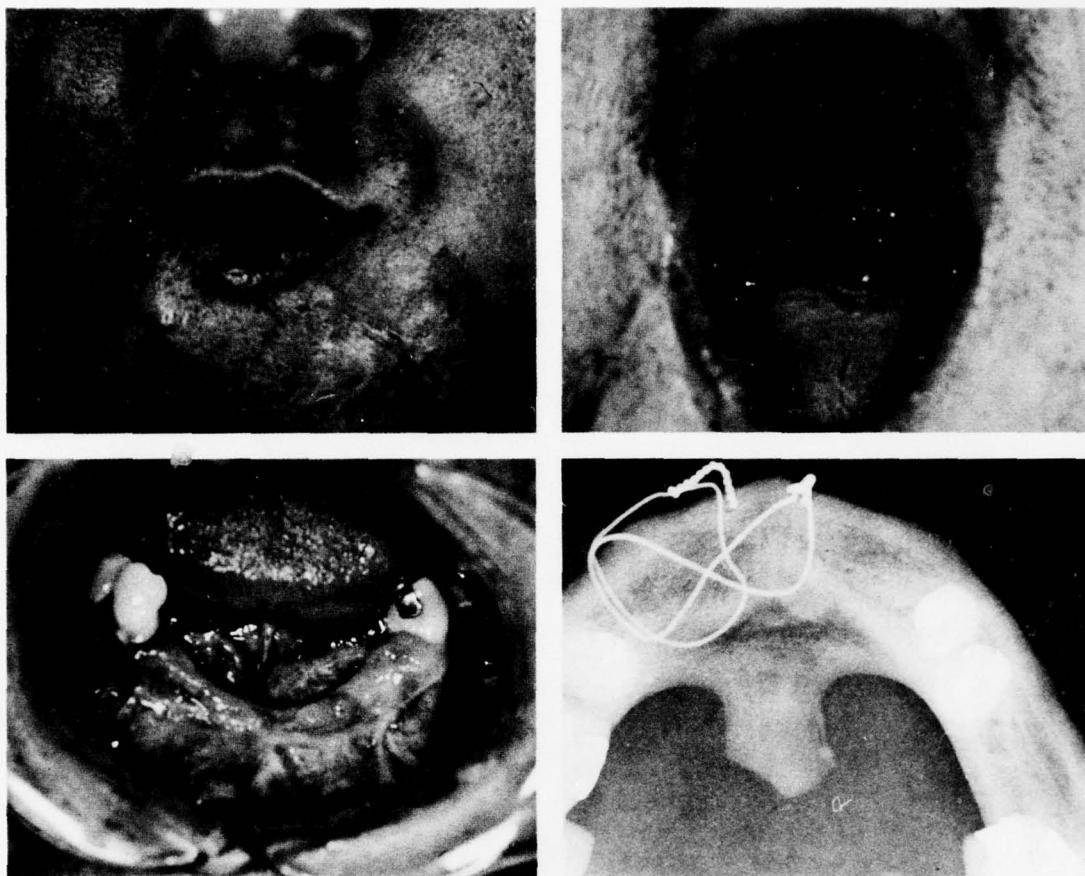
**Intermediate Care:** On the day of discharge from early care the patient was admitted to an intermediate facility where he received supportive care for 6 days and then was medically evacuated to CONUS.

**Late Care:** Admission to a late care hospital occurred after 3 days in transit. Initial examination revealed oral microstomia secondary to the avulsive injury to the lower lip. Two days after admission the intermaxillary fixation was released and the mandible was found to be stable. Eight months post injury an Estlander transposition flap was rotated into the lower lip. This was followed 1 month later by right commissurotomy and later by a vestibuloplasty. Subsequently, the patient underwent secondary local scar revision of the lower lip. A mandibular denture was constructed and at last follow, 6 years and 6 months after injury, the patient manifested a satisfactory cosmetic and functional condition.

---



*Upper left:* Appearance of a 19-year-old casualty who sustained an injury to the lower face and oral cavity resulting from a helicopter blade. *Upper right:* Lateral radiograph showing the mandibular fractures. *Middle left:* Appearance of patient 21 days post injury. There had been avulsion of soft tissue from the lip and it was necessary to suture mucosa to skin in order to permit primary closure. *Middle right:* Posteroanterior radiograph, 6 months post injury, showing the well-healed, correctly aligned, and symmetrical mandible. Mandibular fractures had been treated by open reduction at the inferior border and intermaxillary fixation with arch bars. *Lower left and lower right:* Appearance of patient 60 months post injury. The lip had been reconstructed by a series of soft tissue procedures that included scar excision, Estlander flap, right commissurotomy, and vestibuloplasty. Although a slight degree of microstomia existed, the lip was supple. There was adequate vestibular depth for a prosthesis which had been successfully constructed.



*Upper left, upper right, and lower left: See figure legends on previous page. Lower right: Occlusal radiograph, 60 months post injury, showing well-healed and normally contoured mandibular symphysis. What appear to be hypertrophic genial tubercles are in fact consolidated fragments of the lingual cortex which had been drawn lingually by the genial muscles at the time of injury.*



## CASE NUMBER 03

**Description of Injuries:** This 19-year-old casualty sustained multiple fragment wounds of the face, neck, and upper extremities. These injuries included a compound, comminuted fracture of the right and left mandible with avulsion of a large segment of the symphysis containing the mandibular left first bicuspid through the right second bicuspid teeth (#21-29) and a penetrating wound of the neck.

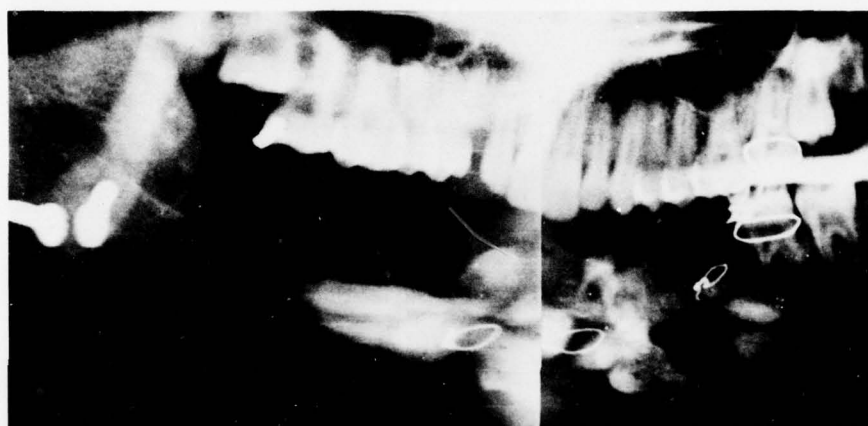
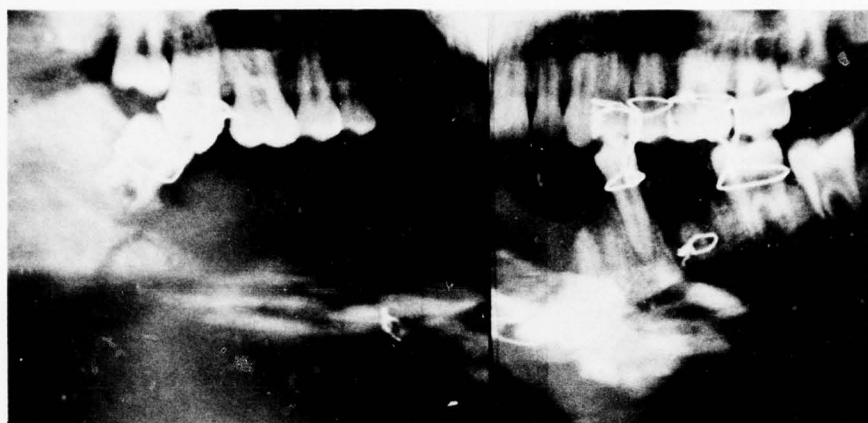
**Early Care:** He was first treated at a 2nd-echelon medical facility where a tracheostomy was performed and blood transfusions were administered. He was evacuated and admitted to a 4th-echelon facility (hospital ship) the day of injury where his maxillofacial injuries were treated. The maxillofacial wounds were debrided and a prolonged scrub with an antiseptic soap solution was carried out because of heavy contamination. This procedure was followed by an open reduction of the mandibular fractures. Soft tissue closure was accomplished from inside-out (mucosa to skin) and 4 polyethylene drains were placed. A portion of the inferior aspect of the wound was left open for drainage because of the extensive avulsion and contamination. The patient was placed in intermaxillary fixation with elastic traction and was discharged to the medical evacuation system 9 days after his initial injury.

**Intermediate Care:** This casualty entered an intermediate hospital the day of his discharge from the early care facility. Supportive care was provided and further debridement was carried out including removal of the roots of the mandibular right first and second molar teeth (#30 and 31). Twenty-one days following admission to the intermediate facility he was medically evacuated to CONUS.

**Late Care:** The patient was admitted to a late care hospital after 2 days in transit. Admission examination revealed a septic and draining mandibular wound that was treated with appropriate systemic antibiotics and local irrigation (antibiotics were selected following bacteriologic studies). The fracture reduction was adequate, but it was necessary to remove the fractured mandibular left first molar tooth (#19) and an obviously devitalized exposed segment of the right alveolus 10 days following admission. Approximately 7 weeks after admission, the mandibular left second bicuspid and right third molar teeth (#20 and 32) were removed because of extensive pararadicular resorption and mobility. Because the right proximal segment of the mandible was now edentulous, a biphasic external skeletal-pin fixation appliance was placed from the right ramus to the right zygoma to control the fragment and maintain stability. Approximately 6½ months post injury, teeth (#17 and 18) were removed because of gross mobility and periodontal pathology. Two weeks later a solid iliac crest bone graft was placed in the area of non-union in the mandibular symphysis. A mandibular vestibuloplasty with split-thickness skin grafting was performed in the right mandible 14 weeks post bone grafting. A complete mandibular denture was delivered 10 weeks following the vestibuloplasty. Further surgical procedures to rehabilitate this patient included revisions of the chin scars and insertion of a silastic implant over the right mandible. At last examination (6 years and 2 months post injury) radiographs revealed excellent bony recontouring of the mandibular graft with acceptable esthetics. There was an adequate mandibular denture-bearing ridge and his complete mandibular denture was functioning satisfactorily.

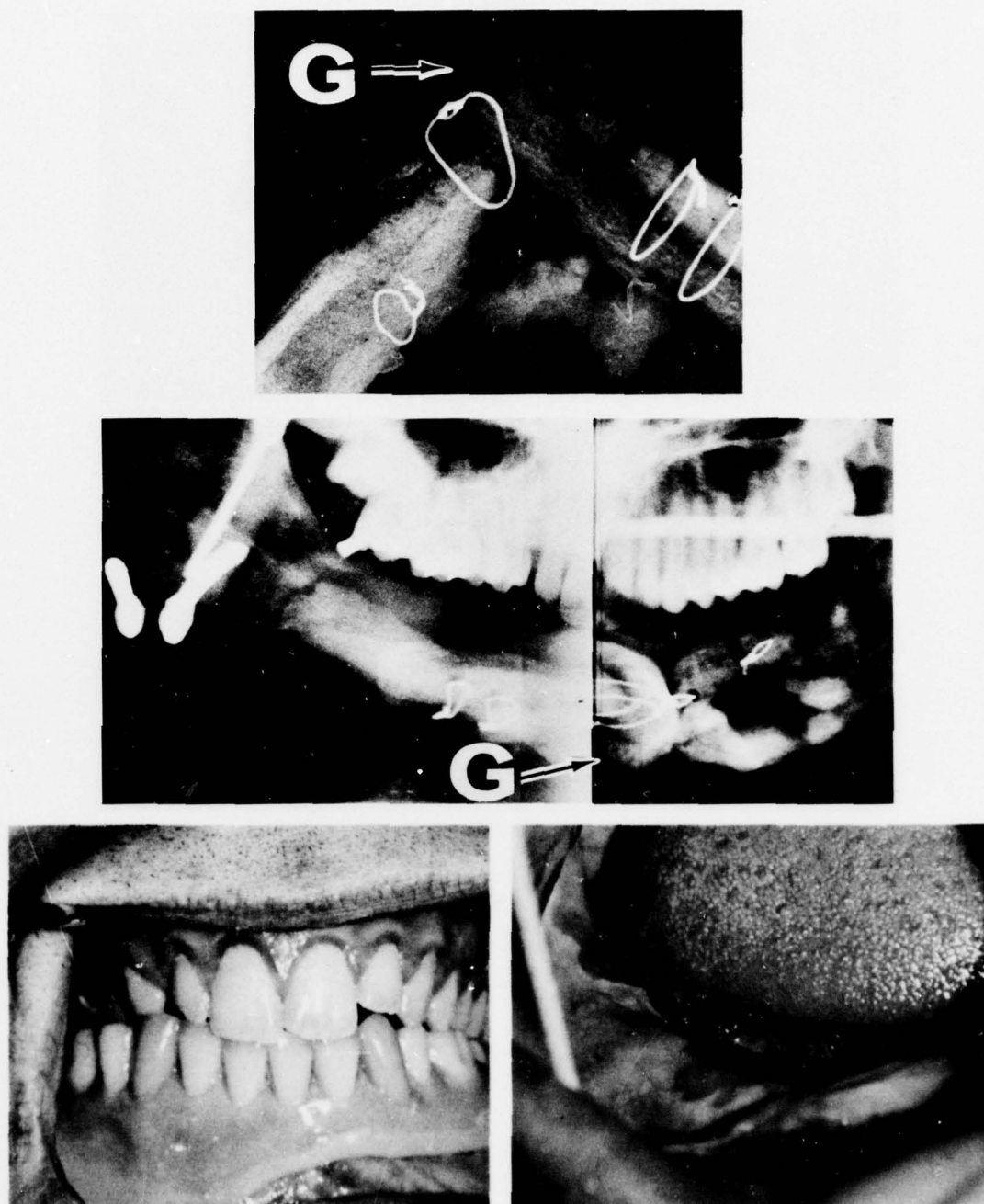


*Upper left:* Appearance of a 19-year-old casualty following fragmentation wounds to the lower face. Note the very contaminated nature of the wound. *Upper right:* Extent of the injury was evident during wound debridement and preparation. *Middle:* Appearance of the patient following fracture fixation and wound closure. *Lower:* Panoramic radiograph 36 days post injury, soon after admission to the late care hospital, showing reduction of the mandibular fragments. The fractured left first molar tooth (#19) and the right mandibular alveolar segment were removed a short time later. The edentulous right alveolar segment was grossly exposed intraorally and was nonviable.



*Upper:* Panoramic radiograph, 7 weeks post injury, showing the progress of osseous healing. The edentulous right alveolar segment and left first molar tooth (#19) had been removed. The mandibular right third molar and left second bicuspid teeth (#32 and 20) were still present but were removed at this time because of their persistent instability and recurrent sepsis. *Middle:* Panoramic radiograph, 5 months post injury, showing progressive healing. A biphase external skeletal fixation appliance had been placed on the right to control the fragments in conjunction with intermaxillary fixation in the opposite molar region. *Lower left:* Appearance of the mandibular symphysis defect at the time of bone grafting 7 months post injury. *Lower right:* Appearance of the autogenous solid iliac graft in place.





*Upper:* Occlusal radiograph, 2 weeks post bone grafting, showing the position of the solid iliac graft (G) in relation to the right and left fragments. Note that a lingually positioned bridge of bone had partially fused the two segments. This bone was residual to the initial injury having been drawn lingually by the genial muscles. *Middle:* Panoramic radiograph, 3 weeks post bone grafting, showing the graft at the symphysis (G) and the biphase pins which were left in place to control the mandible and provide graft stability. The mandible had been mobilized for several weeks prior to grafting by cutting the acrylic connector of the biphase appliance. A metal strut had been placed in the readapted bar to provide additional strength. *Lower left:* Appearance of mandibular denture occlusion 39 months following the bone graft procedure and 35½ months after skin grafting vestibuloplasty. *Lower right:* Appearance of the mandibular right denture-bearing area 46 months post injury.



*Upper left and upper right:* Appearance of the patient 4 years post injury. *Lower:* Panoramic radiograph, 4 years and 3 months post injury, showing remodeling and recontouring of the mandible and graft.

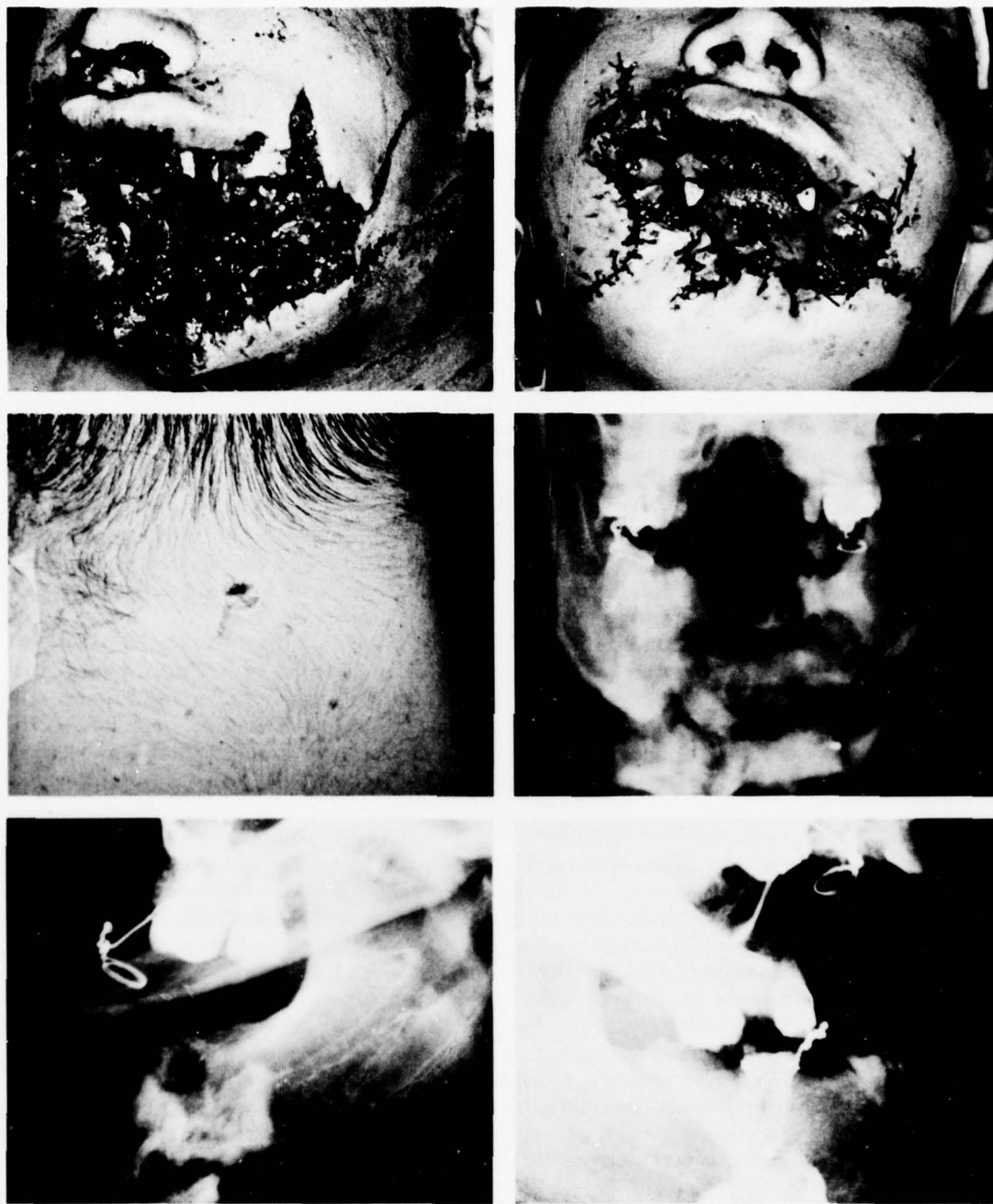
## CASE NUMBER 04

**Description of Injuries:** A 19-year-old casualty sustained a high-velocity missile wound to the neck and face. The perforating missile entered the posterior neck in the midline just inferior to the occipital area and passed anteriorly, exiting in the symphysis region of the mandible. Although the exit wound was extensive with avulsion of a large segment of hard and soft tissue, the entrance wound was almost unnoticeable. Remarkably, there was no vertebral or major neurovascular injury.

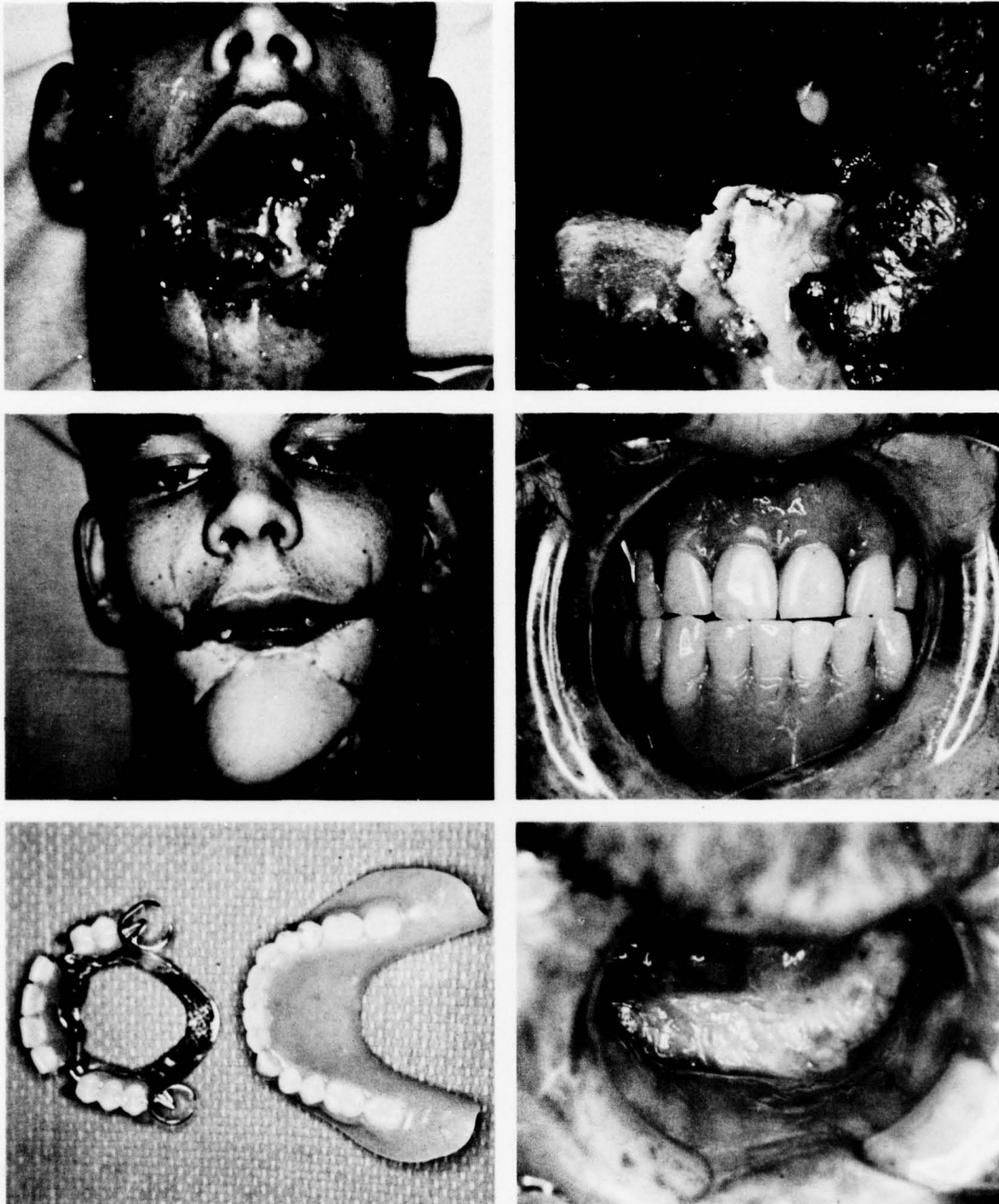
**Early Care:** The patient was received initially the day of injury at a 3rd-echelon medical facility where a tracheostomy was performed, the facial and oral wounds were debrided and closed, and the posterior cervical wound was closed. The remaining major mandibular fragments were immobilized to the maxilla by means of simple circumdental intermaxillary wires. The day following treatment, the patient was transferred to a 4th-echelon facility (hospital ship) where he received supportive care prior to medical evacuation 6 days after injury.

**Late Care:** The patient was evacuated directly to CONUS over a 48-hour period and admitted to a major medical facility 8 days after injury. Initial examination revealed purulent discharge from the tracheostomy site and the mandibular wounds. Twelve days post injury the mandibular wound was debrided, fractured teeth were removed, and a mucosa-to-skin closure was performed following placement of dependent drains. Also at this time, the first stage of a tube pedical flap was accomplished in preparation for restoration of the soft tissue defect that existed in the symphysis region. The immediate postoperative period was complicated by jaundice and a diagnosis of hepatitis was established. The hepatitis gradually resolved and after 25 days laboratory indices of disease had returned to normal. Over the next 6 months a series of surgical procedures, including distal and local flaps and scar revisions, were carried out in conjunction with soft tissue reconstruction of the chin. Fifteen months following injury, an autogenous corticocancellous bone graft was performed from the right iliac crest to the mandibular symphysis. The graft healed uneventfully; however, a chronic infection developed at the iliac crest donor site and was treated successfully on an outpatient basis over a period of several weeks. Six months following the bone graft procedure an anterior mandibular vestibuloplasty with skin grafting was performed. Approximately 2 months after the vestibuloplasty a maxillary partial denture and mandibular full denture were constructed, which the patient was able to wear with minimal difficulty. Over the next 3 years he underwent additional soft tissue procedures to improve his facial appearance and lower lip function. At last follow, 8 years post injury, esthetics and masticatory function were satisfactory. Although the treatment of this patient was complicated, complex, and quite prolonged, the ultimate results were very acceptable.

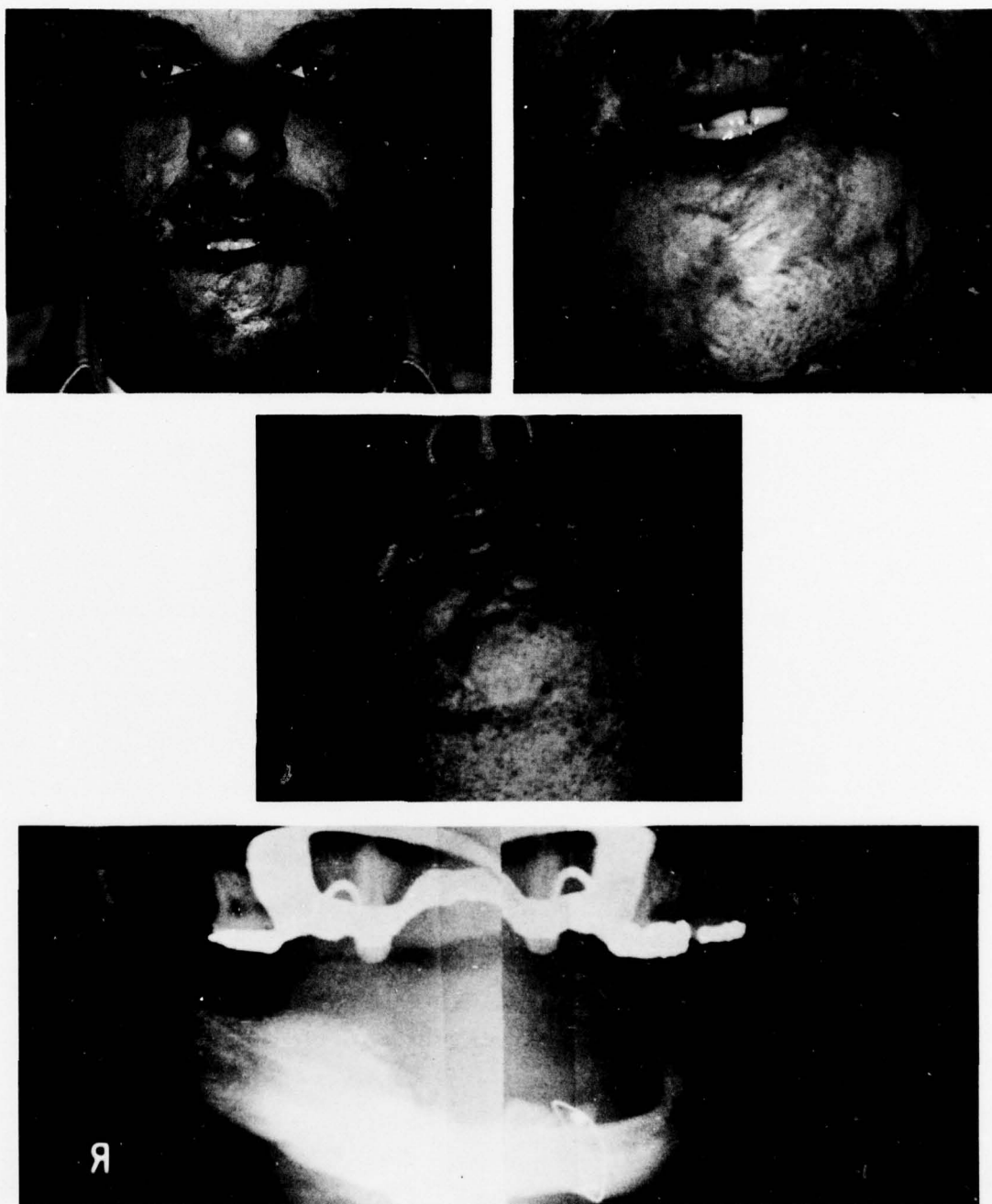




*Upper left:* Pretreatment appearance of a 19-year-old casualty who sustained a high-velocity missile wound with extensive damage to the orofacial area. *Upper right:* Posttreatment appearance of the patient following tracheostomy, limited intermaxillary fixation, and wound closure. There was no attempt to reduce the anterior mandibular fractures. Because of extensive loss of soft tissue in the perioral region, it was necessary to suture mucosa to skin to effect primary closure. *Middle left:* Appearance of small entrance wound in posterior neck as it appeared 9 days post injury. *Middle right, lower left, and lower right:* Posteroanterior, right and left lateral oblique radiographs, 9 days post injury, showing loss of substance and malposition of the anterior mandibular osseous fragments. Simple intermaxillary wiring was ineffective in maintaining the two major mandibular fragments.



*Upper left:* Appearance of orofacial wound 9 days post injury and 1 day after admission to a late care facility. Gross sepsis existed in the face of extensive wound dehiscence and the mandibular fragments were unstable. *Upper right:* Appearance of septic oral wound with exposure of mandibular fragment. *Middle left:* Appearance of patient 6 months post injury. Soft tissue flaps and grafts had been employed to restore the deficit in the symphysis area after sepsis was controlled. The mandibular fragments had been maintained in position with improved intermaxillary fixation. Partial consolidation of the symphysis fragments in a malunited inferior position had occurred although instability still existed. *Middle right:* Appearance of denture occlusion 5 years and 3 months post injury and 47 months following a mandibular bone graft for continuity restoration. *Lower left:* Appearance of prosthetic appliances that were restoring functional occlusion, as seen in *middle right* panel. *Lower right:* Appearance of denture-bearing area in mandibular symphysis region 5 years and 5 months following bone grafting. Vestibuloplasty and skin grafting had been performed 6 months post bone grafting.



*Upper left, upper right, and middle:* Appearance of patient 8 years and 2 months post injury. Numerous secondary soft tissue procedures were performed to enhance the appearance of the chin and function of the lip. Functional denture occlusion was still being maintained. *Lower:* Panoramic radiograph 8 years and 2 months post injury. Mandibular continuity had been restored although normal symmetry did not exist because of the malunion that occurred during the complicated initial phase of late care.



## CASE NUMBER 05

---

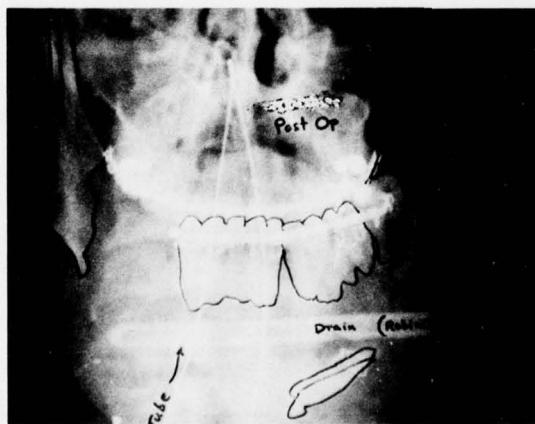
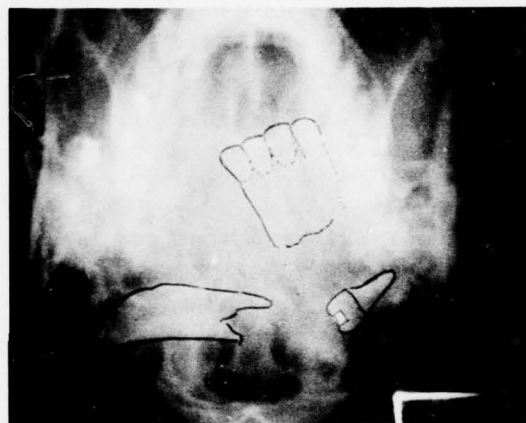
**Description of Injuries:** This 22-year-old casualty sustained a high-velocity gunshot wound resulting in injury to the lower third of the face and neck bilaterally. He sustained a compound, comminuted, avulsive fracture of the anterior mandible, in addition to lacerations to the lower lip, cheek, and neck.

**Early Care:** The patient was initially treated at a 3rd-echelon medical facility where emergency tracheostomy and initial debridement of the wounds were accomplished. On the same day the patient was transferred to a 4th-echelon facility (hospital ship). Following triage, examination, and radiography, the patient was taken to the operating room for evaluation and definitive treatment of wounds. The wounds were conservatively debrided, fractured teeth and unattached bony fragments were removed, and an open reduction of the residual fragments was performed. The mandible was immobilized with maxillary and mandibular arch bars and intermaxillary fixation, after which the soft tissues were closed and drains placed. Postoperatively the patient progressed satisfactorily and was medically evacuated 10 days following injury.

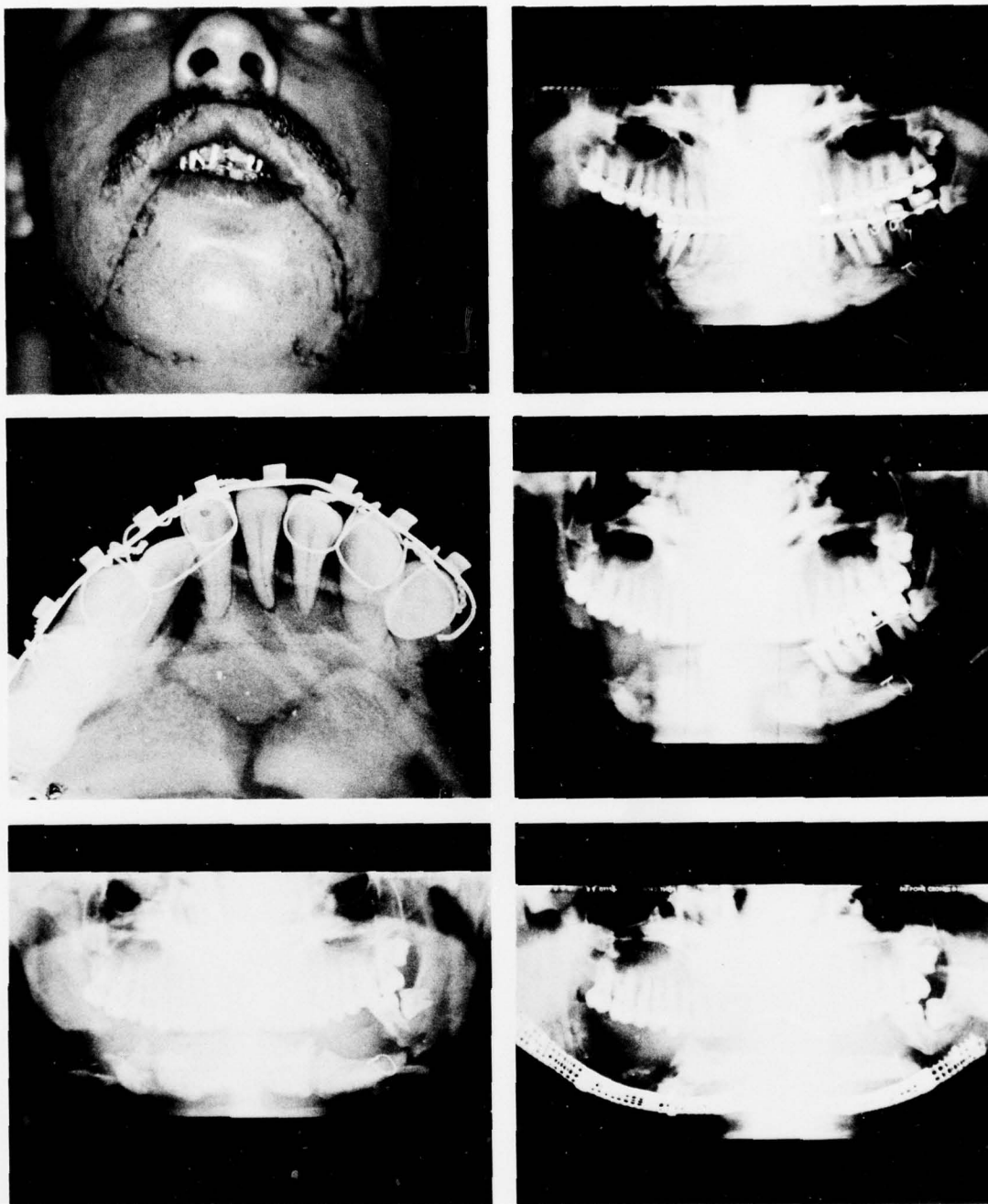
**Intermediate Care:** The patient was admitted to an intermediate care facility after 2 days in transit. Admission examination revealed intraoral areas of denuded bone in the mandibular symphysis and body regions. Supportive and local wound care were provided and the patient was medically evacuated to CONUS after 18 days.

**Late Care:** The patient entered a late care hospital after 2 days in transit. Seven days following admission, a large dentoalveolar sequestrum, including the mandibular right central and lateral incisors and bicuspid teeth (#25-28), was lifted from the oral wound. The patient progressed satisfactorily but continued to sequestrate small bony fragments from the mandibular symphysis region during the next 2 months. Four months after late care admission, another dentoalveolar sequestrectomy was performed including the mandibular left first and second bicuspid, cuspid, and lateral incisor teeth (#20-23). A PCM graft was performed 10½ months post injury to restore mandibular continuity. Postoperatively, the patient progressed well and the metallic crib was removed 8 months post grafting. Six months later, 2 years post injury, a solid corticocancellous autogenous augmentation bone graft was placed in the mandibular symphysis region. A vestibuloplasty with split-thickness skin grafting was performed 6 months later, following which a wound infection developed that responded satisfactorily to local care and antibiotic therapy. At the time of last follow, 5 years and 2 months post injury, the patient was wearing a functionally satisfactory denture and presented a pleasing esthetic appearance.

---



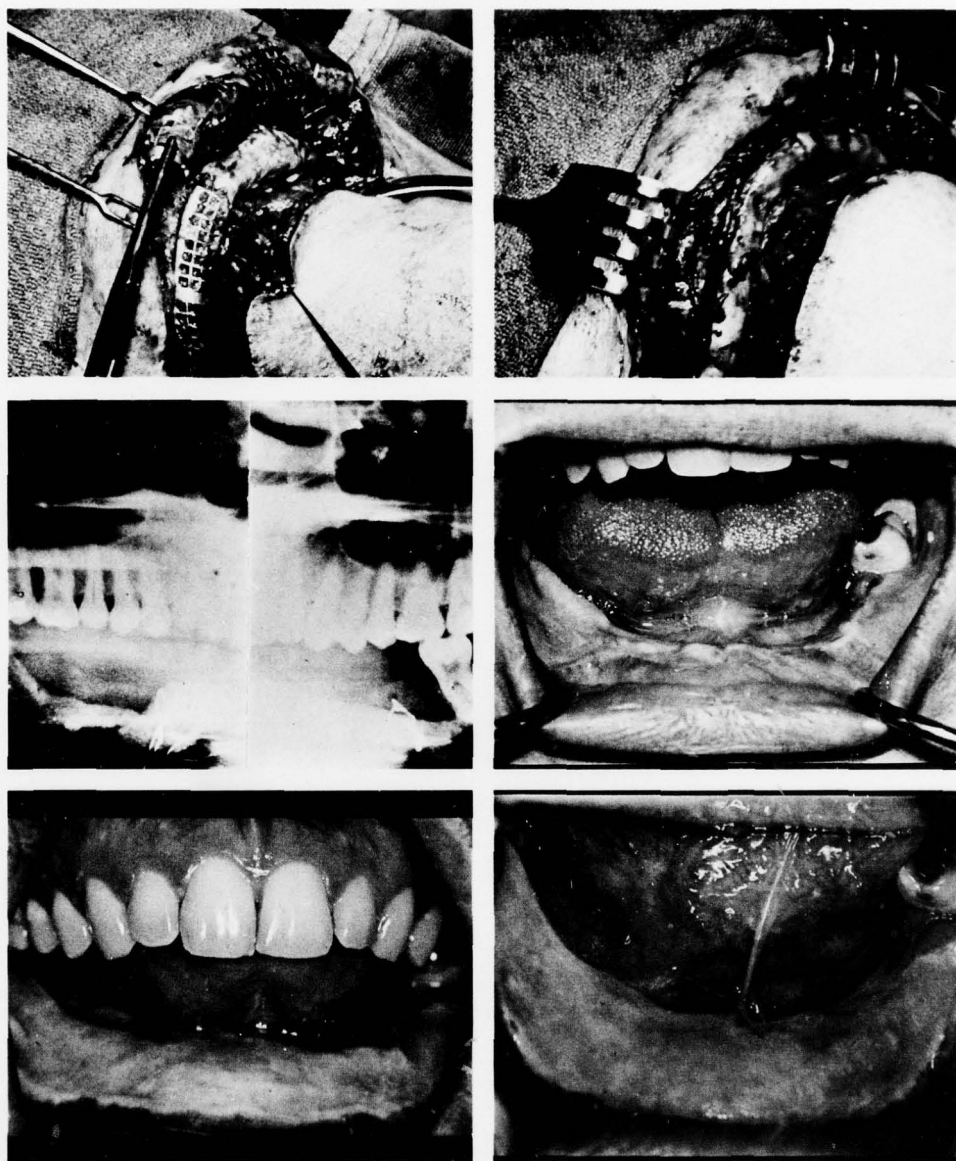
*Upper left:* Appearance of a young man prior to sustaining injury (at time of high school graduation). *Upper right:* His appearance as a casualty on arrival at 4th-echelon facility (hospital ship). At a 3rd-echelon facility a tracheostomy had been performed and temporary tacking sutures placed to secure a large orofacial flap resulting from a high-velocity missile that had perforated the region of the anterior mandibular body in a horizontal plane. *Middle left:* The extent of the orofacial wound and underlying tissue damage was evident following release of the tacking sutures. Gross hard and soft tissue damage had occurred. *Middle right:* Preoperative posteroanterior radiograph showing the displacement of mandibular fragments. *Lower left:* Postoperative posteroanterior radiograph showing the mandibular fragment position after fracture reduction and wound closure. *Lower right:* Appearance of patient immediately following wound closure.



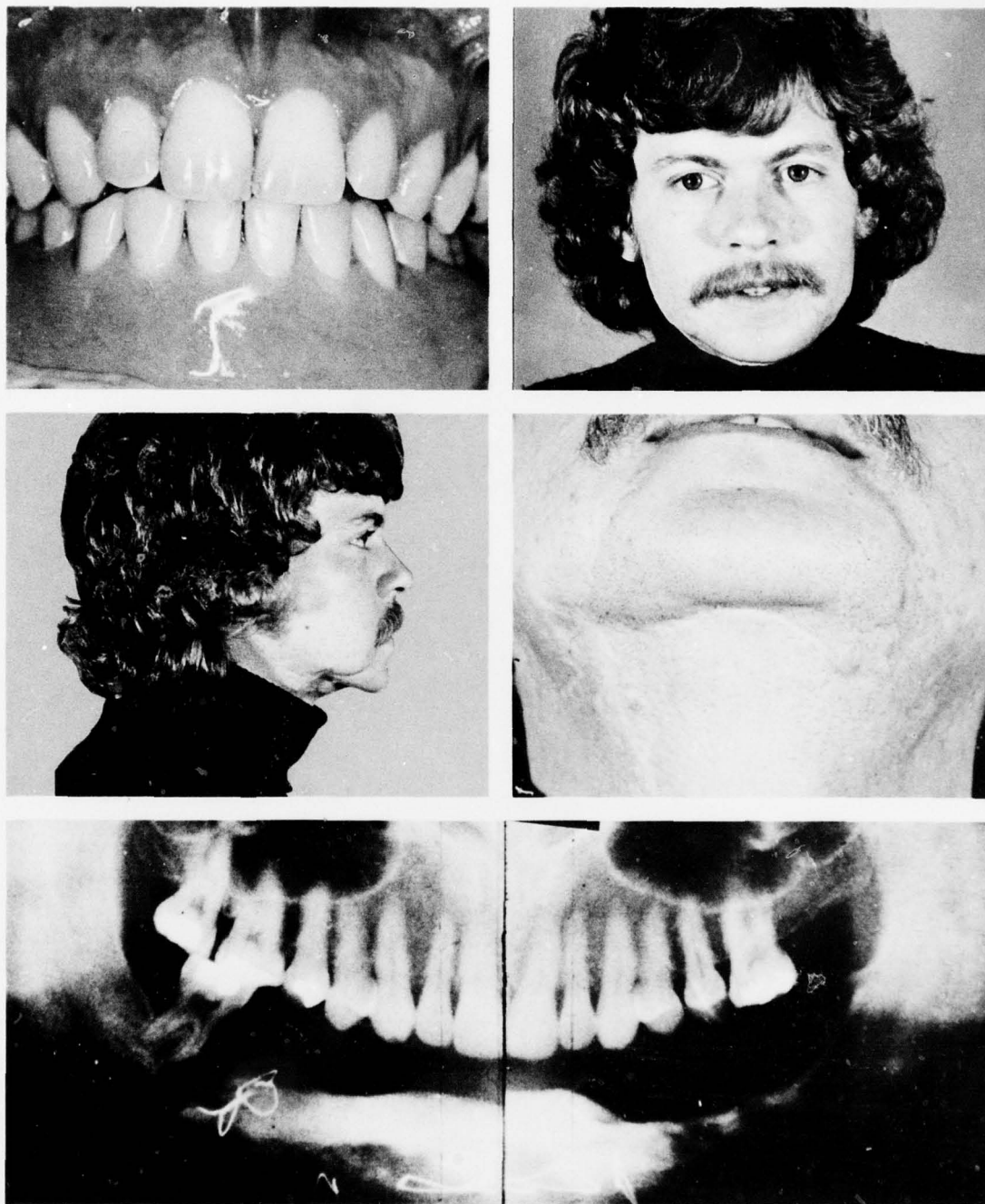
*Upper left:* Appearance of patient 8 days after initial wound care. *Upper right and middle left:* Panoramic and occlusal radiographs, 1 month post injury, prior to removal of anterior mandibular dentoalveolar segment that had become infected and devitalized. Discontinuity existed in the left body region. *Middle right:* Panoramic radiograph 5 months post injury just prior to removal of a large devitalized dentoalveolar segment from the mandibular left body region. *Lower left:* Panoramic radiograph 5½ months post injury following removal of the dentoalveolar segment. *Lower right:* Panoramic radiograph 21 1/2 months post injury and 9 months following placement of a PCM graft to the mandible for restoration of continuity. A cast Vitallium® crib was used as the metallic portion of the graft system.



176 • Case number 05



Upper left and upper right: Appearance of reconstructed mandible at time of metallic crib removal 8 months following the PCM graft to restore continuity. Middle left: Panoramic radiograph 1 month after augmentation bone grafting of the mandible. Middle right: Intraoral appearance of alveolar component of reconstructed mandible 7 months following augmentation grafting just prior to vestibuloplasty. Lower left and lower right: Intraoral appearance of reconstructed alveolar portion of mandible 22 months after vestibuloplasty with skin grafting.



*Upper left:* Restored occlusion 22 months after vestibuloplasty. *Upper right, middle left, and middle right:* Appearance of patient 5 years and 2 months following injury. *Lower:* Panoramic radiograph 52 months following injury, 40½ months following the continuity restoring bone graft, and 28 months following the augmentation bone graft.

AD-A054 648

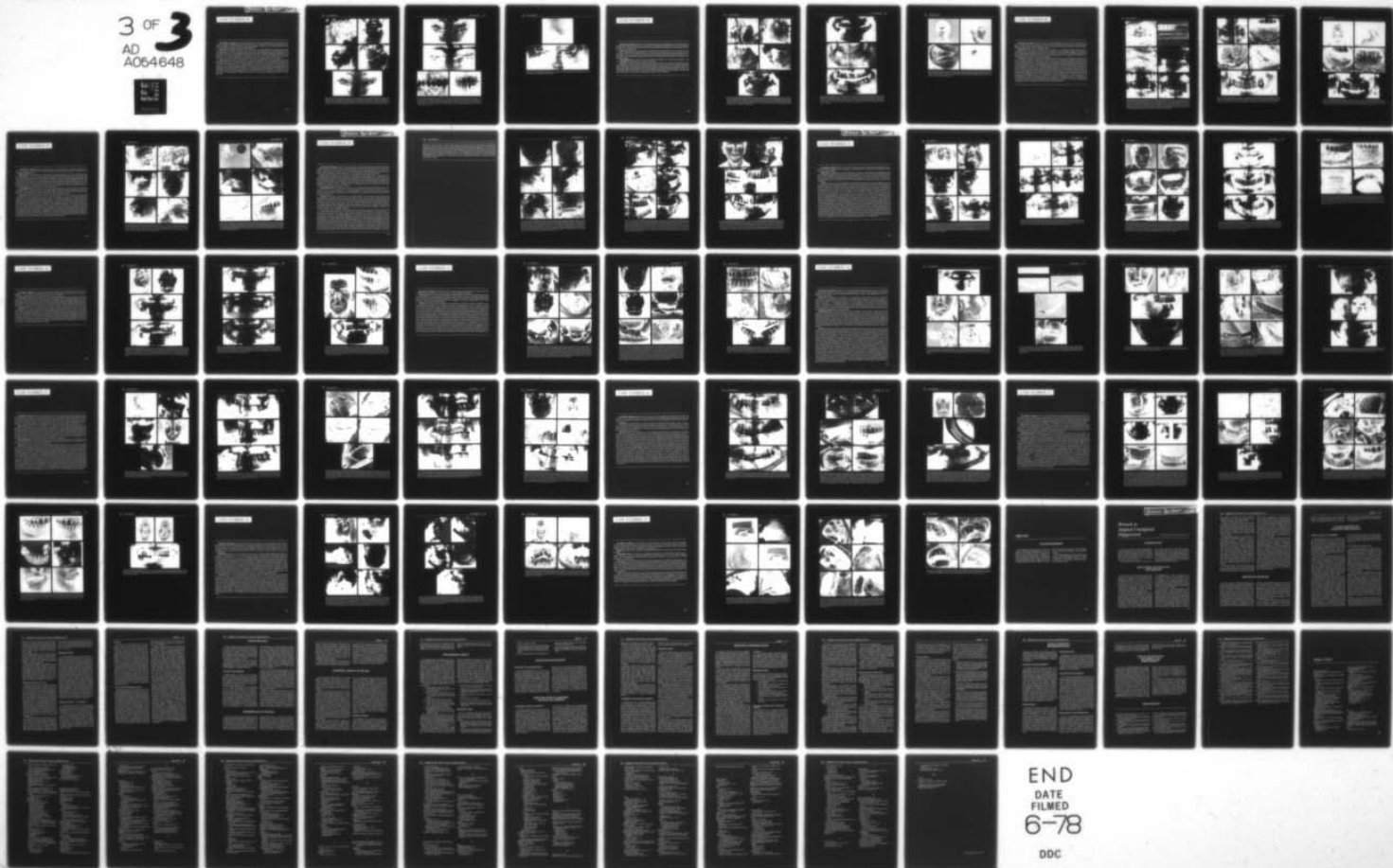
NAVAL MEDICAL RESEARCH INST BETHESDA MD  
MANAGEMENT OF WAR INJURIES TO THE JAWS AND RELATED STRUCTURES.(U)  
APR 78 J F KELLY, P W CONNOLE, W R HIATT  
NMRI-78-23

F/G 6/21

UNCLASSIFIED

NL

3 OF 3  
AD  
A054648







## CASE NUMBER 06

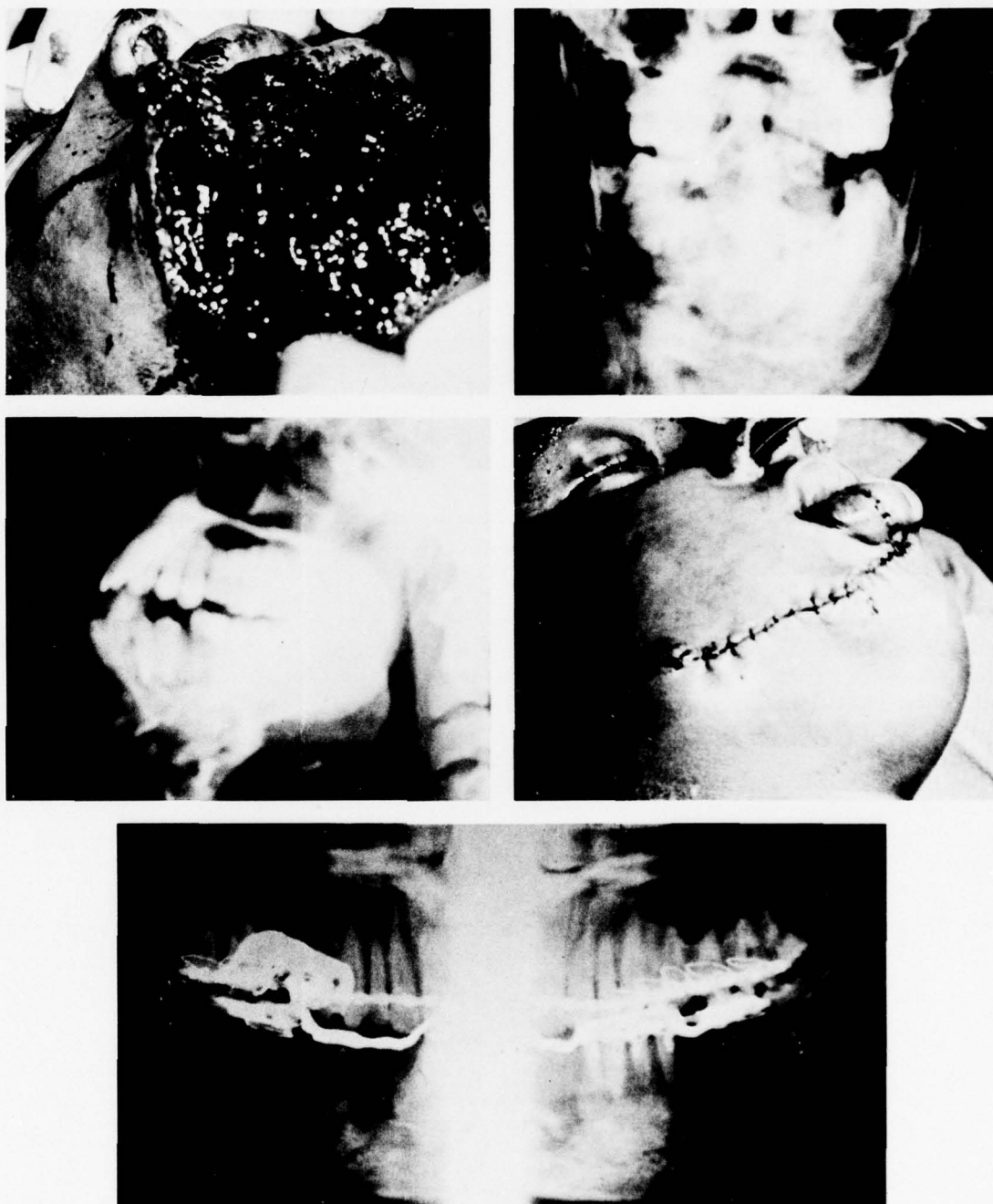
---

**Description of Injuries:** This 19-year-old casualty sustained a high-velocity missile wound to the face that resulted in multiple facial and oral lacerations and a compound, comminuted, avulsive fracture of the mandibular symphysis and body regions. Mandibular teeth that were avulsed included the left central incisor through the right first molar (#24-30).

**Early Care:** The patient was received at a 4th-echelon medical facility the day of injury where after examination, he was taken to surgery where his wounds were debrided and a closed reduction of the mandibular fracture was accomplished with arch bars and intermaxillary fixation. Although there had been loss of soft tissue in the region of the lower lip and cheek, it had been possible to close the wound primarily. One day postoperatively the hematocrit was 26, and 2 units of packed red cells were transfused. The patient stabilized and medical evacuation was initiated 9 days after injury.

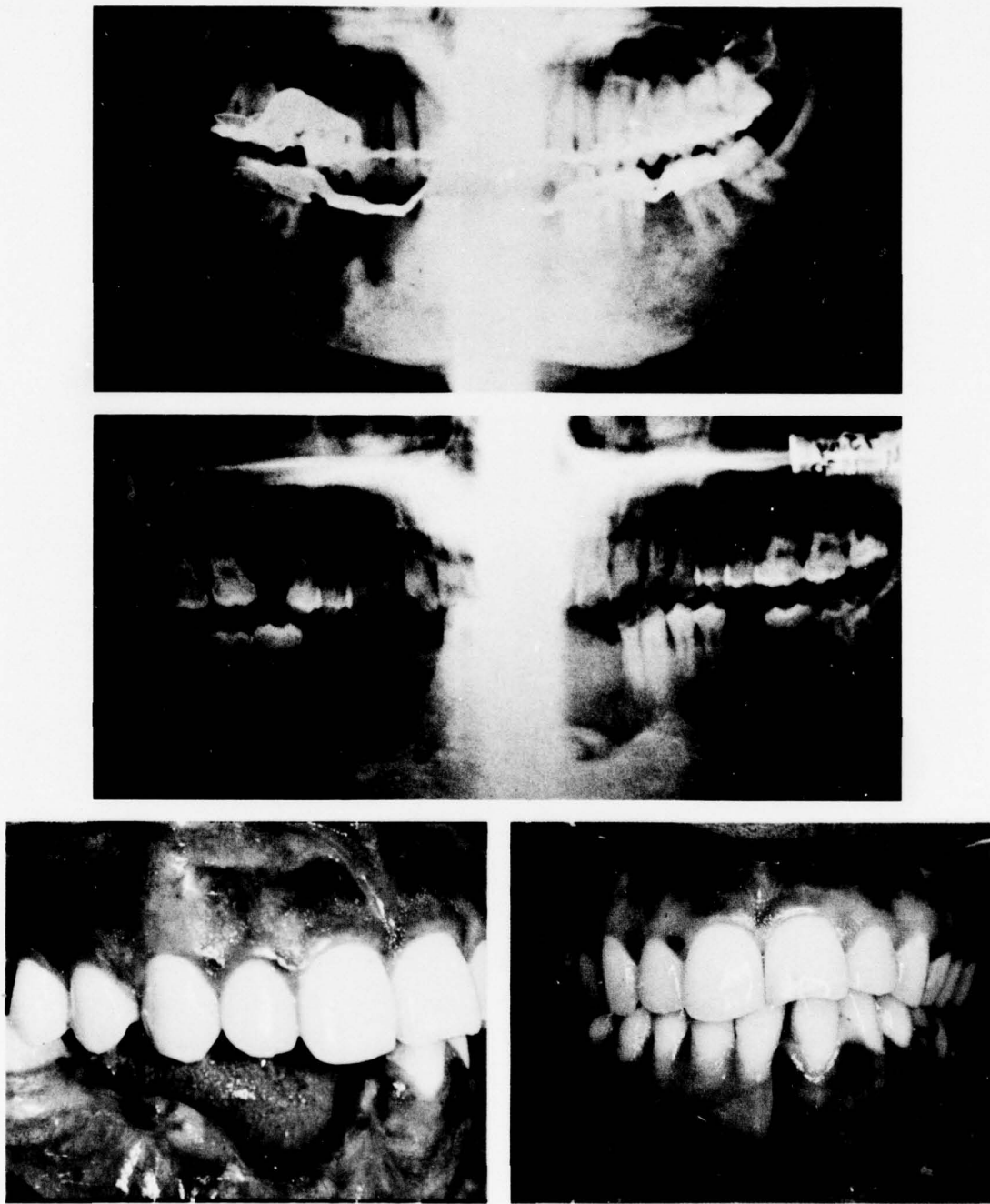
**Late Care:** The patient was admitted to a late care hospital after 2 days in transit. Four days following admission, root fragments of the mandibular right first molar tooth (#30) were removed. Multiple bony sequestra were removed during the next 3 weeks in conjunction with vigorous local wound care. A Vitallium® lingual mandibular splint was inserted 7 weeks post injury. Five and one-half months post injury intermaxillary fixation was released and monoarch fixation was maintained for an additional 6 weeks followed by insertion of a mandibular prosthesis. Revision of facial scars was accomplished at a subsequent hospitalization several months later. At last follow, 5 years and 9 months post injury, the patient had excellent function and was wearing a mandibular prosthesis without difficulty.

---

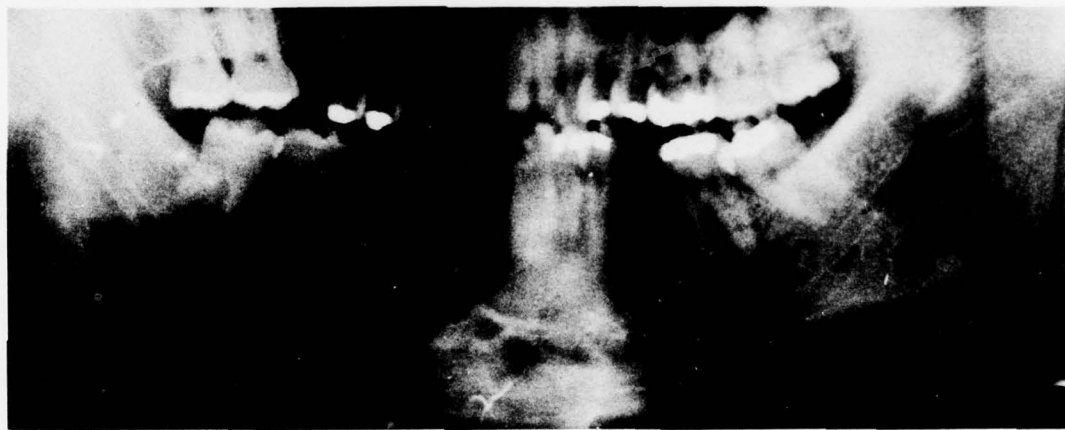
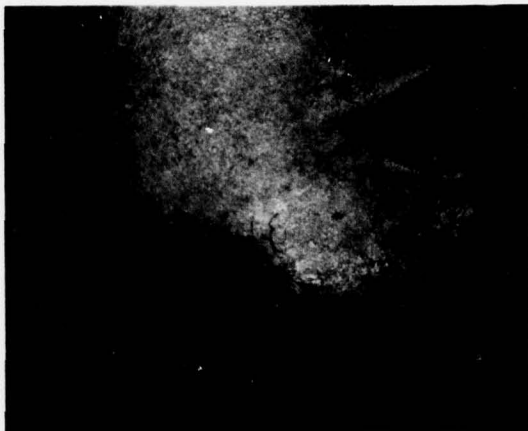


*Upper left:* Appearance of soft tissue wound in a 19-year-old casualty who had been struck by a high-velocity missile. *Upper right:* Posteroanterior radiograph, taken following triage, showing the fracture comminution of the right mandibular body. *Middle left:* Lateral radiograph showing comminution of the mandibular symphysis region. *Middle right:* Appearance of wound closure. Although the wound initially appeared to be associated with extensive soft tissue avulsion, little tissue was actually lost. *Lower:* Panoramic radiograph 18 weeks post injury. At this time the patient was still in intermaxillary fixation.





*Upper:* Panoramic radiograph 22 weeks post injury. At this time the patient's IMF was released and monoarch fixation was continued. *Middle:* Panoramic radiograph 15 months post injury. There had been recontouring and remodeling of the mandibular body, the mandible was stable and firm, and the patient was able to function normally. *Lower left:* Appearance of the mandibular alveolar ridge 69 months post injury showing a deficit with fixed overlying mucosal tissue that permitted denture construction. *Lower right:* Appearance of the dental occlusion with the mandibular prosthesis in place. Excellent oral health had been maintained.



*Upper:* Appearance of the patient 69 months post injury. His esthetic results have been improved by secondary scar revision.  
*Lower:* Panoramic radiograph 69 months post injury.

## CASE NUMBER 07

---

**Description of Injuries:** This 21-year-old casualty sustained a fragmentation wound of the face that resulted in a compound, comminuted, avulsive fracture of the right mandible, fracture of the mandibular right second bicuspid, first and second molar teeth (#29-31), and laceration of the tongue, floor of the mouth, and right cheek.

**Early Care:** The patient was admitted to a 4th-echelon medical facility the day of injury where his wounds were debrided, teeth (#29-31) were removed, and the wounds closed. A closed reduction of the mandibular fracture was performed utilizing arch bars and intermaxillary wire fixation. Postoperatively, the patient was maintained on supportive care until he was admitted to the medical evacuation system 7 days after injury.

**Intermediate Care:** The patient was received at an intermediate care facility where supportive care was continued for 4 days prior to transfer to CONUS.

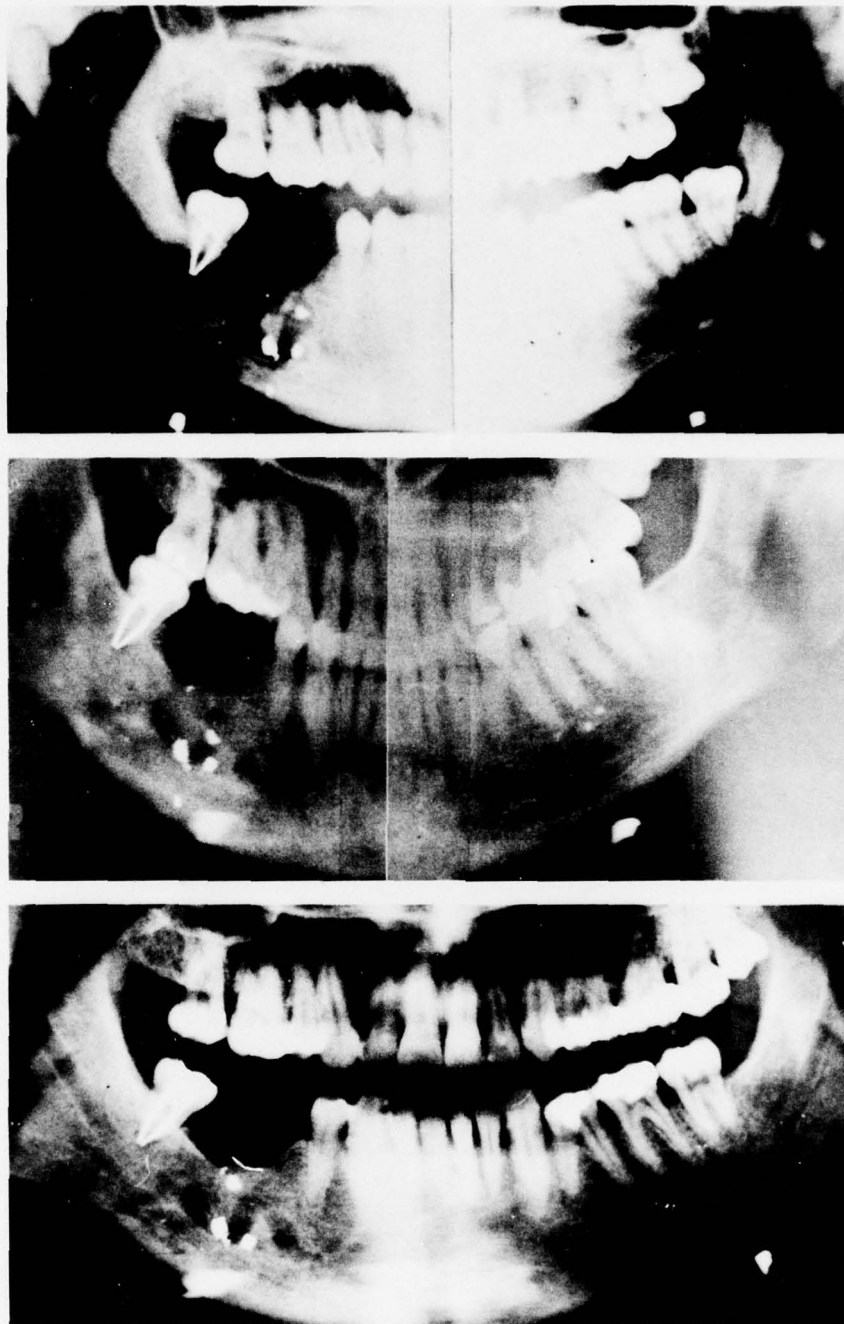
**Late Care:** The patient entered a late care hospital after 3 days in transit. Six weeks following injury, the mandible was clinically stable and the fixation appliances were removed. The maxillary right third molar tooth (#1) was removed 10 weeks following injury. Endodontic therapy was performed on the mandibular right third molar (#32) 3 months post injury. A mandibular partial denture was inserted 4 months post injury. At last follow, 6 years and 5 months following injury, the mandible was stable with good masticatory function and no significant residual cosmetic deficiency.

---





*Upper left:* Fragmentation wound of right cheek in a 21-year-old casualty. *Upper right:* Lateral radiograph showing comminuted fracture of right mandible involving the dentition. *Middle left:* Closure of cheek wound. *Middle right:* Posttreatment, lateral oblique radiograph of right mandible showing area of injury. Teeth had been removed and the fragments had been molded into position without direct wire reduction. The third molar tooth was retained to effect control of the proximal fragment through occlusion with opposing maxillary dentition. *Lower:* Panoramic radiograph, 13 days following injury, showing fragments that were molded into correct position.



*Upper:* Panoramic radiograph, 3½ months post treatment, showing satisfactory osseous healing and maintenance of mandibular morphology and symmetry. Endodontic therapy had been performed 3 months after injury on the critically positioned third molar. *Middle:* Panoramic radiograph, 19 months post injury, showing excellent osseous healing at the injury site. The second molar tooth was still in place and functioning. *Lower:* Panoramic radiograph, 77 months post injury, showing further maturation of osseous tissues at injury site. Although wounding fragments were still in the tissues, they afforded the patient no difficulty.



*Upper left:* Full-face photograph of patient 57 months post injury. *Upper right:* Right lateral facial photograph 57 months post injury. *Lower left:* Dental occlusion on the side of injury with partial denture prosthesis in place 57 months post injury. *Lower right:* Partial denture which was being used to restore occlusion and which was partially supported by a molar tooth that was clasped by a distal extension of the prosthesis.



## CASE NUMBER 08

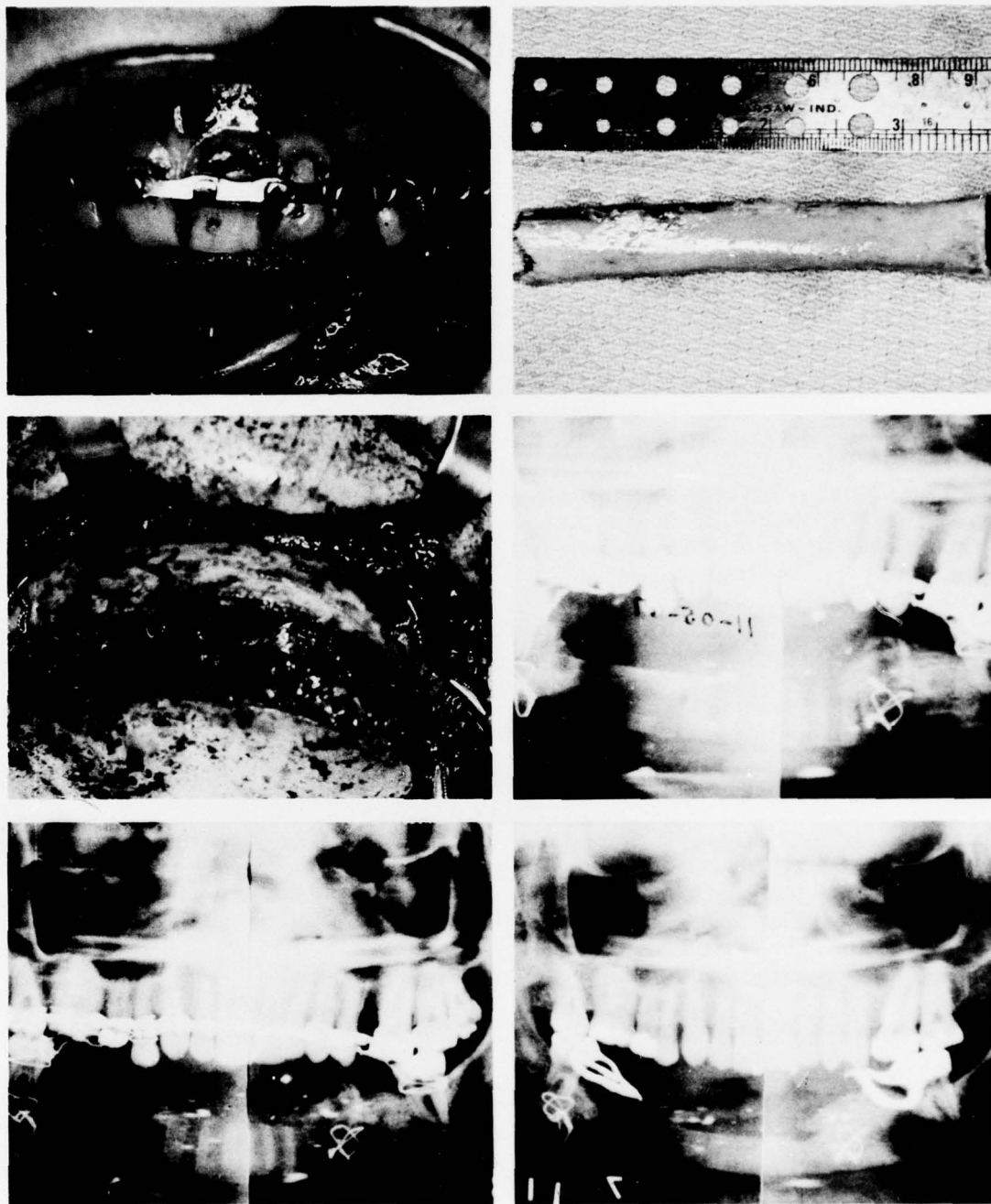
---

**Description of Injuries:** This 21-year-old casualty sustained an injury to the orofacial area as a result of small arms fire. A missile entered the right mandibular body, traveled in an anteromedial direction, and exited through the right lower lip. A compound, comminuted fracture and avulsive injury to the anterior portion of the mandible resulted.

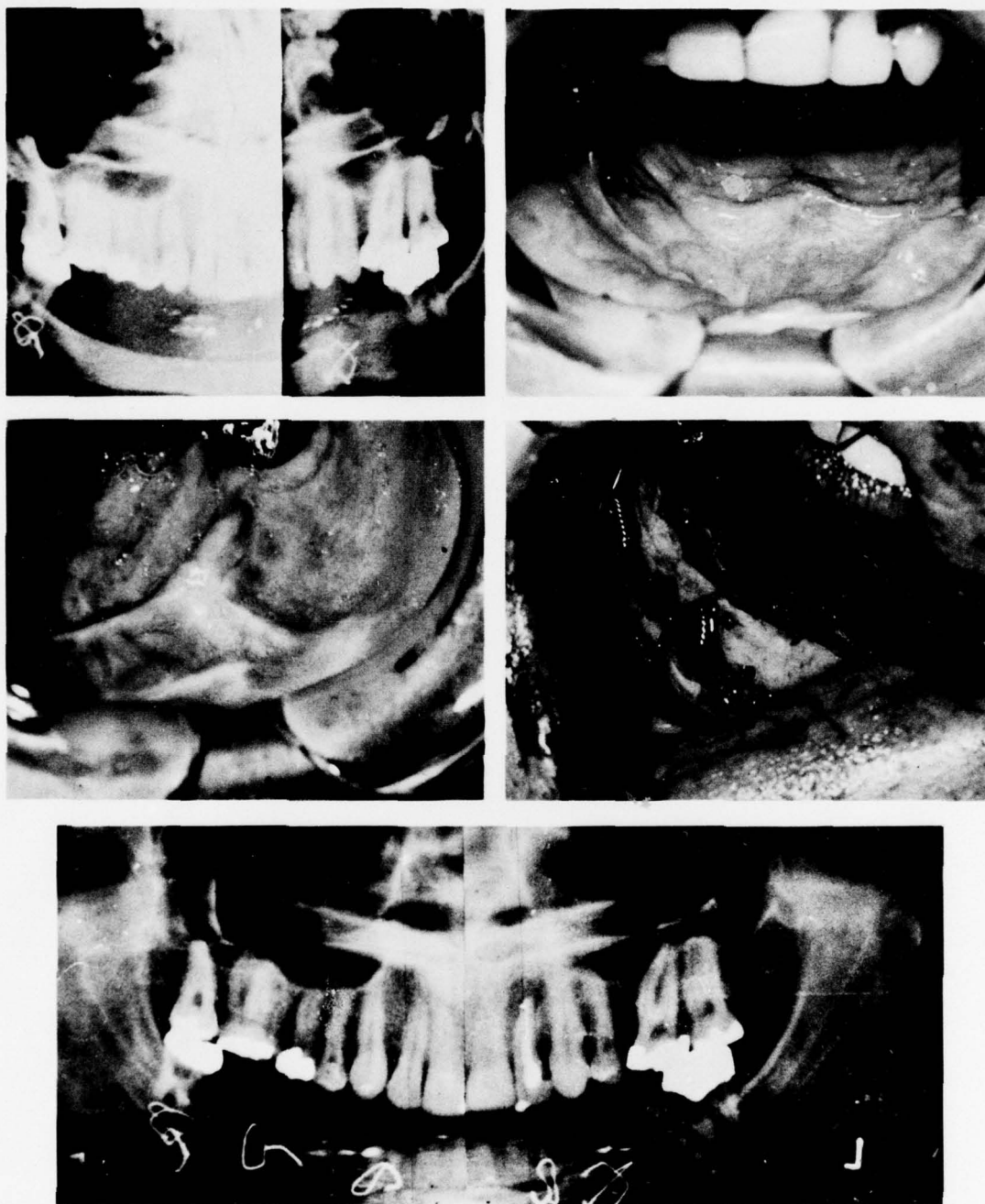
**Early Care:** After injury, the patient was evacuated to a 4th-echelon medical facility where a tracheostomy was performed, the wounds were debrided, and an alloplastic implant was placed to maintain mandibular fragment position. The soft tissues were closed and the mandible was immobilized with maxillary and mandibular arch bars and intermaxillary fixation. The patient was admitted to the medical evacuation system 2 days following injury.

**Late Care:** Evacuation was directly to CONUS and admission to a late care hospital occurred after 2 days in transit. Admission examination revealed erosion of the alloplastic implant through the oral mucosa although there was no overt suppuration. The patient was placed on antibiotic therapy intermittently in the face of chronic wound infection about the implant. Intermaxillary fixation was maintained to control fragment position. The alloplastic implant was finally removed 3 months post injury and the wounds healed. Two months later, 5 months following injury, an autogenous rib graft was placed to restore continuity to the anterior mandible. The graft healed without complications. Revision of lower lip scars was accomplished 4 months following the bone graft. As a result of recall in conjunction with the maxillofacial casualty study, 65 months post injury, it was determined that the partial denture had failed because of an inadequate tissue base. Augmentation bone grafting with an autogenous rib was accomplished 68 months following continuity bone grafting. Vestibuloplasty with skin grafting was performed 18 months after augmentation bone grafting. A mandibular denture was subsequently constructed and at the time of last follow, 8 years and 4 months post injury, the patient was functioning satisfactorily without complaint and manifested acceptable esthetics.

---

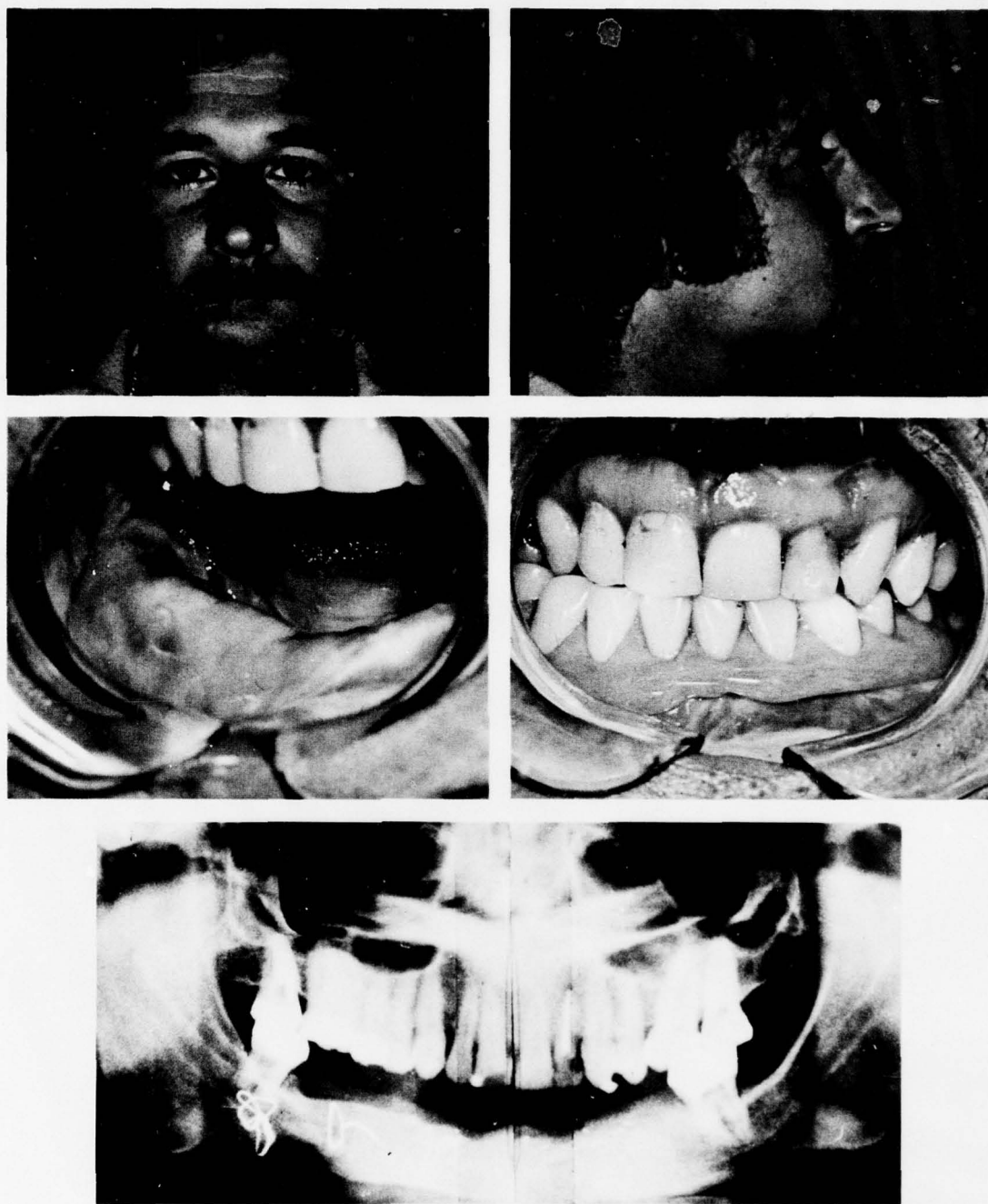


*Upper left:* Appearance of alloplastic implant that had eroded through the oral mucosa at the time of admission of the patient to CONUS facility. The implant had been placed at the time of initial wound care to restore avulsed osseous tissue. *Upper right:* Appearance of 8th rib after resection before insertion as a mandibular graft to restore continuity. *Middle left:* Rib graft secured in place across symphysis defect. *Middle right:* Panoramic radiograph 6 days following autogenous rib grafting to the anterior mandible. *Lower left:* Panoramic radiograph 6 weeks after rib grafting to the mandible. *Lower right:* Panoramic radiograph 9 months following autogenous rib graft to the mandible. The graft had consolidated well. The framework of a partial denture, which is partially supported by the residual molar teeth, was evident in the radiograph.



*Upper left:* Panoramic radiograph, 68 months post bone grafting, showing well-healed and remodeled rib graft in the mandible. *Upper right and middle left:* Intraoral appearance of patient, 68 months post bone grafting, showing inadequate tissue base for a denture principally in the right anterior region. *Middle right:* Appearance of autogenous augmentation rib graft secured in place at time of grafting. *Lower:* Panoramic radiograph 15 days following rib graft augmentation of the mandible.





*Upper left and Upper right:* Appearance of patient 32 months after augmentation bone grafting. *Middle left:* Intraoral appearance of reconstructed mandible 32 months following augmentation bone grafting and 14 months after vestibuloplasty. *Middle right:* Appearance of occlusion with mandibular denture against natural maxillary dentition. *Lower:* Panoramic radiograph 26 months following augmentation bone grafting and 7 years and 5 months after grafting for continuity.

## CASE NUMBER 09

---

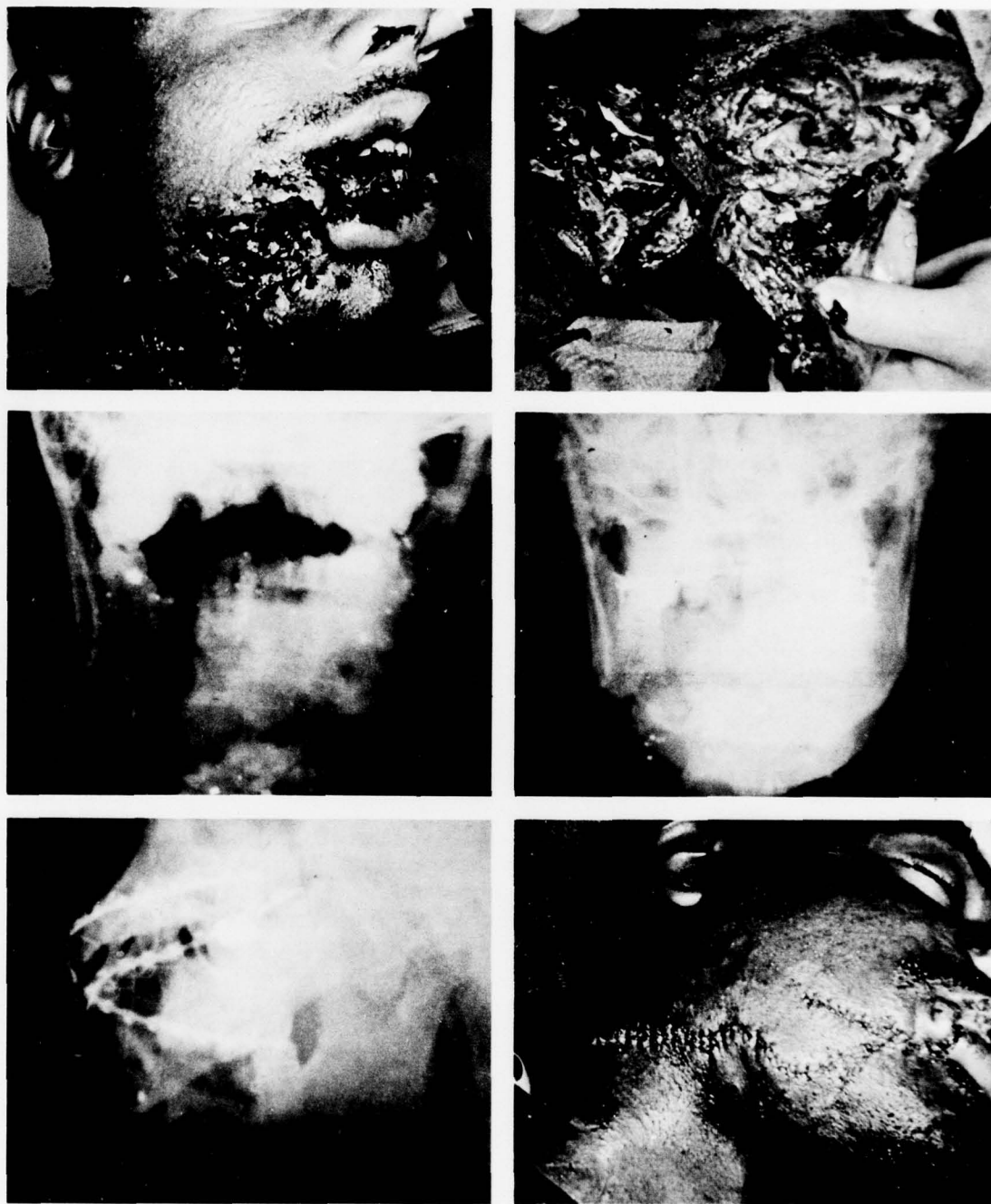
**Description of Injuries:** This 21-year-old casualty received fragment wounds of the right lower face. He sustained severe facial and oral lacerations and a compound, comminuted, avulsive fracture of the right mandibular body.

**Early Care:** He was evacuated to a 4th-echelon medical facility the day of injury. Following triage and radiography, he was taken to the operating room where debridement was carried out and the fractured maxillary right first bicuspid (#5), cuspid (#6), central incisor (#8), and mandibular right central incisor (#25) teeth were removed and a closed reduction of the mandibular fracture was performed. The mandible was immobilized with arch bars and intermaxillary elastic fixation. The soft tissue wounds were then closed and a penrose drain was placed. Before the anesthetic period was completed an elective tracheostomy was performed. The postoperative course was satisfactory and he entered the medical evacuation system 6 days post injury.

**Intermediate Care:** The patient was received at an intermediate medical facility 1 day following admission to the evacuation system. At the intermediate facility he received supportive care for his orofacial wounds and fractures. The tracheostomy tube was removed and the stoma closed spontaneously. He was evacuated to CONUS after 9 days at the intermediate facility.

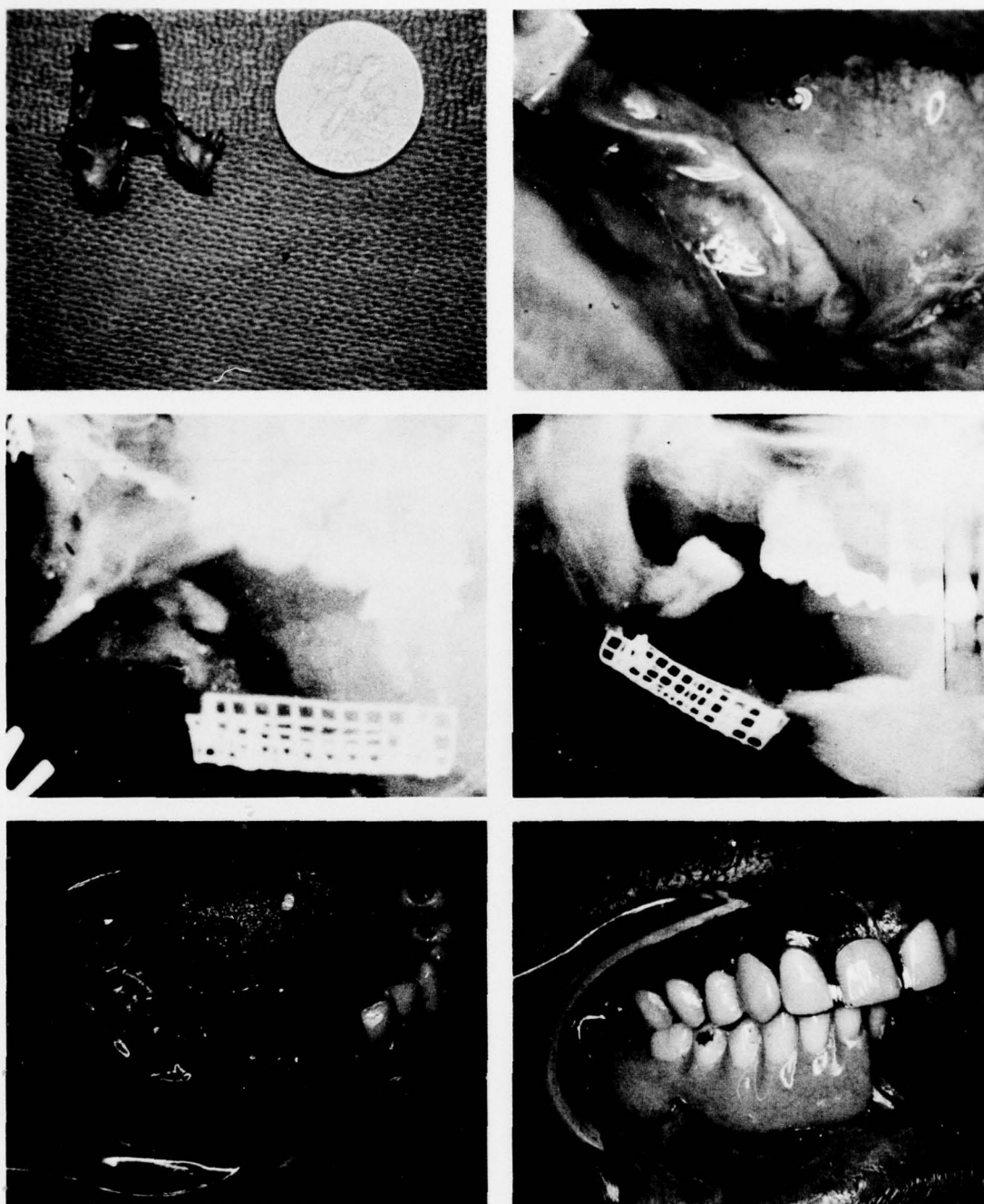
**Late Care:** The patient arrived at a late care hospital after 5 days in transit. He was provided supportive care until 3 months post injury when intermaxillary fixation was released and lack of consolidation of the mandibular fragments was noted. To stabilize the fragments, a custom mandibular splint was constructed and secured to the mandible with circumferential wires to provide monoarch stabilization. The mandible did not consolidate and the splint was removed 3 months later just prior to bone grafting, at which time there was collapse of the mandibular fragments. The tissues of the mouth floor were supple and thus the fragments were not bound by dense scar tissue. Two days later, 6 months post injury, an autogenous PCM graft to the mandible was performed following satisfactory repositioning of the fragments and preparation of the graft bed. The mandible was immobilized with arch bars and intermaxillary fixation. Postoperative radiographs revealed the fragments to be in good position and intermaxillary fixation was discontinued after 11 weeks, at which time the grafted mandible was stable. A mandibular partial denture was inserted 9 months post grafting. The patient's masticatory function and appearance were acceptable when last examined 6 years after injury.

---



*Upper left:* Appearance of 21-year-old casualty following fragmentation wound to lower face. *Upper right:* Appearance of wound at time of debridement during early definitive treatment showing the extent of tissue damage. *Middle left:* Posteroanterior radiograph on the day of injury showing extent of damage to the mandible. *Middle right and lower left:* Posteroanterior and lateral oblique radiograph showing position of fragments following closed reduction. *Lower right:* Appearance of patient after closure of wounds and establishment of dependent drainage.





*Upper left:* Missile jacket that was recovered from the wound. *Upper right:* Intraoral appearance of wound area 6 months post injury just prior to mandibular bone grafting for continuity. *Middle left:* Lateral oblique radiograph several days following a PCM graft to the mandible. *Middle right:* Panoramic radiograph, 5 years and 3 months post bone grafting, showing continuity of the mandible and maturation of osseous tissue in the graft region. *Lower left and lower right:* Intraoral appearance 6 years post grafting. Although the bulk of the alveolous was deficient, the soft tissues were fixed to the underlying bone and it was possible to construct a functional prosthesis.

## CASE NUMBER 10

**Description of Injuries:** This 21-year-old casualty received fragmentation wounds from mortar fragments that entered his left cheek, passed through the left body of the mandible, floor of the mouth, larynx, right sternoclavicular joint, and entered the apex of the right pleural space. He sustained a compound, comminuted, avulsive fracture of the left mandibular body and angle, compound fracture of the thyroid cartilage, sternoclavicular joint, and lacerations of the right vocal cord.

**Early Care:** The patient was evacuated to a 4th-echelon medical facility the day of injury where, following triage and radiographic examination, he was taken to the operating room. A tracheostomy was performed and chest tubes were placed. Following maxillofacial wound debridement, open reduction of the fractured mandible was accomplished with transosseous wires and the mandible immobilized with intermaxillary fixation. Drains were placed and the wounds closed. The neck wounds were closed after debridement, laryngeal repair, and placement of a laryngeal finger stent. The patient entered the medical evacuation system 5 days post injury.

**Intermediate Care:** The patient was received at an intermediate medical facility the day of discharge from the early care facility. He was provided supportive care during this interval and was reported to have a continual spiking fever. The laryngeal stent was removed and replaced. A pleural-cutaneous fistula in the neck was observed to be closing. He was medically evacuated to CONUS 22 days after his initial injury.

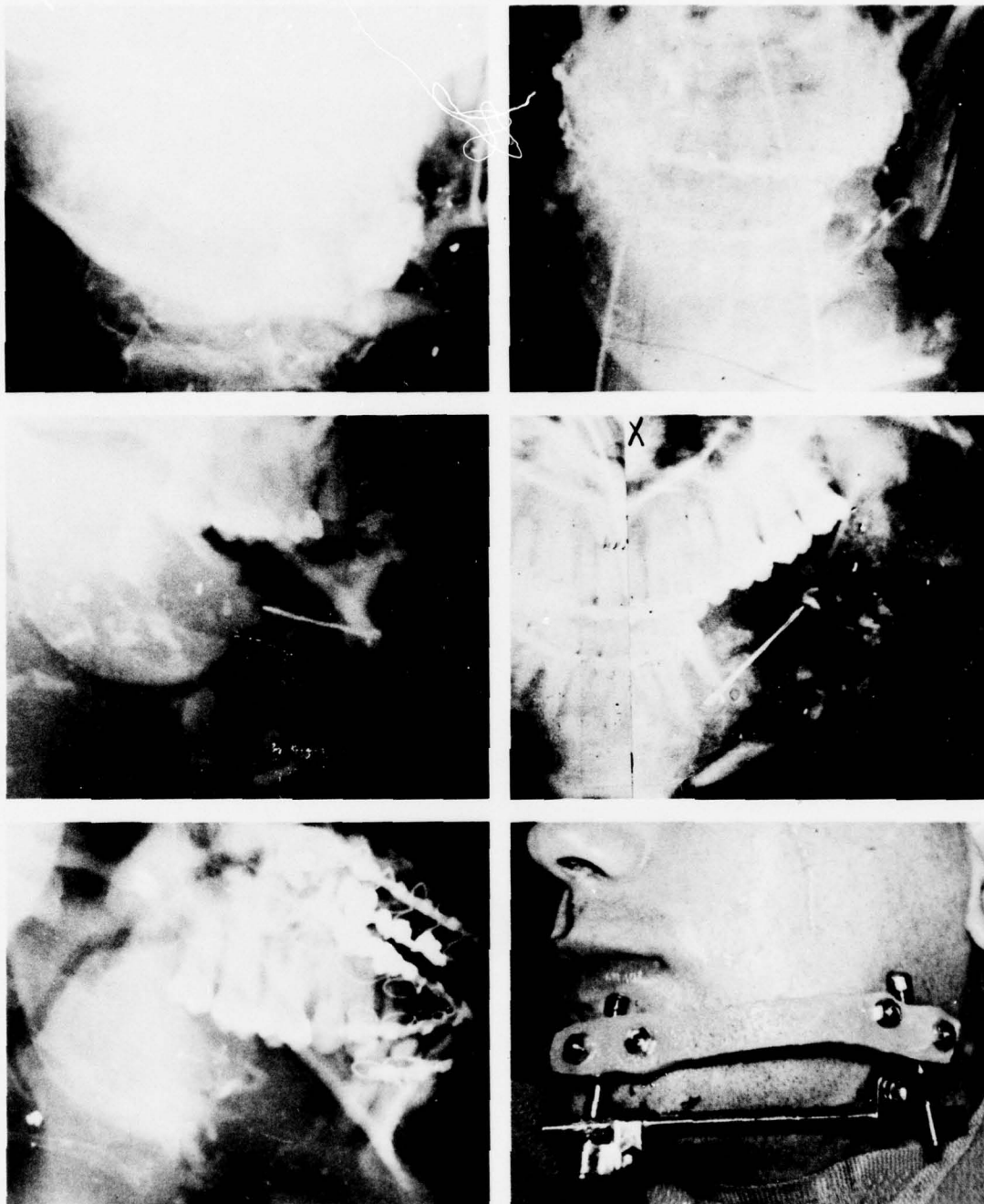
**Late Care:** The patient arrived at a late care hospital after 4 days in transit. Upon admission his maxillofacial, laryngeal, and chest wounds were infected. Initial care consisted of vigorous local and systemic treatments for these infections. The tracheal stent was expelled by the patient during vigorous coughing; however, there was no airway compromise and the laryngeal wound was managed satisfactorily without further surgical intervention. The facial wounds were debrided of exposed transosseous wires and devitalized osseous fragments 17 days after admission to the late care hospital. At this time the mandibular fractures were repositioned and an external skeletal-pin fixation appliance (biphase) was placed to stabilize the mandibular fragments.

The general medical condition of the patient improved following control of his infection and the chest and tracheostomy tubes were removed 45 days after late care admission. In preparation for a mandibular bone graft, the mandibular right cuspid tooth (#22) was removed 13 weeks after admission to the late care facility. The biphase appliance was removed after it had been in place 4 months. Immobilization was maintained with intermaxillary fixation until a PCM graft from the right ilium to the left mandible was performed 5½ months following initial injury. Although radiographically the mandible appeared to be intact, clinical evaluation had revealed that it was unstable as digital pressure had resulted in flexion and mobility of the fragments. At surgery a fibrous union was observed at the junction of the ramus with the body. Postoperatively, the patient developed an infection overlying the region of the bone graft and was treated with antibiotics following appropriate microbiologic testing. The infection failed to resolve after repeated courses of antibiotics, and 3 months following surgery the metallic crib and microporous filter were removed. At the time of crib removal there was evidence of new bone

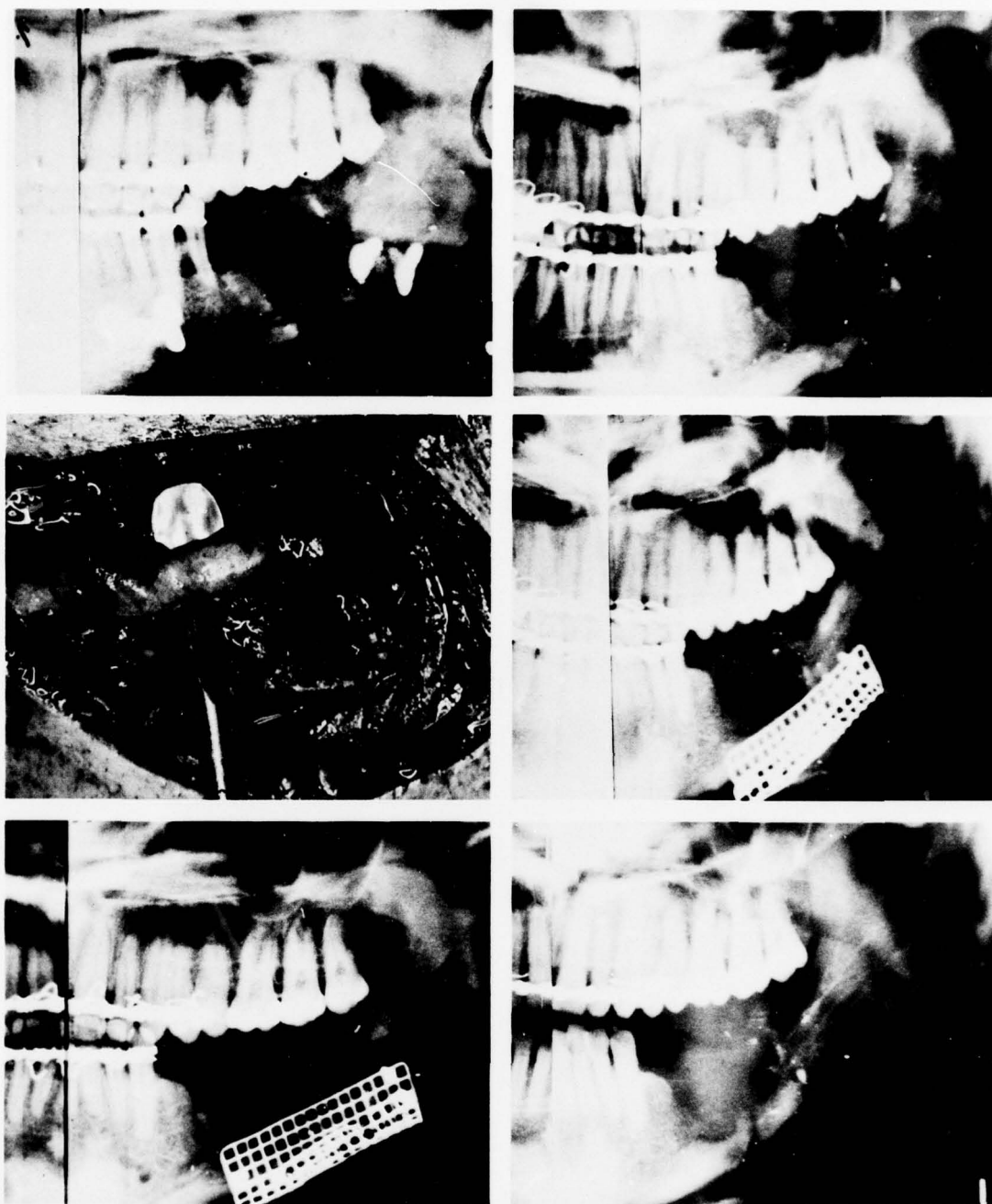
formation; however, there was still clinical mobility at the graft site. Postoperatively, intermaxillary fixation was continued for 6 weeks at which time the patient was placed in function. Over the next 8 months the graft consolidated, and 18 months following initial injury the mandible was in continuity and stable. At last follow, 6 years and 10 months after initial injury, the patient had excellent incisal opening (52 mm) and normal range of mandibular motion. The mandibular contour had been maintained and facial esthetics were acceptable. Masticatory function was adequate in the mind of the patient although considerable dental treatment was indicated, as well as preprosthetic surgery, to restore optimum masticatory capacity.

---

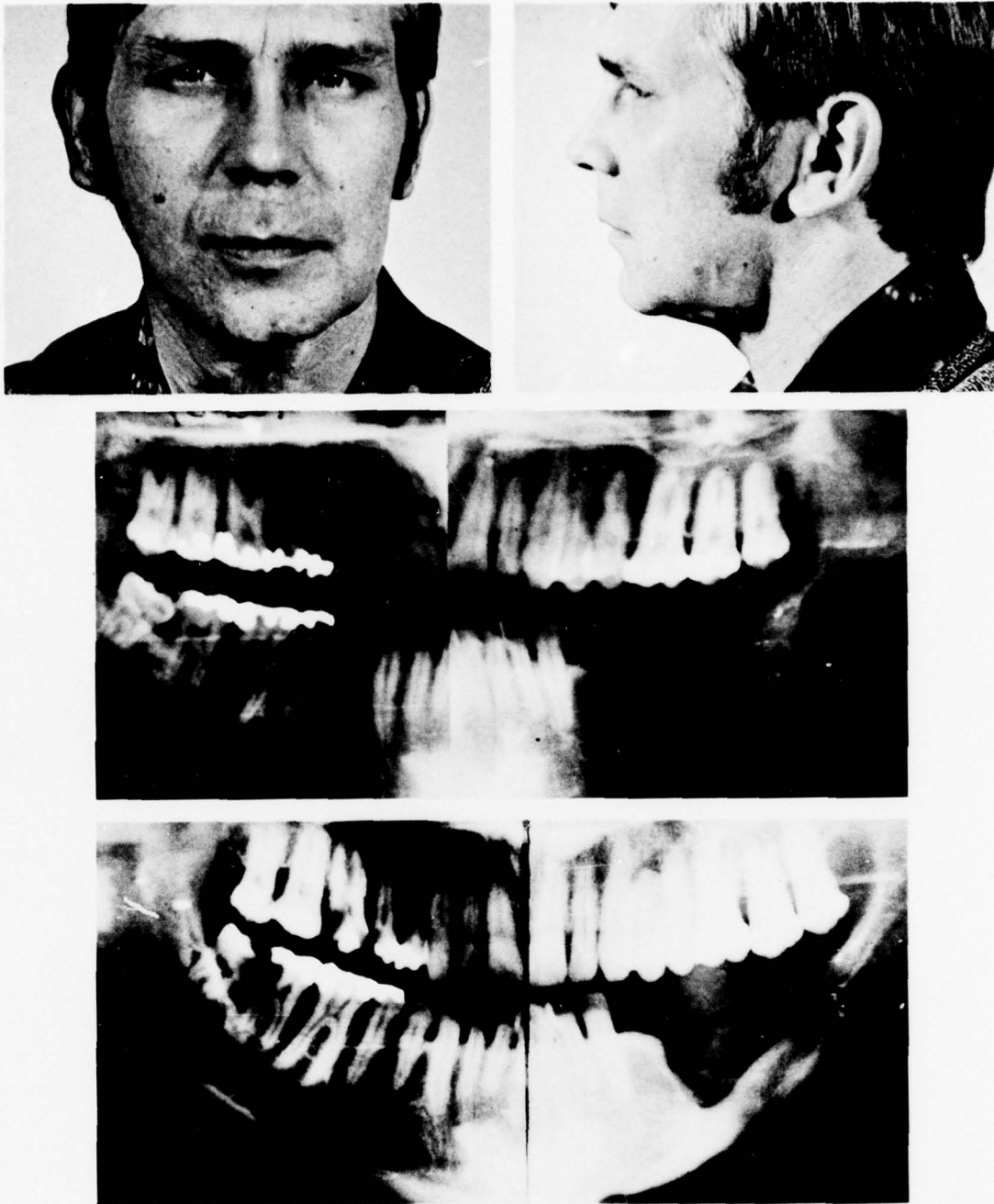




*Upper left:* Posteroanterior radiograph on the day of injury showing severely comminuted left mandible. *Upper right:* Posteroanterior radiograph, immediately post treatment on the day of injury, showing inadequate reduction of the mandibular fragments but establishment of intermaxillary fixation with arch bars. *Middle left:* Left lateral oblique radiograph, taken at intermediate care facility, showing inadequate reduction of osseous fragments with malalignment of ramus. *Middle right:* Panoramic radiograph on day of admission to late care facility. *Lower left:* Left lateral oblique radiograph showing a discontinuity defect after local debridement that was necessitated by oral wound dehiscence and suppuration. *Lower right:* Appearance of patient at time of application of biphase external skeletal fixation appliance shortly after debridement of oromandibular wound. The first phase connector had not as yet been removed.



*Upper left:* Left panoramic radiograph showing position of fragments and progress of healing 2½ months following injury and 1 month after application of biphase appliance. *Upper right:* Left panoramic radiograph 5 months post injury following removal of biphase appliance prior to bone grafting. Fragments had consolidated at the inferior border; however, there remained flexion and instability of the mandible. *Middle left:* Appearance of mandible at the time of bone grafting showing a consolidated bony strut and a line of fibrous union adjacent to the periosteal elevator. *Middle right:* Left panoramic radiograph 48 hours following PCM grafting. *Lower left:* Left panoramic radiograph, 3 months post grafting, just prior to crib removal that was necessitated by recurrent graft infection. *Lower right:* Left panoramic radiograph 1 month following removal of the metallic crib. A linear area of radiolucency is seen in midportion of the osseous bridge. The mandible was stable although at this interval there was still flexion.



*Upper left and upper right:* Appearance of patient, 7 years post injury, showing mandibular symmetry and minimal residual deformity. *Middle:* Panoramic radiograph 1 year post grafting. The mandible was stable, the area of the graft was consolidated, and the osseous bulk had increased since the crib was removed 9 months previously. *Lower:* Panoramic radiograph at last follow up, 7 years post injury. Very dense bone had developed in the area of injury and grafting. This is compensatory to the consolidation of functional stress in this thin region of the mandible. Although an alveolar defect existed, the patient was not interested in further treatment. Dental disease was extensive in both the maxilla and mandible. If teeth are lost and function becomes dependent on a prosthesis, some type of preprosthetic surgery will be required to maintain a masticatory capacity.



## CASE NUMBER 11

---

**Description of Injuries:** This 19-year-old casualty sustained a through-and-through high-velocity missile wound to the lower face that resulted in a compound, comminuted fracture and partial avulsion of the anterior mandible.

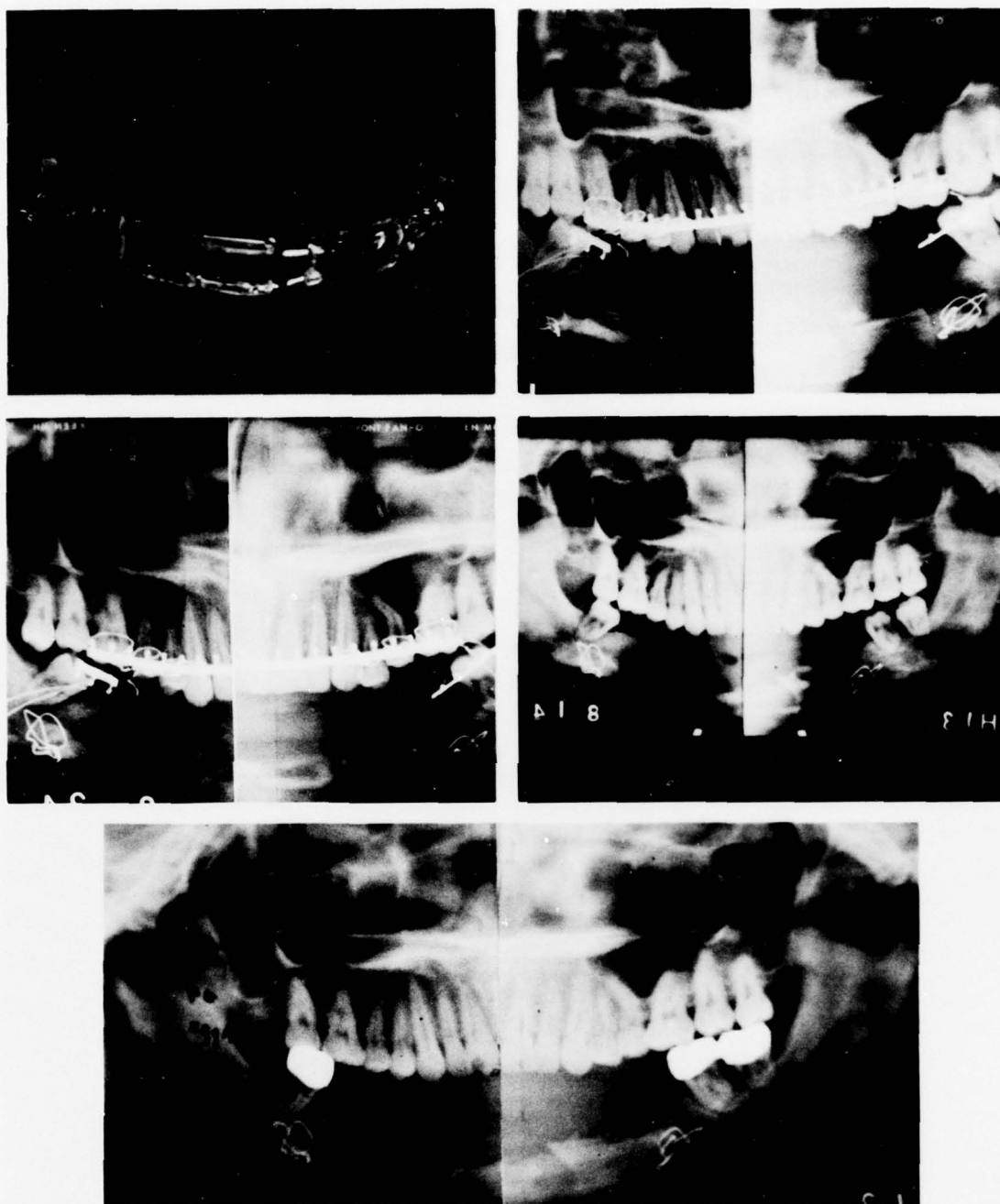
**Early Care:** At a 4th-echelon medical facility, the wounds were debrided and an alloplastic implant was fabricated from Kirschner wire and acrylic blocks and secured to the proximal mandibular fragments. The mandible was immobilized with intermaxillary wire fixation, the orofacial wounds were closed primarily, and a through-and-through drain was placed along the missile tract. The patient's postoperative course was satisfactory and he was discharged to the medical evacuation system 5 days after injury.

**Late Care:** There was no intermediate facility admission, and the patient was admitted to a late care facility after 4 days in transit at which time intraoral wound drainage was present. Antibiotic therapy (based on culture and sensitivity testing) as well as local wound care were successful in resolving the infection. However, over the next several months there were repeated exacerbations of the infection with facial and oral drainage. Ten months post injury the alloplastic implant eroded through the oral mucosa and it was removed. After the implant was removed, the infectious process resolved and 2 months later the mandible was reconstructed with an autogenous rib graft. An infection developed about circummandibular wires that had been placed to secure an acrylic stent used to stabilize the fragments. The infection was managed with local wound care and a variety of antibiotics over a 2½-month period. Fortunately, loss of graft substance was limited. Intermaxillary fixation was maintained for 4 months, and subsequently, a mandibular denture was constructed that was partially supported by precision attachments to crowns on the remaining molar teeth. There was deficiency of alveolar structure in the anterior mandible and inadequate marginal seal of the denture flange in the buccal vestibule. The molar teeth subsequently loosened as a result of the torquing action of the mandibular denture and were removed; the patient's ability to satisfactorily masticate was lost. Fifty-five months following the successful continuity graft to the mandible, an autogenous iliac graft was performed to augment the deficient alveolar portion of the mandible. Wound dehiscence with partial graft sequestration occurred on the right side following the procedure. When last examined 3 years after preprosthetic bone graft augmentation of the mandible and 9½ years following injury, the patient was wearing a denture that provided satisfactory masticatory function although vestibuloplasty had been recommended.

---

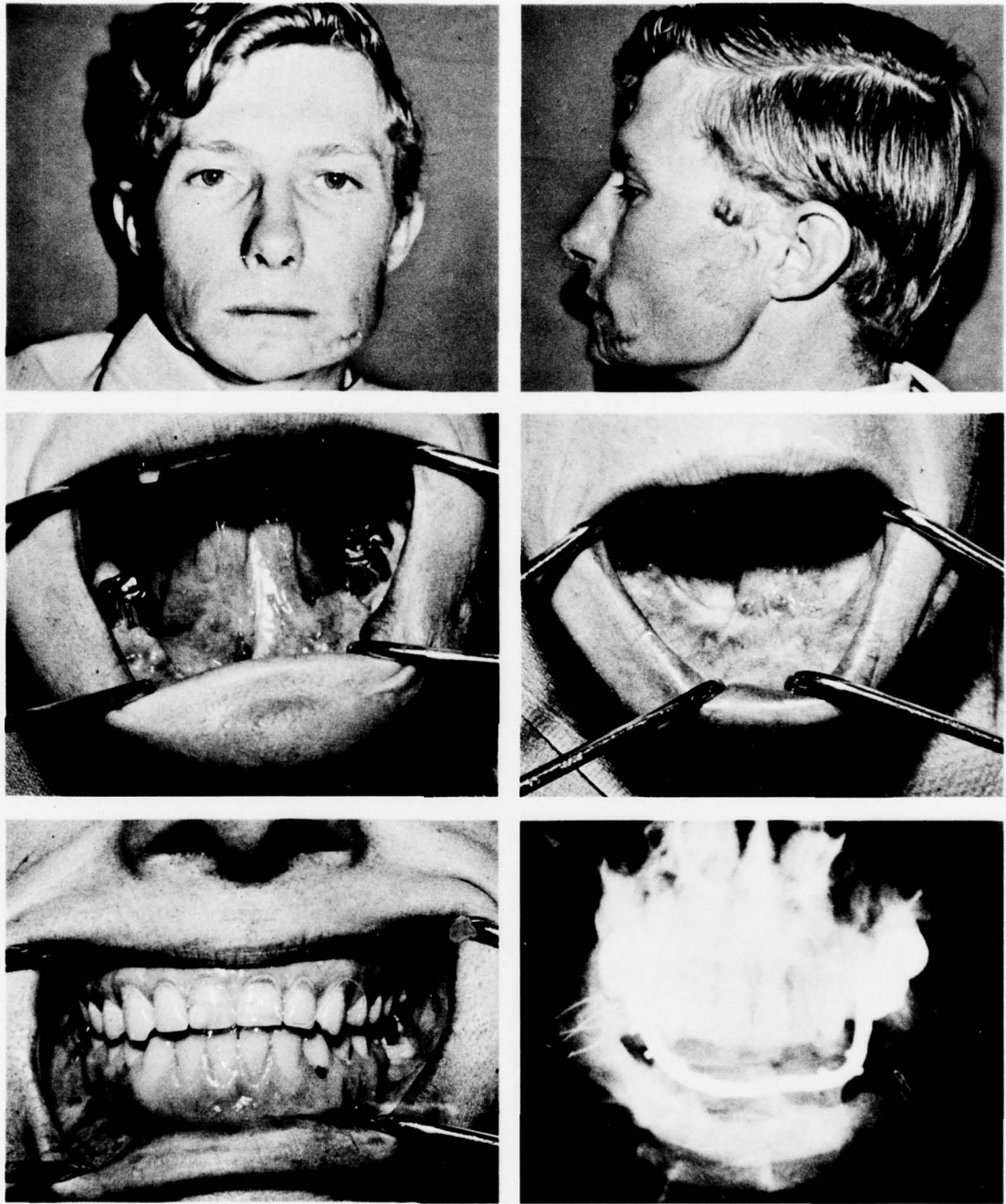


*Upper left:* Appearance of a 19-year-old casualty at time of triage following a high-velocity missile wound to the lower face. *Upper right:* Appearance after fracture reduction, soft tissue closure, and through-and-through wound drainage. *Middle left and middle right:* Posteroanterior and lateral oblique radiographs prior to initial debridement and treatment. *Lower left:* Appearance 2 months after injury showing an abscess that had formed in the right cheek overlying the alloplastic implant. *Lower right:* Panoramic radiograph, 9 months post injury, showing the alloplastic implant still in place. The implant was removed a month later because of chronic infection and the fact that it precluded definitive hard and soft tissue reconstruction of the mandible to a functional status.

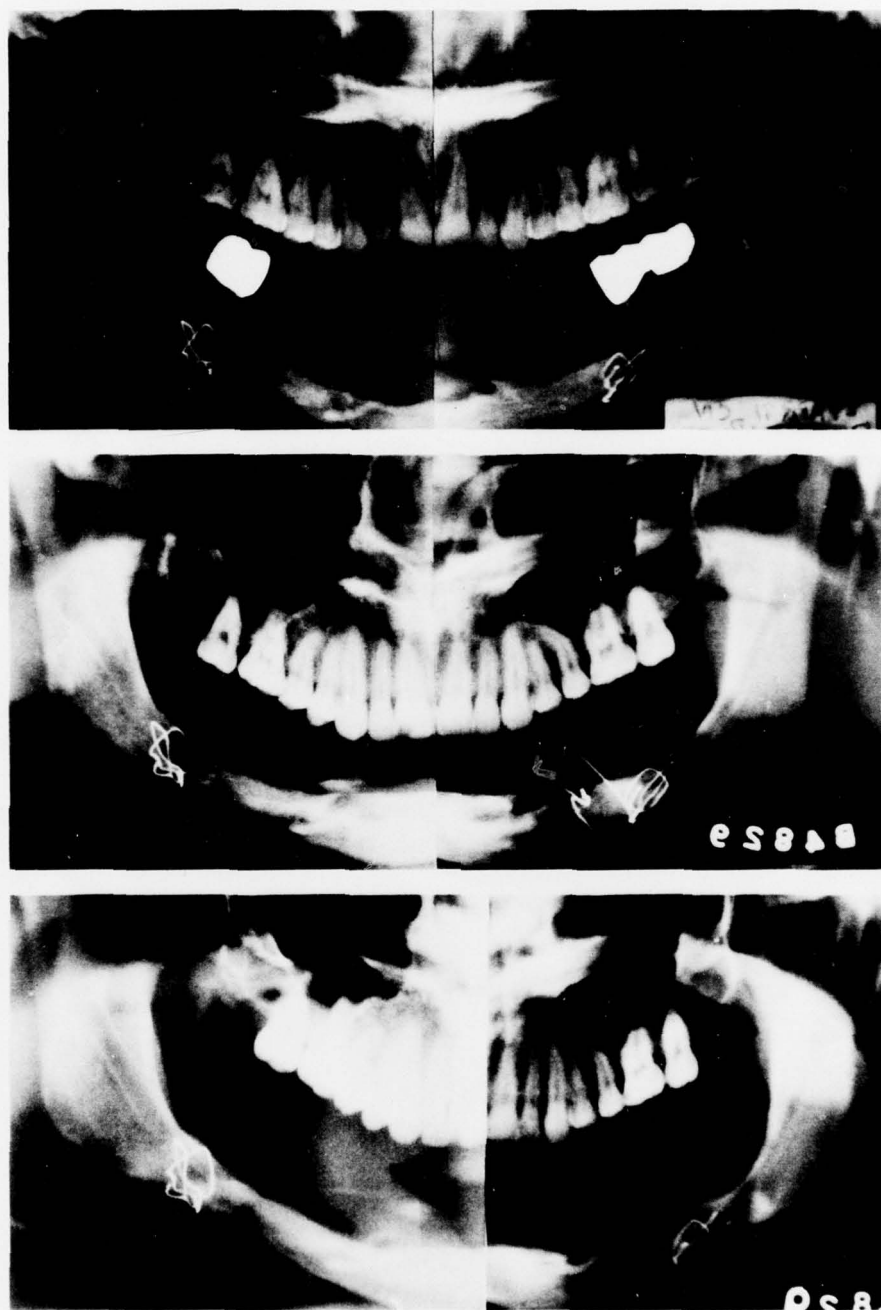


*Upper left:* Appearance of the alloplastic implant at the time of removal 10 months post injury. The implant had been fabricated from Kirschner wires and acrylic blocks. *Upper right:* Panoramic radiograph 3 weeks after rib graft reconstruction of the mandible. *Middle left:* Panoramic radiograph 17 weeks post grafting. *Middle right:* Panoramic radiograph 9 months post grafting. *Lower:* Panoramic radiograph, 11 months post grafting, showing consolidation of the graft.





*Upper left and upper right:* Appearance of patient 54 months after injury. There was excellent symmetry in the lower one third of the face where the anterior mandible had been reconstructed. *Middle left:* Intraoral appearance of patient, 42 months following rib grafting of the mandible, showing gold crowns on the remaining molar teeth that supported a precision attachment denture. *Middle right:* Appearance of floor of mouth with deficient alveolar process and inadequately stable mouth floor-vestibular mucosa. *Lower left:* Appearance of precision attachment mandibular denture in occlusion with natural maxillary dentition. *Lower right:* Posteroanterior radiograph, 42 months post grafting, showing mandibular symmetry, as well as molar crowns and extension bar, that supported the mandibular denture in a cantilever fashion.



*Upper:* Panoramic radiograph, 42 months following rib graft reconstruction of the anterior mandible, showing the mature and well-consolidated graft. *Middle:* Panoramic radiograph, 9 months following augmentation of the mandible, with an autogenous iliac corticocancellous graft. The molar teeth that had supported the denture had been loosened by the torquing action of the cantilever-like prosthesis and had been removed approximately 44 months after insertion of the denture. A portion of the augmentation graft had been lost on the right side subsequent to wound dehiscence. *Lower:* Panoramic radiograph 35 months following augmentation grafting of the mandible.



*Upper left:* Appearance of mandibular alveolus 35 months after reconstruction by an autogenous iliac graft. *Upper right:* Appearance of denture flange on stable vestibular mucosa 35 months following alveolar bone graft augmentation. *Lower left:* Appearance of denture occlusion at same interval described in upper left and upper right. *Lower right:* Occlusal radiograph of reconstructed mandible 8 years and 7 months post injury, 7 years and 7 months following grafting for continuity, and 35 months after grafting for functional augmentation. Maturation of the bone graft was evident. Fragments of lingual cortex that had been retracted into the mouth floor at the time of initial injury were still evident although they afforded no functional impairment to the patient.



## **CASE NUMBER 12**

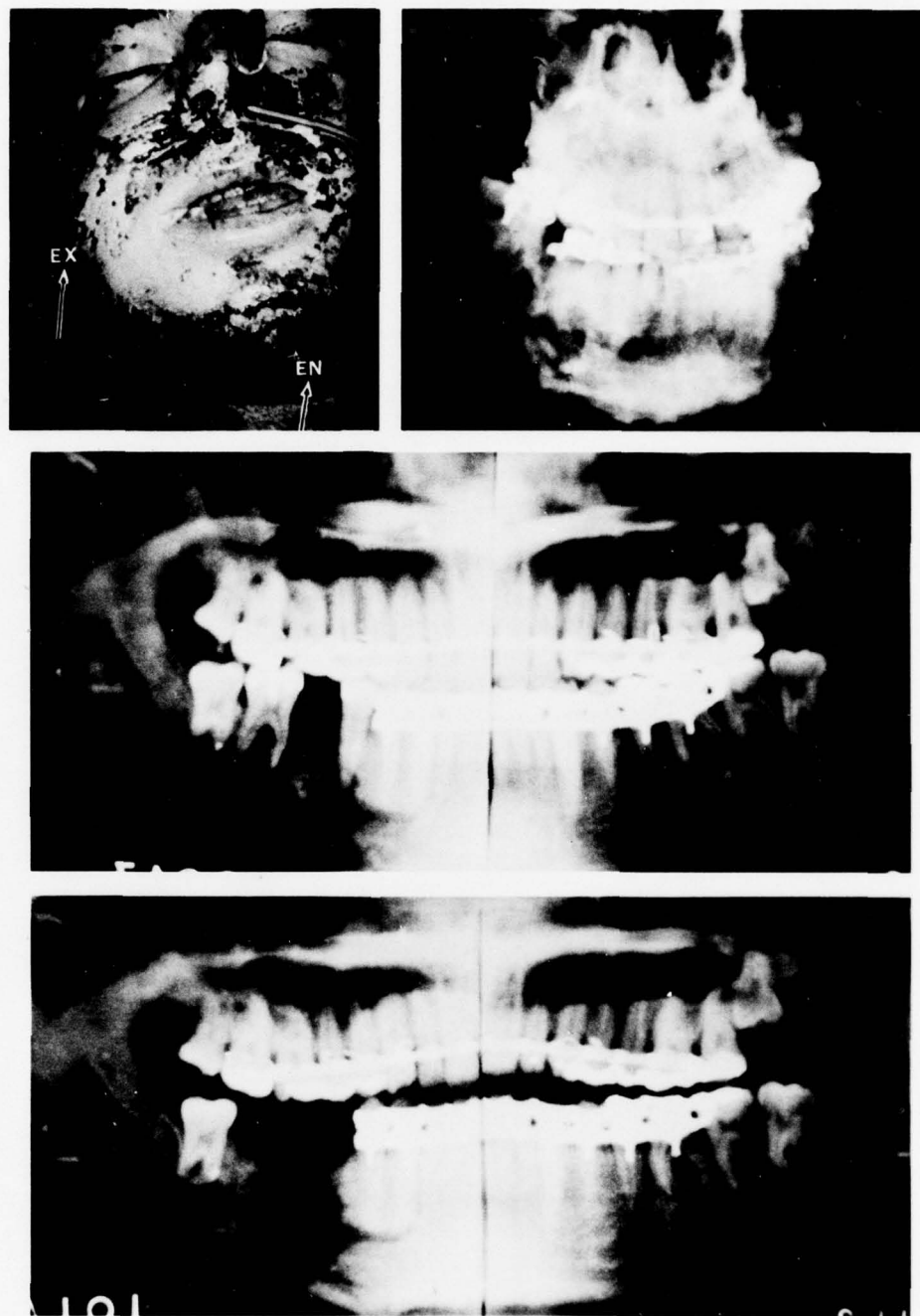
---

**Description of Injuries:** This 23-year-old casualty sustained a penetrating wound of the face when fragments from a booby trap entered the left chin area and exited the right cheek resulting in a compound, comminuted fracture of the right body of the mandible.

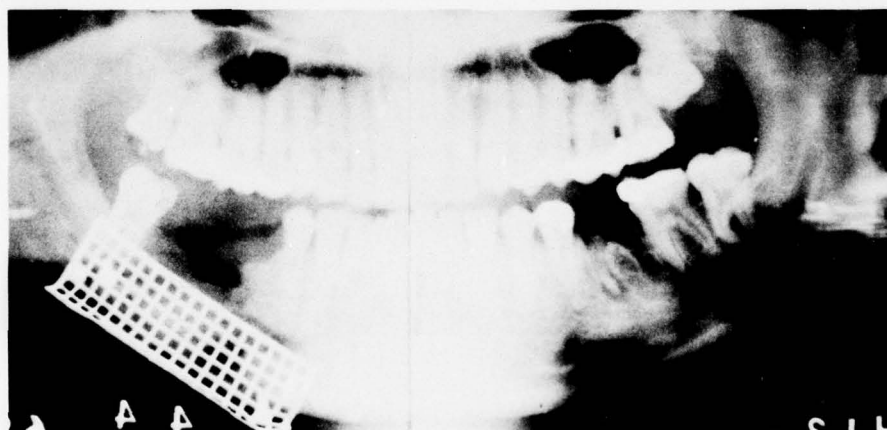
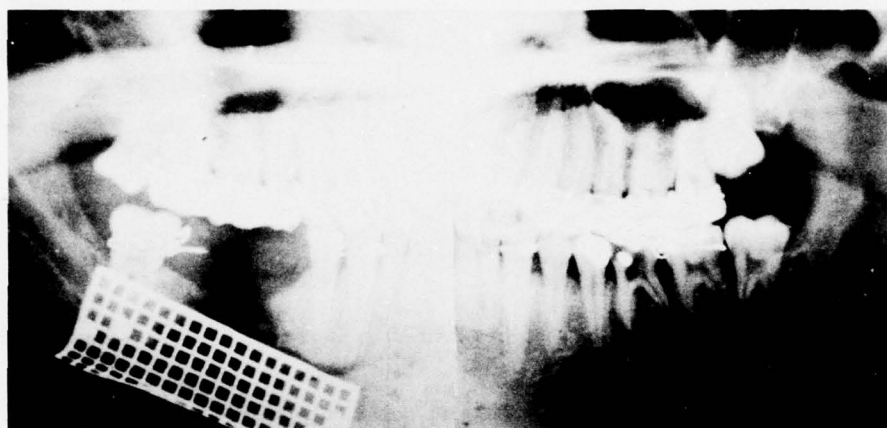
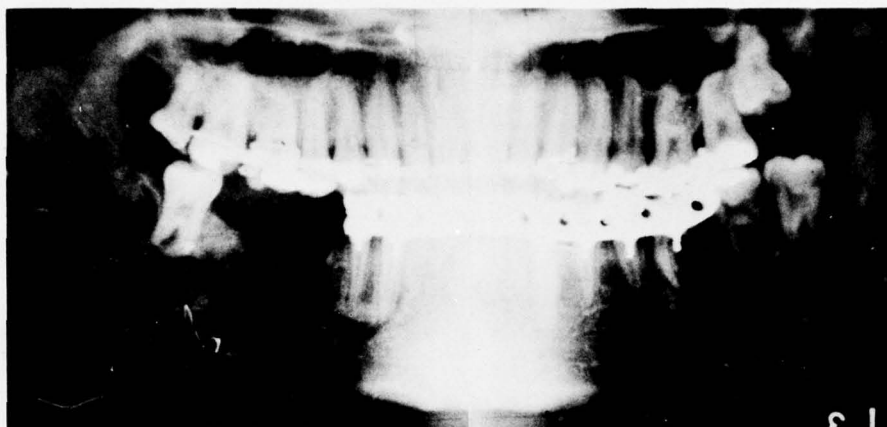
**Early Care:** The patient was admitted to a 4th-echelon medical facility the day of injury. Following triage and radiography it was necessary to control orofacial bleeding in the surgical staging area. In the operating room, a closed reduction of the fractured mandible was accomplished with arch bars and intermaxillary elastic fixation, the wounds were debrided and the fragments of the mandibular right first molar (#30) were removed, soft tissue wounds were closed primarily, drains were placed, and an elective tracheostomy was performed. The patient was medically evacuated to CONUS 28 days following injury.

**Late Care:** There was no admission to an intermediate facility and the patient was received at a late care hospital after 2 days in transit. Chronic infection had developed in the region of the right mandibular wound and teeth and bone were debrided intraorally in a series of procedures that extended over a 5-month period. Instability of the mandible was still present 6 months post injury and an open reduction was performed in an unsuccessful attempt to obtain osseous union. A PCM graft was placed 10 months post injury to restore continuity. Six weeks post grafting the mandible was mobilized and found to be stable. At last follow, 7 years and 9 months post injury, there was normal mandibular function and the patient was wearing a mandibular partial denture without difficulty. The appearance of the patient was satisfactory with minimal evidence of injury.

---

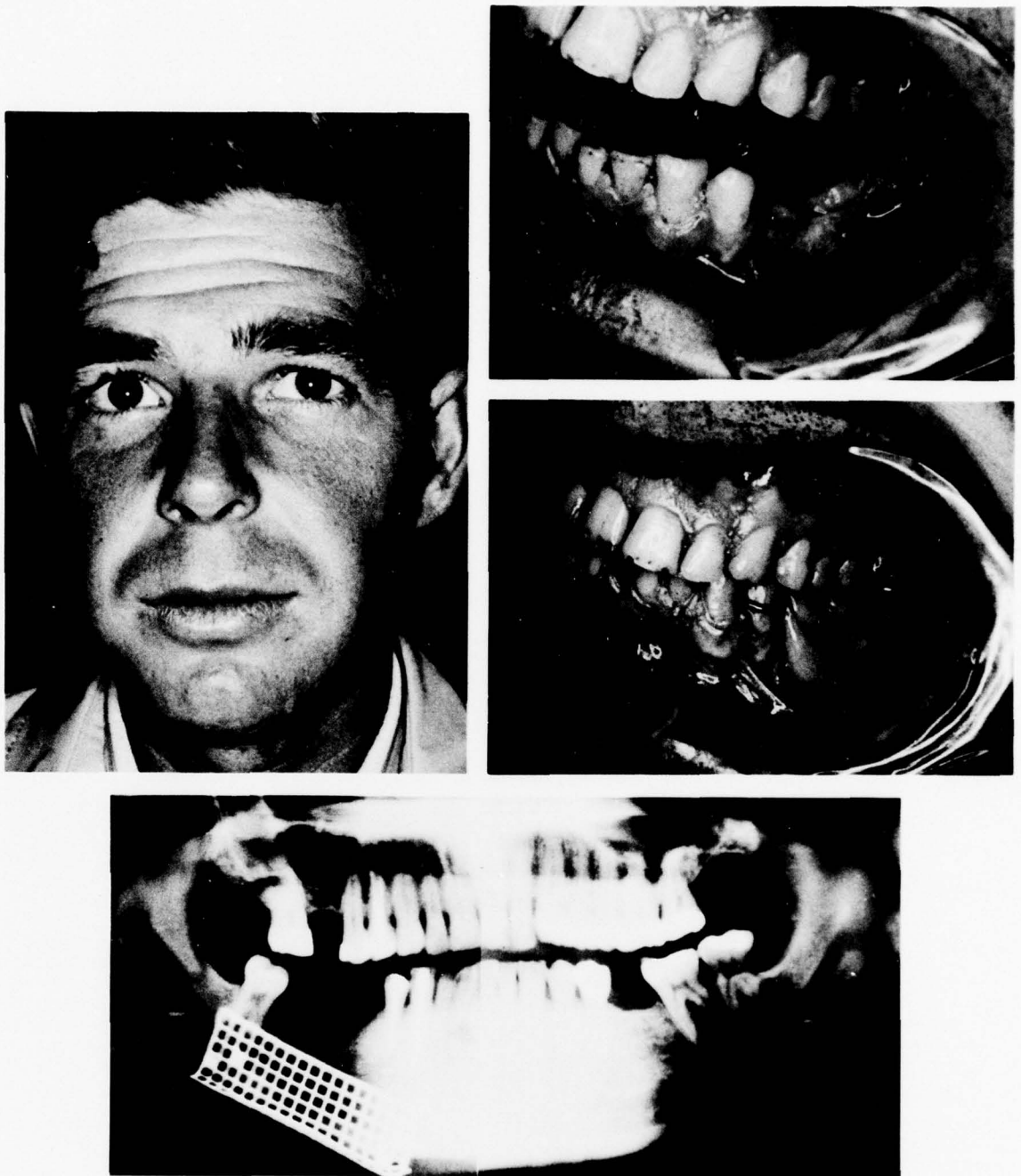


*Upper left:* Appearance of patient at surgery on the date of injury, showing the wounds of entrance (EN) and exit (EX). *Upper right:* Posteroanterior radiograph, on the date of injury, showing the position of the mandibular fragments after treatment. *Middle:* Panoramic radiograph, following admission to a late care hospital 2 months post injury, showing teeth projecting into the region of comminuted fracture. *Lower:* Panoramic radiograph, 6 months post injury, showing the extent of the osseous defect that had resulted from the necessity to repeatedly debride the region of fracture to control chronic infection. The mandibular right second bicuspid and second molar had been removed at the late care facility in conjunction with debridement.



*Upper:* Panoramic radiograph 6½ months post injury following open fracture reduction that was accomplished in an attempt to effect consolidation of the mandible. *Middle:* Panoramic radiograph 10 months post injury and 48 hours following PCM bone grafting that was necessitated by lack of union at the fracture site. *Lower:* Panoramic radiograph, 8 weeks post grafting, showing osseous repair. The mandible was stable at this interval and the patient was in full function. The mandibular left first molar had been removed just prior to the time of this X-ray.





*Left:* Appearance of patient, 47 months post injury, 37 months post bone grafting, showing facial symmetry and minimal evidence of the extensive wounding. *Upper right:* Intraoral appearance, 47 months post injury, showing right alveolus in region of injury and grafting. *Middle right:* Intraoral appearance, 47 months post injury, showing prosthetic restoration of occlusion with removable partial denture. *Lower:* Panoramic radiograph 7 years and 9 months post injury and 7 years post bone grafting. Mandibular teeth adjacent to graft region have been endodontically treated. The high flange margin of the metallic crib was affording the patient no functional impairment nor discomfort, although its presence would compromise the ability to perform preprosthetic surgery.

## CASE NUMBER 13

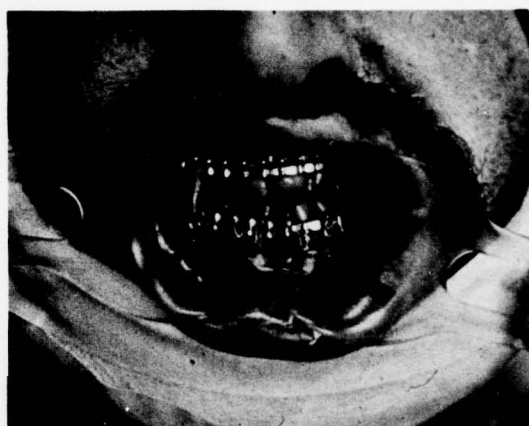
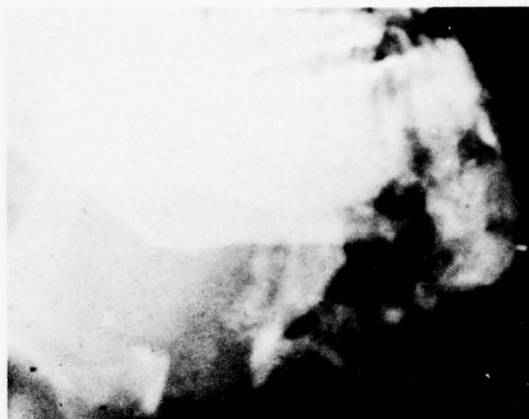
---

**Description of Injuries:** This 32-year-old casualty received fragmentation wounds to the face resulting in a compound, comminuted fracture of the mandibular symphysis.

**Early Care:** He was first seen at a 2nd-echelon medical facility where first aid was provided. He was then evacuated to a 4th-echelon medical facility where his facial wounds were debrided and an open reduction of the fractured mandible was performed. The soft tissues were closed, through-and-through drains were placed, and intermaxillary fixation was applied. The patient was admitted to the medical evacuation system 2 days postoperatively.

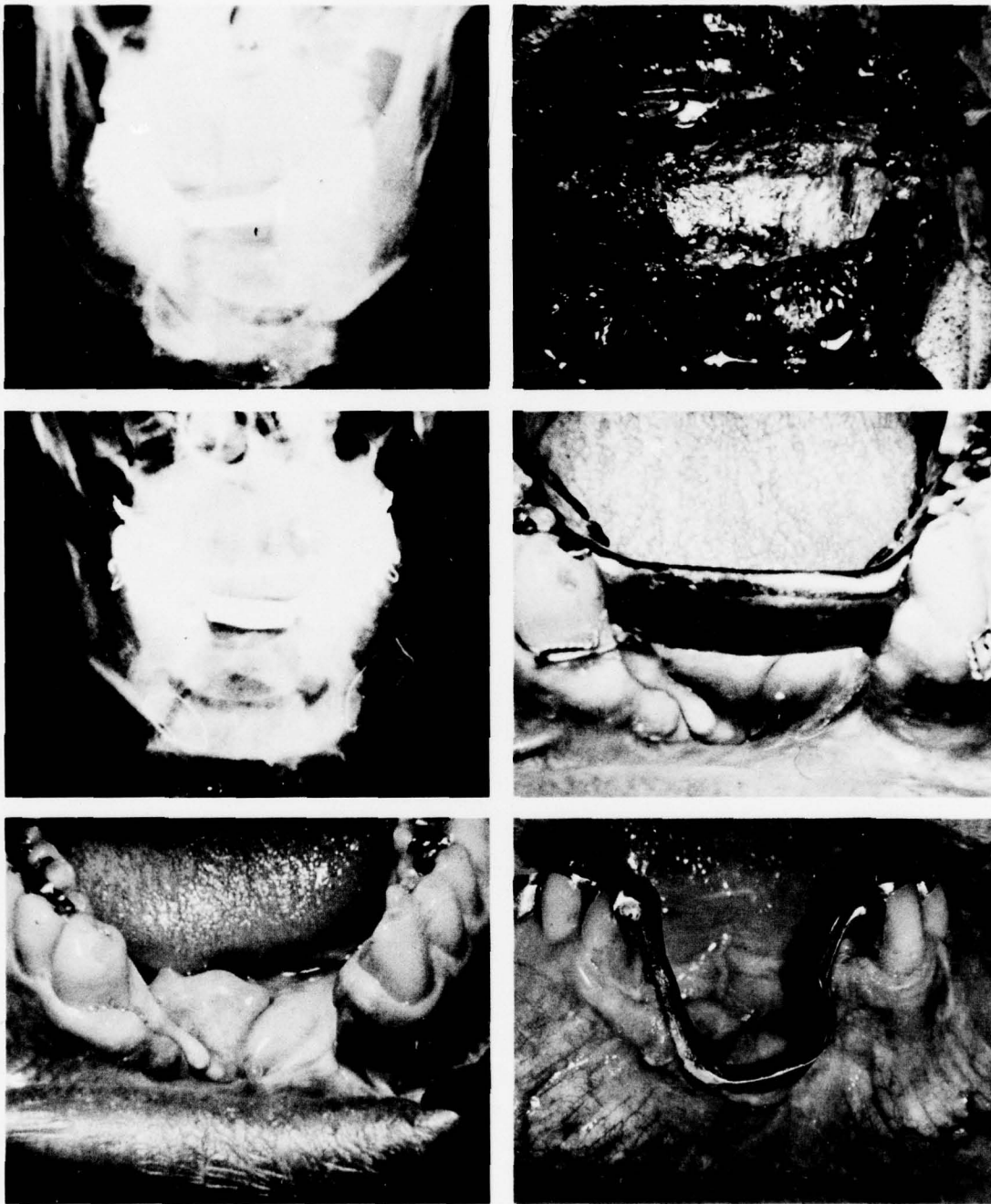
**Late Care:** The patient was medically evacuated directly to CONUS without an admission to an intermediate care facility and was admitted to a late care hospital after 3 days in transit. An acute infection had developed during the transit period and upon admission there was a draining orofacial wound. The infection was treated with local care and systemic antibiotics. Over the next 2 months the oral wound required repeated debridement of loose wires and nonvital bone fragments. In addition, it was necessary to remove the mandibular incisors and right cuspid teeth (#23-27) because of the necrotic process in the symphysis region. A cast mandibular splint was inserted at the time of initial debridement to provide additional stability to the mandible. An autogenous cancellous block graft from the right iliac crest to the mandibular symphysis was performed 16 weeks after injury. The postoperative course was uneventful. Intermaxillary fixation was discontinued 8 weeks after grafting and monoarch stabilization with a metallic lingual splint was maintained for another 6 weeks. No attempt had been made to reconstruct the alveolar portion of the mandible, and for this reason, it was necessary to construct a removable partial denture that depended on a fixed-bar prosthesis for its stability and support. At the last follow, 8 years and 6 months after injury, the patient had a full range of mandibular motion. Although he was wearing his partial denture, the abutment teeth for the fixed-bar prosthesis had lost an extensive amount of osseous support. If these teeth are lost, preprosthetic surgery will be necessary to restore masticatory function. Facial symmetry had been restored and there was little residual deformity.

---



*Upper left:* Appearance of 32-year-old casualty showing penetrating submental fragmentation wounds. *Upper right:* Lateral radiograph showing severe comminution of the mandibular symphysis region. *Middle left:* Posteroanterior radiograph on date of injury following open wire reduction of the parasymphysis fractures and intermaxillary fixation with arch bars. *Middle right:* Appearance post treatment, with patient in arch-bar intermaxillary fixation. No anterior mandibular teeth had been removed at the time of initial wound management. *Lower left:* Appearance of oral wound 21 days post injury and 14 days following initial debridement and tooth removal at late care facility. The mandibular left lateral and central incisors, right lateral and central incisors, and right cuspid had been removed. Debridement was necessitated by dehiscence and suppuration that developed during direct transfer to CONUS. *Lower right:* Custom monoarch splint that was applied after additional secondary debridement to maintain fragment position and permit jaw function before bone grafting.





*Upper left:* Posteroanterior radiograph 4 months after injury just before bone grafting. A second splint had been constructed for fixation in conjunction with the bone graft. Although there was some consolidation at the symphysis, flexion still existed as well as lack of contour. *Upper right:* Intraoperative appearance of solid, autogenous, iliac bone graft that was onlaid to the symphysis defect. *Middle left:* Posteroanterior radiograph 48 hours after bone grafting. *Middle right:* Intraoral appearance 8½ weeks post grafting showing the monoarch splint that was providing continued stability to the healing graft. *Lower left:* Intraoral appearance 4 months post grafting before construction of a prosthesis. The mandible was firm and the occlusion stable, but a dentoalveolar defect existed with absence of an osseous base to support a prosthesis and distortion and instability of vestibular soft tissues. The normal relation of the dental arches had been maintained. *Lower right:* Appearance 5 years and 9 months post injury of fixed-bar appliance that was constructed to support a removable partial denture prosthesis 5 months after the bone graft. Recession of periodontal tissues about the abutment teeth was occurring but the teeth and appliance were stable. Preprosthetic surgery had not been considered at the time of partial denture fabrication.



*Upper left:* Appearance of mandibular partial denture and occlusion 5 years and 9 months post injury. *Upper right:* Appearance of fixed-bar appliance 7 years and 9 months following its insertion. Periodontal recession had continued and the bar and teeth were becoming unstable. *Middle left and middle right:* Facial appearance of patient 8 years and 6 months post injury. *Lower:* Panoramic radiograph 8 years and 6 months post injury. Limited osseous support of the abutment teeth for the fixed-bar appliance is evident. If these teeth are lost, preprosthetic surgery will be necessary for satisfactory prosthetic restoration.

## CASE NUMBER 14

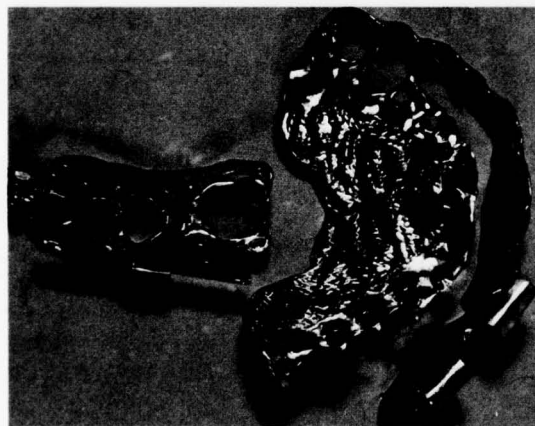
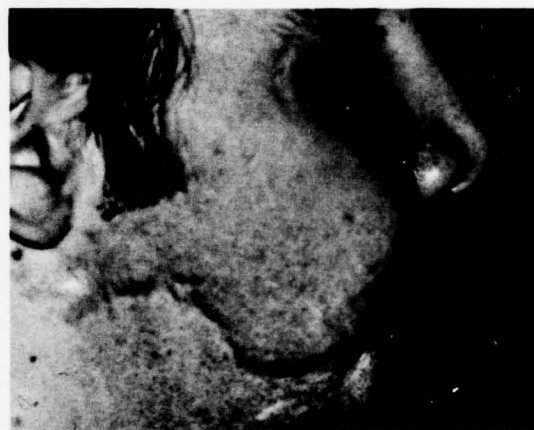
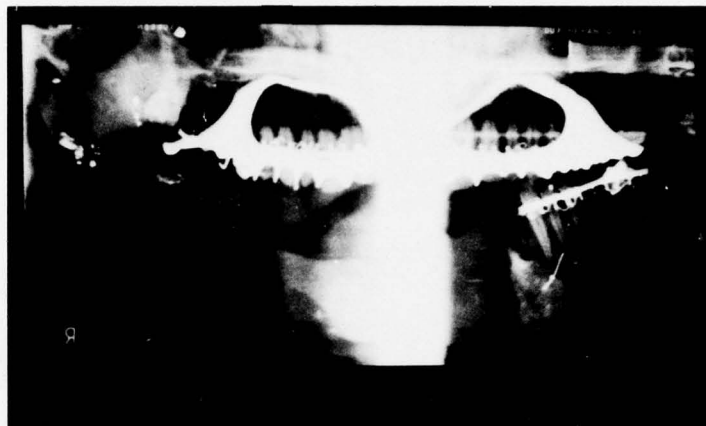
**Description of Injuries:** This 23-year-old casualty sustained fragmentation wounds to the face that resulted in an extensive avulsive injury of soft and hard tissues. These wounds included a compound, comminuted, avulsive fracture of the right mandible from the ramus to the symphysis and a Le Fort II fracture of the maxilla.

**Early Care:** The patient was admitted to a 3rd-echelon medical facility where an emergency tracheostomy was performed. His wounds were debrided and an avulsive wound of the tongue was closed with available oral mucosa from the floor of the mouth. Following extensive debridement, a closed reduction of the mandibular fractures was accomplished with arch bars and intermaxillary fixation to stabilize the remaining fragments. An open reduction was performed on the maxillary fracture with direct osseous wiring and antral packing. The postoperative course was satisfactory, the antral packing was removed on the 4th postoperative day, and on the 7th postoperative day the patient was admitted to the medical evacuation system.

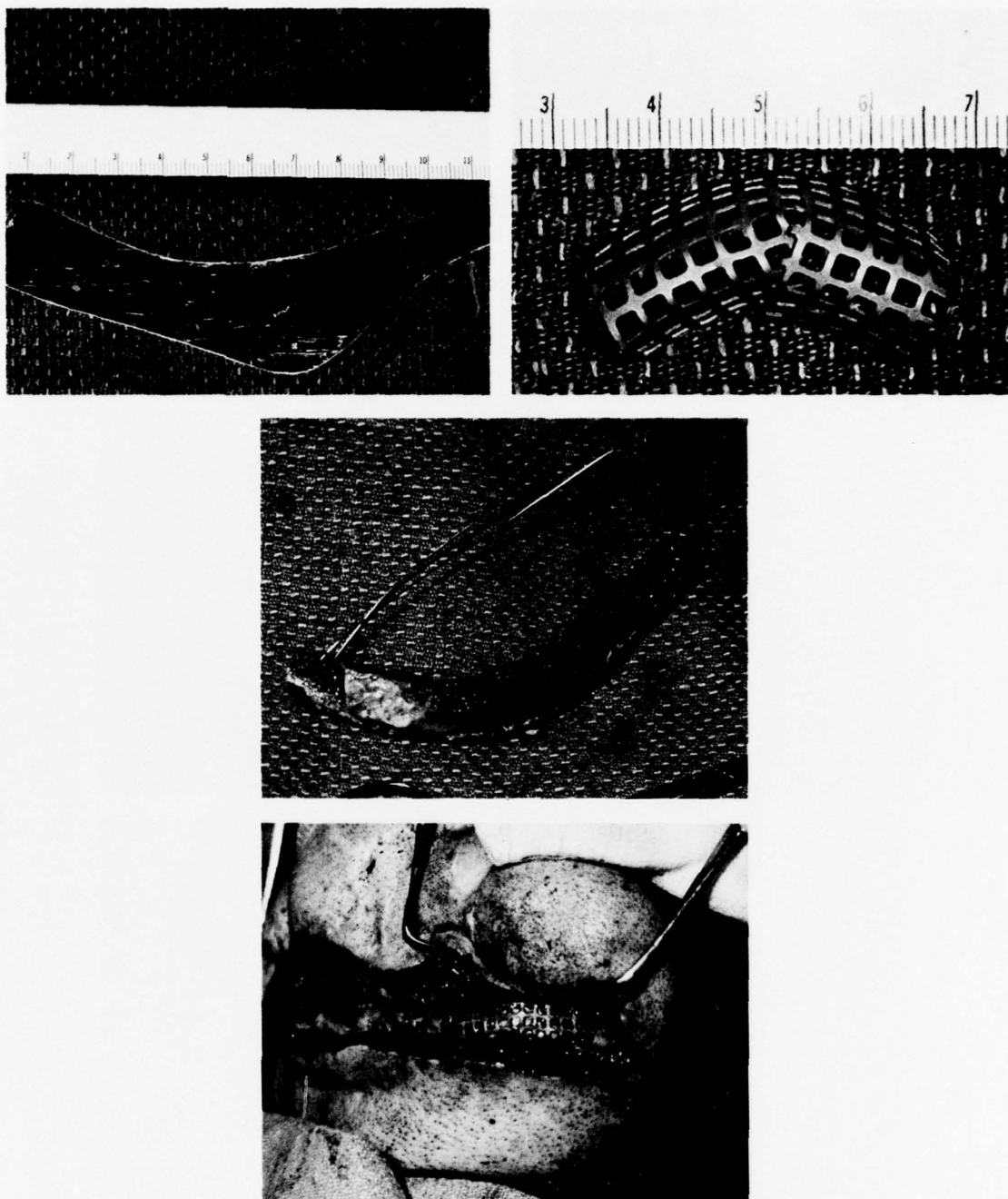
**Intermediate Care:** The patient entered an intermediate care facility after 2 days in transit. On admission the orofacial wound was draining a purulent exudate. The wounds were debrided, cleansed, irrigated, and appropriate antibiotic therapy was initiated. After 6 days drainage ceased and the wounds healed spontaneously. Eleven days after admission (20 days post injury) a cast palatal splint designed to immobilize maxillary fractures was secured to the dentition under general anesthesia. During this anesthetic period the maxillary right second and third molar teeth and retained root of mandibular left central incisor (#1, 2, 23) were removed. An oroantral fistula was closed and revision of the floor of the mouth was performed to obtain mobility of the tongue. The patient's postoperative course was uneventful and 2 days following surgery he was released to the medical evacuation system for transfer to CONUS.

**Late Care:** The patient arrived at the late care hospital after 9 days in transit. The osseous wounds healed slowly and required minimal debridement. Over the next 6 months, several soft tissue procedures were performed to improve the function of the lower lip. Six months following return to CONUS and 8 months following injury, a bone graft to the mandible was performed to restore continuity. The graft consisted of an autogenous, corticocancellous block from the left ilium combined with a PCM extension that established the distal union. Because of insufficient stability postoperatively, an external skeletal fixation appliance was applied. The patient was maintained in fixation for 16 weeks. After satisfactory graft consolidation, numerous procedures for cosmetic revision of the lower lip and facial scars were performed, including a skin graft to the right floor of the mouth, accomplished in an unsuccessful attempt to provide more stable support for a removable prosthetic appliance. Twenty-five months following continuity grafting, bone graft augmentation of the mandible graft was performed utilizing autogenous rib. At the time of surgery, incision in the right floor of the mouth resulted in profuse release of confined mucinous salivary secretions. Postoperatively, a small dehiscence occurred in the line of closure and an exudate of saliva persisted for a short time. Six months after this procedure, a vestibuloplasty with split-thickness skin grafting was performed. Eleven months post grafting a portion of the augmentation rib graft sequestered. The area healed well by secondary granulation and no further sequelae developed. At last follow, 6 years and 2 months after injury, the patient still required an additional bone graft that was now possible because of a softening of scar tissue and soft tissue relaxation. An additional soft tissue procedure, with or without augmentation bone grafting, would permit construction of a more functional prosthesis.





*Upper:* Panoramic radiograph, 7 months following injury, showing a large discontinuity defect of the mandible extending from a small residual fragment of the right ramus to the left parasymphysis area. *Middle left and middle right:* Appearance of patient 7 months following injury. *Lower left and lower right:* Cast metal splints that were constructed for fixation at the time of bone grafting.



*Upper left:* Template that was fabricated to simulate the size and configuration of the mandibular defect to aid in design and recovery of an autogenous iliac graft. *Upper right:* Metallic crib that served as a PCM graft extension of the solid graft to bridge the symphysis defect, enhance graft union, and establish the necessary curvature to the graft in the symphysis region. *Middle:* Solid autogenous iliac graft with PCM grafting system extension attached. *Lower:* Combined solid iliac and PCM graft secured in the graft bed.

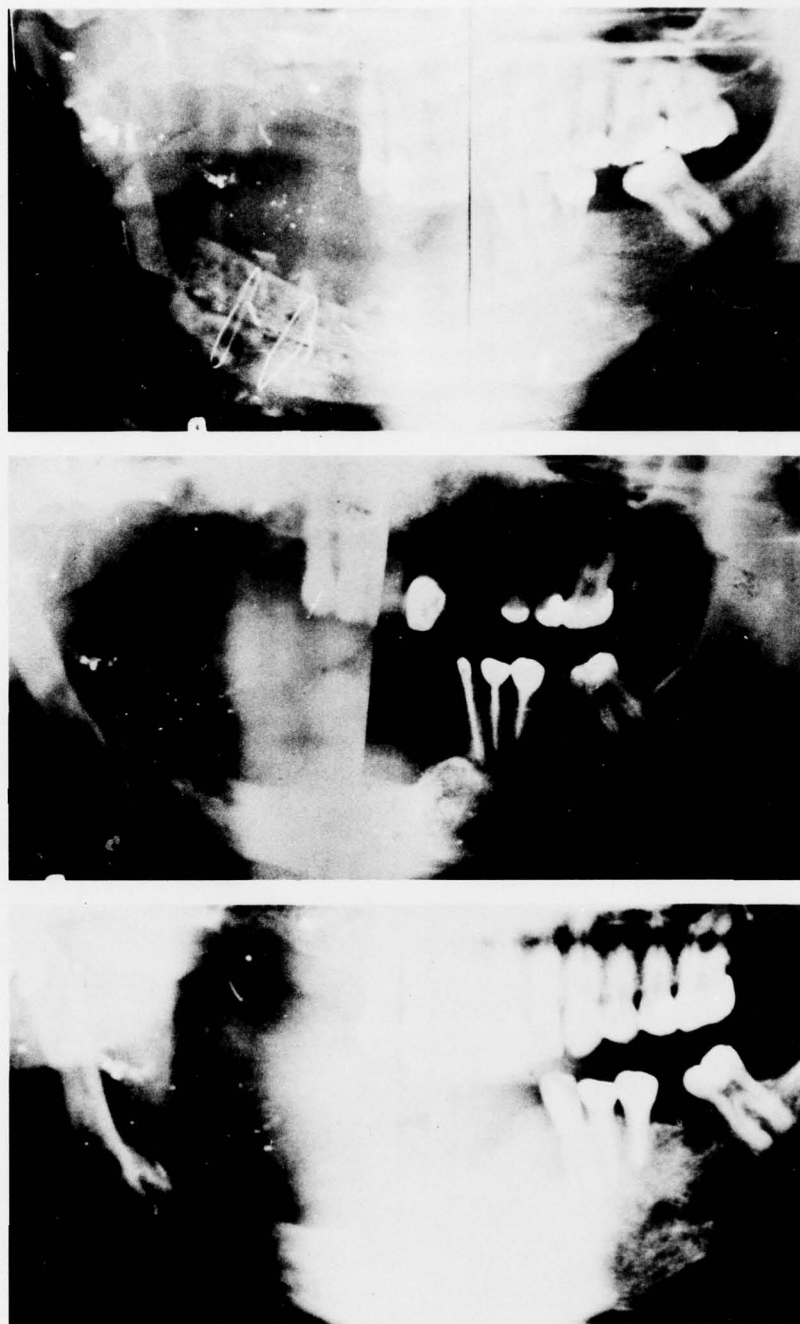


*Upper left and upper right:* Biphasic external skeletal fixation appliance that was placed 14 days post grafting to enhance stability of the graft and host fragments. *Middle:* Panoramic radiograph 9 months following continuity bone grafting. *Lower:* Panoramic radiograph 21 months following continuity bone grafting.





*Upper left:* Appearance of patient 21 months following continuity bone grafting just prior to augmentation bone grafting. *Upper right:* Appearance of parasympysis graft-host junction and crib just before its removal at time of augmentation bone grafting 25 months following the continuity bone graft. *Middle left:* Appearance of right side and symphysis region of mandibular continuity bone graft following crib removal at time of augmentation bone grafting. *Middle right and lower left:* Appearance of autogenous rib segment that had been prepared to augment the continuity bone graft. *Lower right:* Appearance of augmentation rib graft secured in place with circumferential wires.



*Upper:* Panoramic radiograph 1 week following rib graft augmentation of the mandible. *Middle:* Panoramic radiograph 15 months following augmentation grafting and 40 months following continuity grafting. *Lower:* Right mandibular panoramic radiograph 42 months following augmentation grafting and 67 months following continuity grafting.

## CASE NUMBER 15

---

**Description of Injuries:** This 21-year-old casualty received a high-velocity missile wound to the face. The projectile entered the left nasolabial fold area and exited the right submandibular region resulting in extensive avulsion of hard and soft tissues in the path of the missile. There were fractures of the maxillary right and left first molars, lateral incisor (#3, 14, and 10), and the hard palate as well as laceration of overlying soft tissue. A large segment of the tongue was avulsed and there was fracture avulsion of the right mandible with associated teeth from the symphysis region to the ramus.

**Early Care:** The patient was evacuated to a 4th-echelon medical facility (hospital ship) where an emergency tracheostomy was performed under local anesthesia. The maxillary first molar and second bicuspid teeth (#3 and 4) were removed and the maxillary antra explored bilaterally and packed with petrolatum gauze exited through nasal antrostomies. The oromandibular-facial wounds were debrided and a rotation flap turned from the neck to assist closure of the exit wound. Dependent drainage was established. Intermaxillary fixation was effected with maxillary and mandibular arch bars and circum-zygomatic suspension wiring was placed to assist stabilization of the fractures. He was admitted to the medical evacuation system 9 days post injury in satisfactory condition.

**Intermediate Care:** The patient was received at an intermediate facility the day of discharge from the early care facility. Necessary wound debridement was performed and supportive care provided until his medical evacuation 21 days following admission.

**Late Care:** The patient entered a late care hospital (CONUS) after 5 days in transit. His mandible was mobilized and suspension wires were removed 4 days following admission. Over the next 8 weeks, he underwent several surgical debridement procedures. A compound odontoma and an associated impacted cuspid tooth (#27) were removed from the mandibular parasymphysis 11 weeks after admission, in addition to the impacted right maxillary and mandibular third molars (#1 and 32). Twelve weeks following admission, a transmastoid, extratemporal exploration and decompression of the facial nerve was accomplished in an attempt to reestablish integrity of motor function. At surgery perineural scarring was found, although the facial nerve was intact. Postoperatively only minimal return of facial nerve function was appreciated. Thirteen months post injury, an autogenous iliac corticocancellous block graft augmented with particulate cancellous marrow was placed to restore continuity. The postoperative course was satisfactory and he was placed in function 12 weeks post grafting at which time the mandible was firm and stable. At the time of last follow, 5 years and 10 months post injury and 4 years and 9 months post grafting, all wounds were well healed. The mandible was stable, but preprosthetic surgery was required in the mandible if the patient was to wear a prosthesis. He was disinclined to receive any further treatment. He had normal mandibular range of motion but was not wearing a dental prosthesis.

---





*Upper left:* Appearance of 21-year-old casualty showing the entrance (EN) and exit (EX) wounds that resulted from a high-velocity missile. *Upper right and middle left:* Lateral and posteroanterior radiographs on day of injury showing the extent of underlying skeletal damage to the maxilla and mandible. *Middle right and lower:* Appearance of patient 1 month post injury. The wound scars were healing satisfactorily although there was a flaccid appearance to the right side of the face, secondary to facial nerve damage that resulted from the injury.

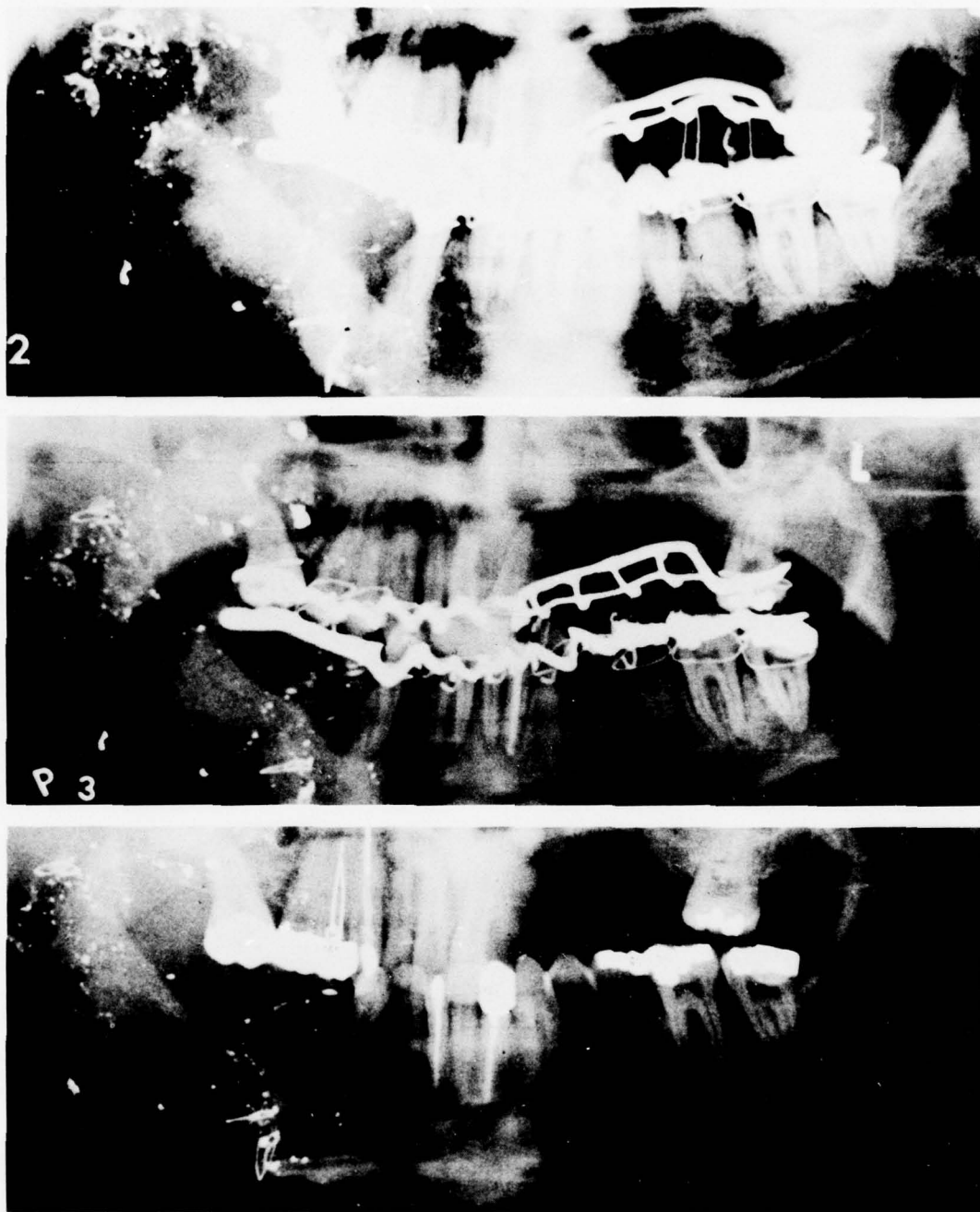


*Upper:* Panoramic radiograph, 4 months post injury, showing an extensive discontinuity defect of the right mandible and a healing defect of the left maxilla. An impacted cuspid tooth and an odontoma were present in the symphysis region. *Middle:* Panoramic radiograph 6 months post injury. The unerupted cuspid and odontoma had been removed. *Lower:* Panoramic radiograph 13 months post injury. The osseous injuries were well healed and the discontinuity of the right mandible remained. Endodontics had been performed on the mandibular left lateral incisor (#24).

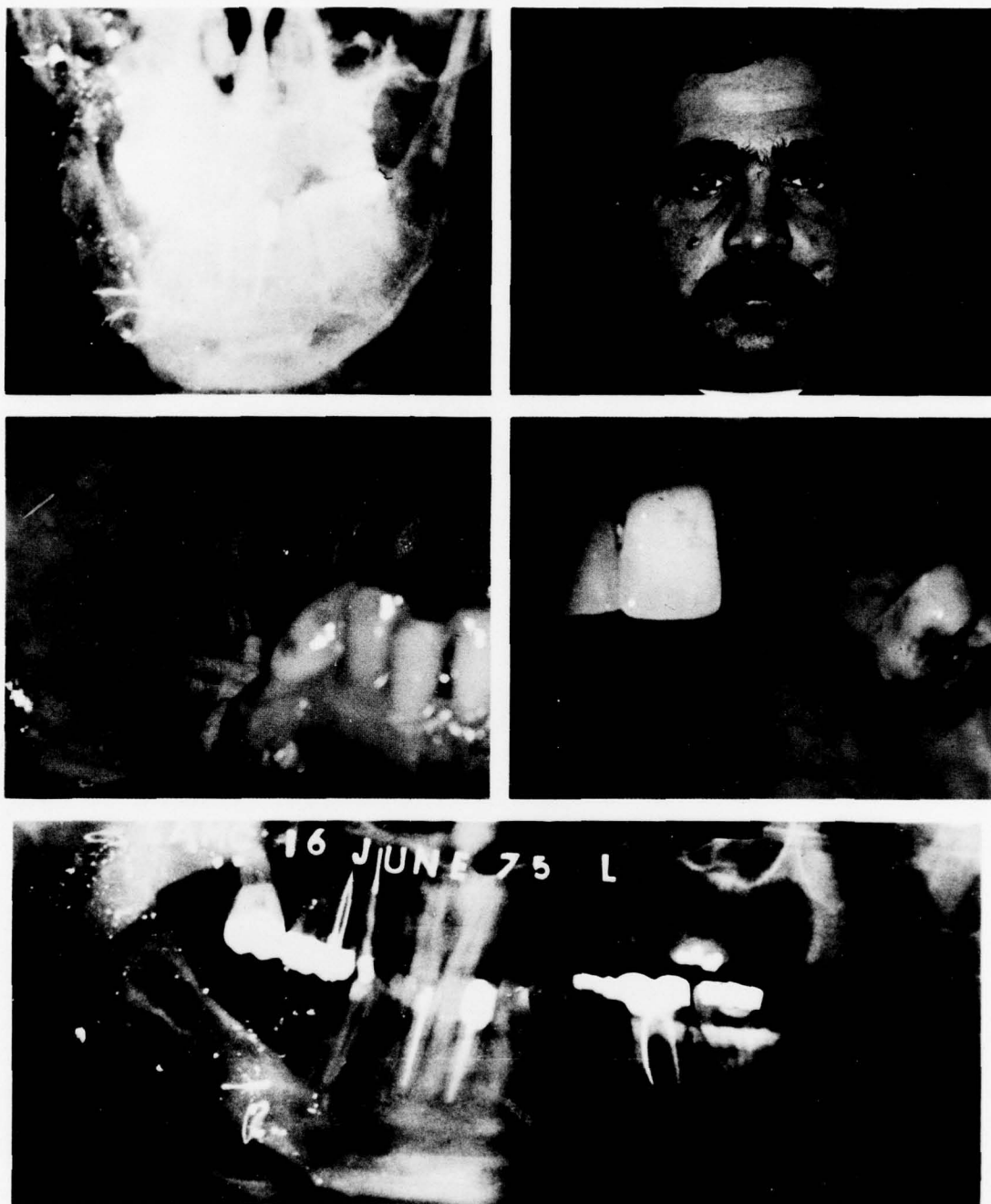


*Upper left:* Appearance of operative site for bone grafting to the mandible showing outline of hypertrophic scar excision that was performed in gaining access to the discontinuity defect. The graft operation was performed 13 months post injury. *Upper right:* Appearance of mandibular discontinuity defect at time of bone grafting showing proximal and distal fragments. *Middle left:* Appearance of autogenous, corticocancellous iliac bone graft onlaid to the lingual cortex of the proximal and distal fragments. *Middle right:* Appearance of graft augmented with particulate cancellous marrow. *Lower:* Appearance of wound closure. The vertical segment of the hypertrophic scar was also excised and the wound was drained from a separate, dependent incision in the neck.





*Upper:* Panoramic radiograph, 1 month post bone grafting, showing the custom splints used for intermaxillary fixation and the size and contour of the graft that restored the area of discontinuity. *Middle:* Panoramic radiograph, 3 months post bone grafting, showing evidence of osseous consolidation. The graft was stable at this interval and the intermaxillary fixation was discontinued. *Lower:* Panoramic radiograph 18 months post grafting. The graft had healed well and remodeled with limited reduction in bulk. Additional endodontic and restorative dental procedures had been performed.



*Upper left:* Posteroanterior radiograph, 18 months post grafting, showing the symmetrical appearance of the reconstructed mandible. *Upper right:* Appearance of patient, 30 months post grafting, showing facial symmetry and acceptable esthetics. *Middle left:* Intraoral appearance of graft area in the right mandible 30 months post grafting. Continuity had been restored but there remained a need for additional preprosthetic surgery if a mandibular partial denture was to be constructed. At that time the patient was reluctant to accept treatment. *Middle right:* Appearance of well-healed maxilla 30 months post injury. *Lower:* Panoramic radiograph, 4 years and 9 months post grafting. The graft had remodeled in response to the functional requirements of the mandible and displayed normal trabeculation oriented to the vectors of stress within the bone. Endodontics had been performed on the mandibular left first molar.

## CASE NUMBER 16

---

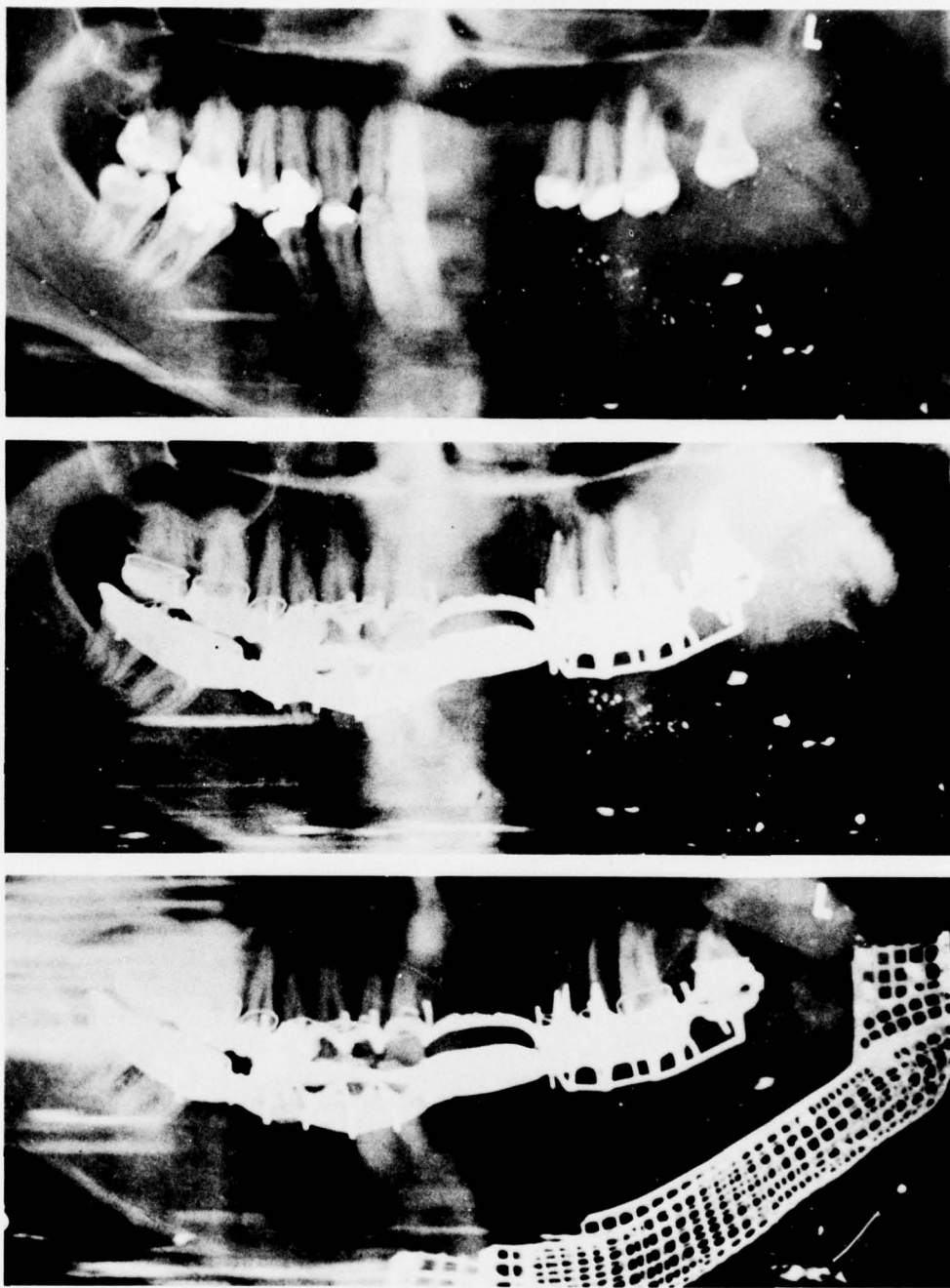
**Description of Injuries:** This 21-year-old casualty received a high-velocity missile wound to the face and neck. The missile entered the mouth and exited the left mandible entering the left shoulder. He sustained a compound, comminuted, avulsive fracture of the left mandibular body from the symphysis to the ramus.

**Early Care:** He was medically evacuated to a 3rd-echelon facility the day of injury where emergency care was provided including a tracheostomy, debridement and closure of soft tissue injuries, as well as closed reduction of the mandibular fractures. He was transferred to a 4th-echelon facility 2 days following injury where supportive care was provided. On the 5th postoperative day he was admitted to the medical evacuation system.

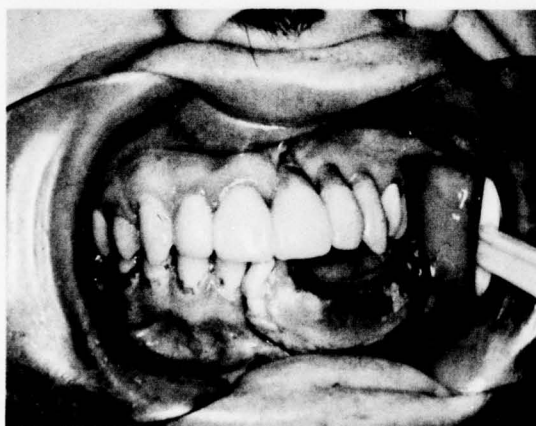
**Late Care:** There was no admission to an intermediate facility and he was received at a CONUS hospital 12 days post injury after 7 days in transit. Debridement of the fractured maxillary left incisor, cuspid, and second molar teeth (#10, 11, and 15) was accomplished in the first week following admission. Twenty-two weeks after injury, a vestibuloplasty with mucosal grafting of the left mandibular alveolar sulcus was performed to release adhesions of the tongue and floor of the mouth. The mucosa graft was taken from the right cheek. Nine months post injury a PCM graft was placed to restore mandibular continuity. The postoperative period was complicated by infection which responded to antibiotics and local wound care. The mandible stabilized, and 5 months following bone grafting, another vestibuloplasty with a free-mucosal palatal graft was performed to extend the left mandibular alveolar sulcus. At last follow, 6 years and 1 month following injury, the metallic crib remained in place and, although there was limitation of mandibular opening to 21 mm, the mandible was stable. A prosthesis had been constructed although it was providing very limited function. The remaining mandibular dentition manifested paradicular radiolucencies and their future efficacy as aids to a prosthesis was questionable. The large crib was presumably providing the major support to the mandible since the amount of osseous tissue within the crib appeared to be quite limited in the body-symphysis region. Bony augmentation or extension of the vestibuloplasty was not advisable because of the height of the crib. If teeth are lost and a full removable denture is required, it is anticipated that crib removal will be necessary followed by bone grafting for increased stability as well as restoration of an alveolar base. Vestibuloplasty will also be necessary.

---

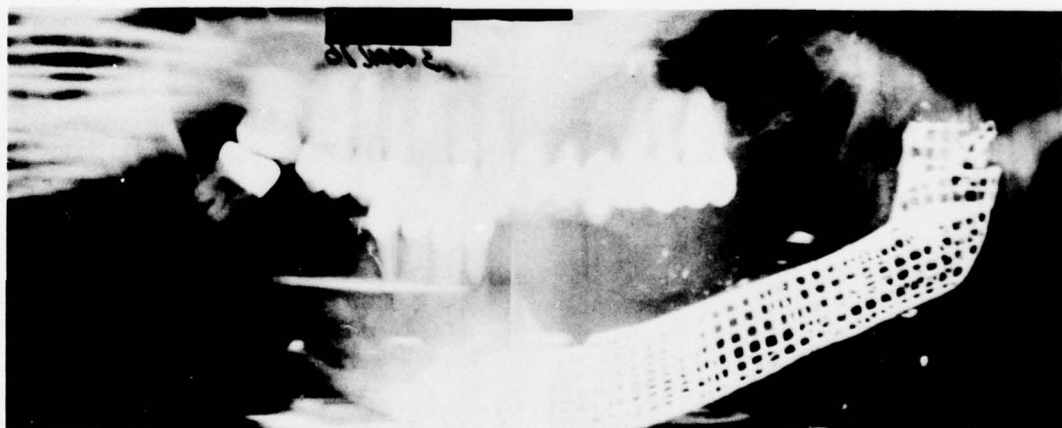
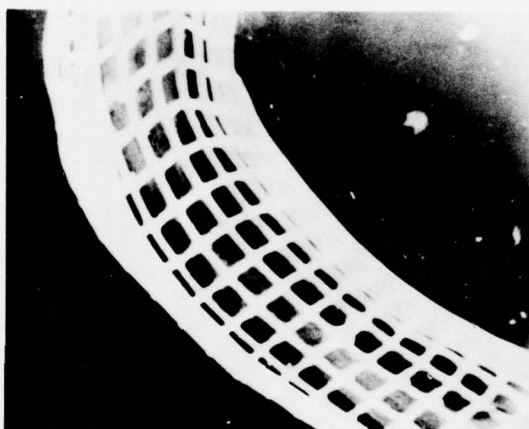
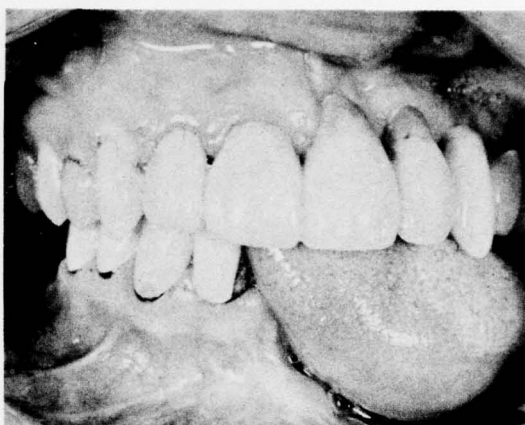
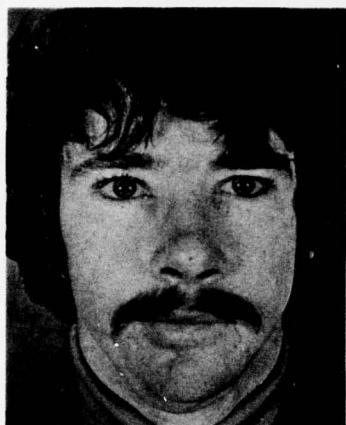




*Upper:* Panoramic radiograph of a 21-year-old casualty 5 months following a high-velocity missile wound to the orofacial area. A discontinuity defect of the left mandible existed. *Middle:* Panoramic radiograph, 9 months post injury just prior to bone grafting, showing the presence of custom splints that were used for intermaxillary fixation. *Lower:* Panoramic radiograph 4 days following bone graft reconstruction of the mandible with a PCM graft system. A metallic crib had been custom fabricated for the procedure.



*Upper:* Panoramic radiograph, 4 months post grafting, showing the metallic crib in place with evidence of osseous proliferation above the level of the crib in the angle-body and symphysis regions of the graft. *Middle left:* Intraoral appearance of tissue overlying the bone graft 27 months post grafting. Continuity was present but there was essentially no alveolar ridge and, although the soft tissues were partially stabilized by vestibuloplasty, a truly adequate denture base did not exist. The vestibuloplasty was compromised by the presence of the metallic crib. *Middle right:* Appearance of occlusion 27 months post grafting. Normal intermaxillary relations and occlusion were maintained on the right side. Considerable gingival recession was evident about the maxillary left anterior teeth. *Lower left:* Appearance of temporary soft-lined stent that the patient was wearing 27 months post grafting. *Lower right:* Appearance of prosthesis that was worn 51 months post grafting.



*Upper left:* Appearance of patient, 5 years and 4 months post injury. *Upper right:* Appearance of prosthesis that was worn 5 years and 4 months post grafting. Note the abnormal bulk of the denture flange which was resting on thin mucosal tissue covering the rim of the metallic crib. If additional teeth are lost prosthesis construction will be extremely difficult without additional preprosthetic surgery which in turn is precluded by presence of the metallic crib. *Middle:* Occlusal radiograph 5 years and 4 months post grafting. There was only a thin strut of bone evident within the metallic crib which was providing the major stability to the mandible. *Lower:* Panoramic radiograph 5 years and 4 months post grafting. In the 5 years since the X-ray displayed in the lower panel (p. 228) there had been fracture and collapse of the crib at the ramus junction. A unique osseous appearing structure, perhaps an enlarged styloid process, was seen contacting the distal-superior corner of the crib.



## CASE NUMBER 17

---

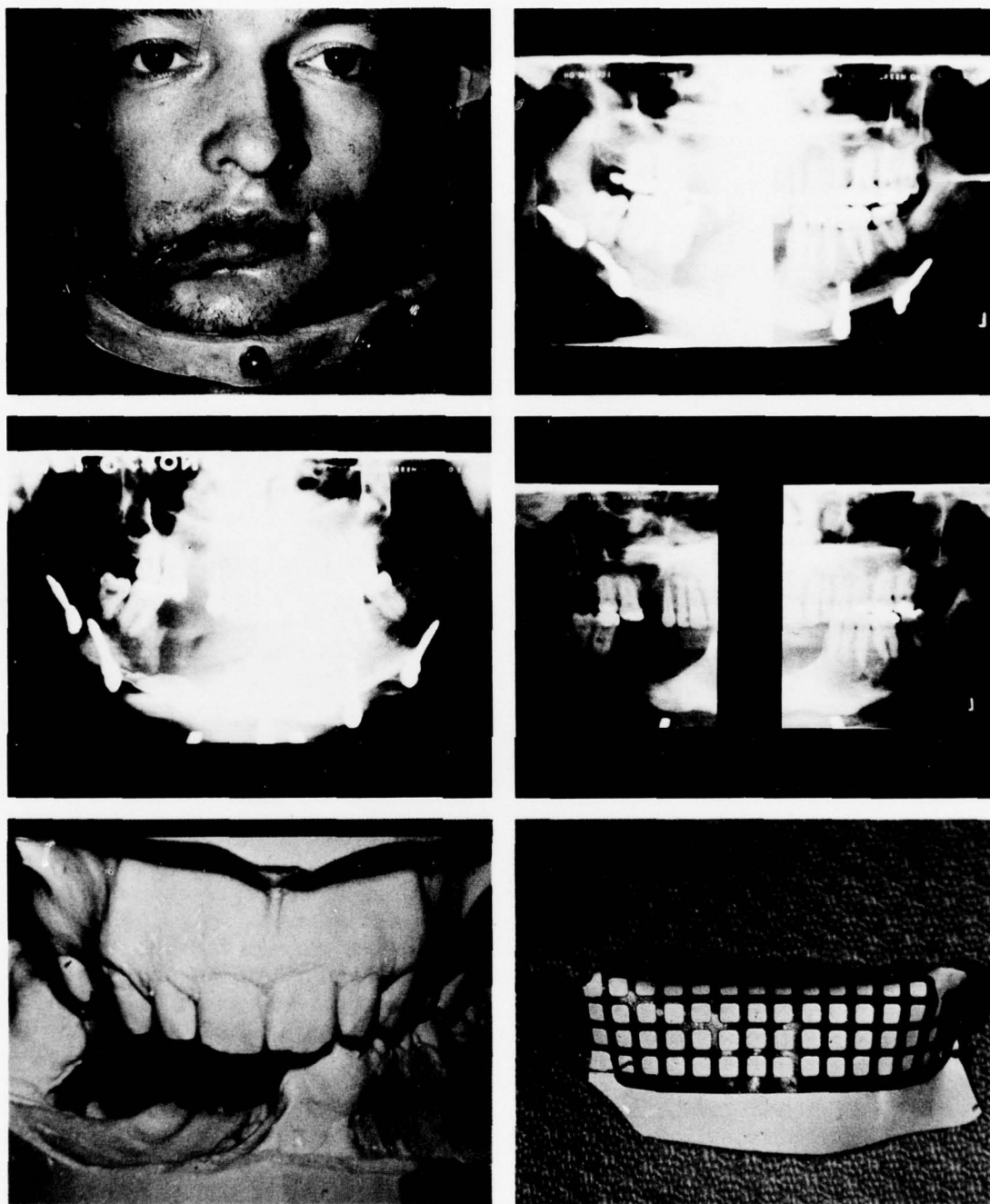
**Description of Injuries:** This 23-year-old casualty received a high-velocity missile wound to the lower face. The wound entrance was just inferior to the left mandibular angle and the missile exited at the right commissure of the mouth. There were lacerations of the face, right oral commissure and oral cavity, as well as avulsion of teeth and supporting alveolar structure from the left mandible including the region from the lateral incisor tooth (#23) to the mandibular right second bicuspid tooth (#29).

**Early Care:** Following injury this patient was taken to a 3rd-echelon medical facility where a tracheostomy was performed to ensure an airway. The soft tissue wounds were then debrided and closed primarily. A closed reduction of his mandibular fractures was performed utilizing arch bars and a biphasic external skeletal fixation appliance. The patient's postoperative course was satisfactory and he was admitted to the medical evacuation system 2 days after injury.

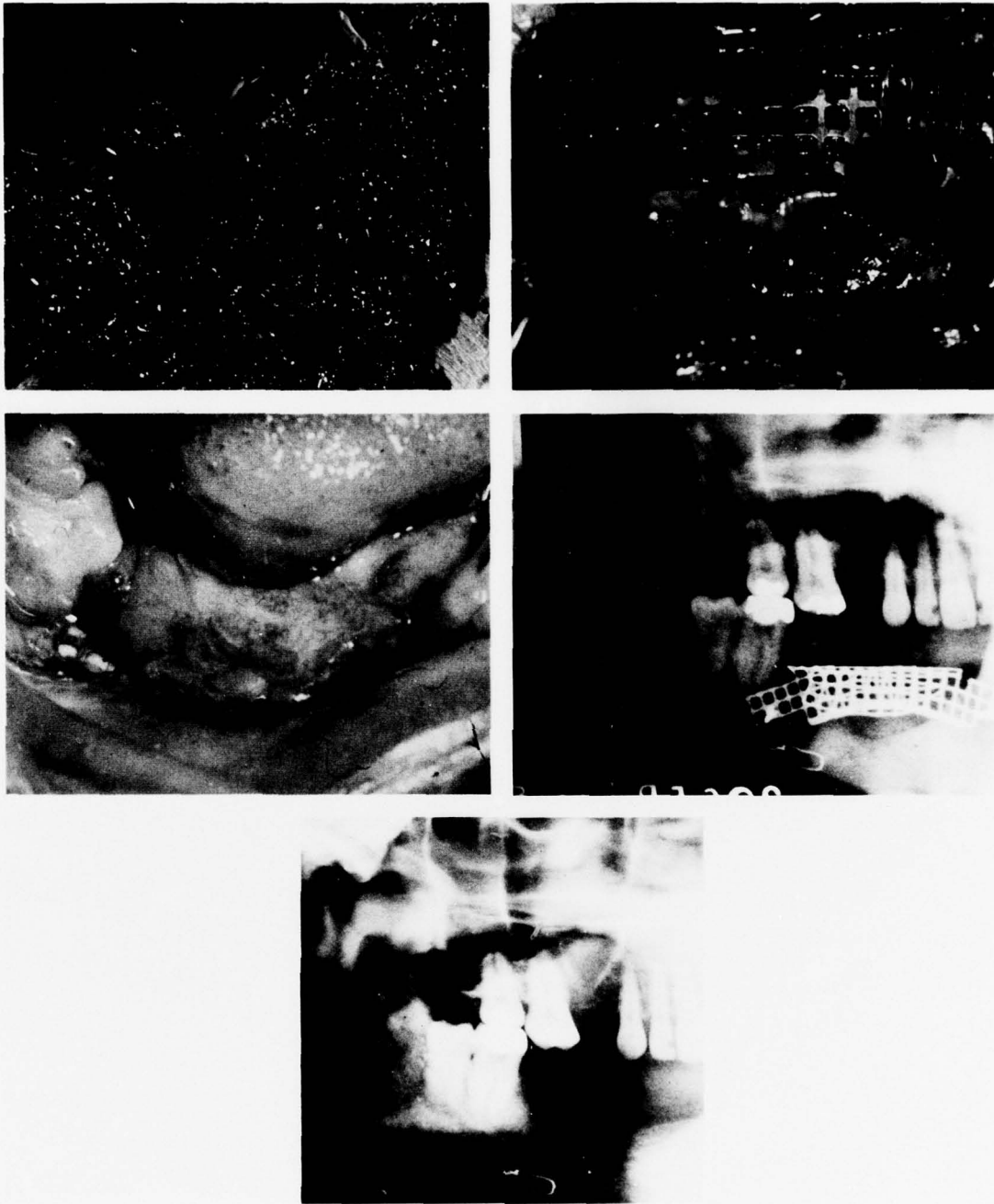
**Intermediate Care:** The patient entered an intermediate care facility the day of transfer. An extraoral open reduction of the mandibular fracture was performed 9 days following admission. The patient was made available to the medical evacuation system 4 days postoperatively (17 days post injury).

**Late Care:** Admission to a late care hospital occurred after 2 days in transit. Intermaxillary fixation was discontinued 7 days following admission (10 days after open reduction) and stability was maintained with a biphasic appliance. Over the next several weeks the mandibular right first molar (#30) and the maxillary left third molar (#16) were removed and the fracture of the mandible stabilized very slowly. A removable partial denture was constructed and delivered 4 months following injury while the biphasic appliance was still in place. Three weeks later, the external skeletal fixation was removed. Although the mandible was grossly stable and there was radiographic evidence of osseous repair, the partial denture was functionally inadequate because of deficient alveolar structure, unstable underlying soft tissue, and flexion at the thin strut of bone in the midbody. Subsequently, several scar revisions were accomplished to release the contracture at the right lip commissure. An autogenous PCM graft was placed 11½ months after injury to reconstruct the dentoalveolar deformity. Twelve months following bone graft augmentation, a mandibular vestibuloplasty with skin grafting was performed to complete reconstruction of the mandible. At last follow, 6 years and 4 months post injury and 5 years and 5 months following augmentation bone grafting, the patient was wearing a mandibular denture without difficulty, had full range of mandibular motion and demonstrated satisfactory masticatory function. The region of the graft was fully mature with normal osseous architecture and the level of augmentation was essentially the same as 2 months post grafting.

---

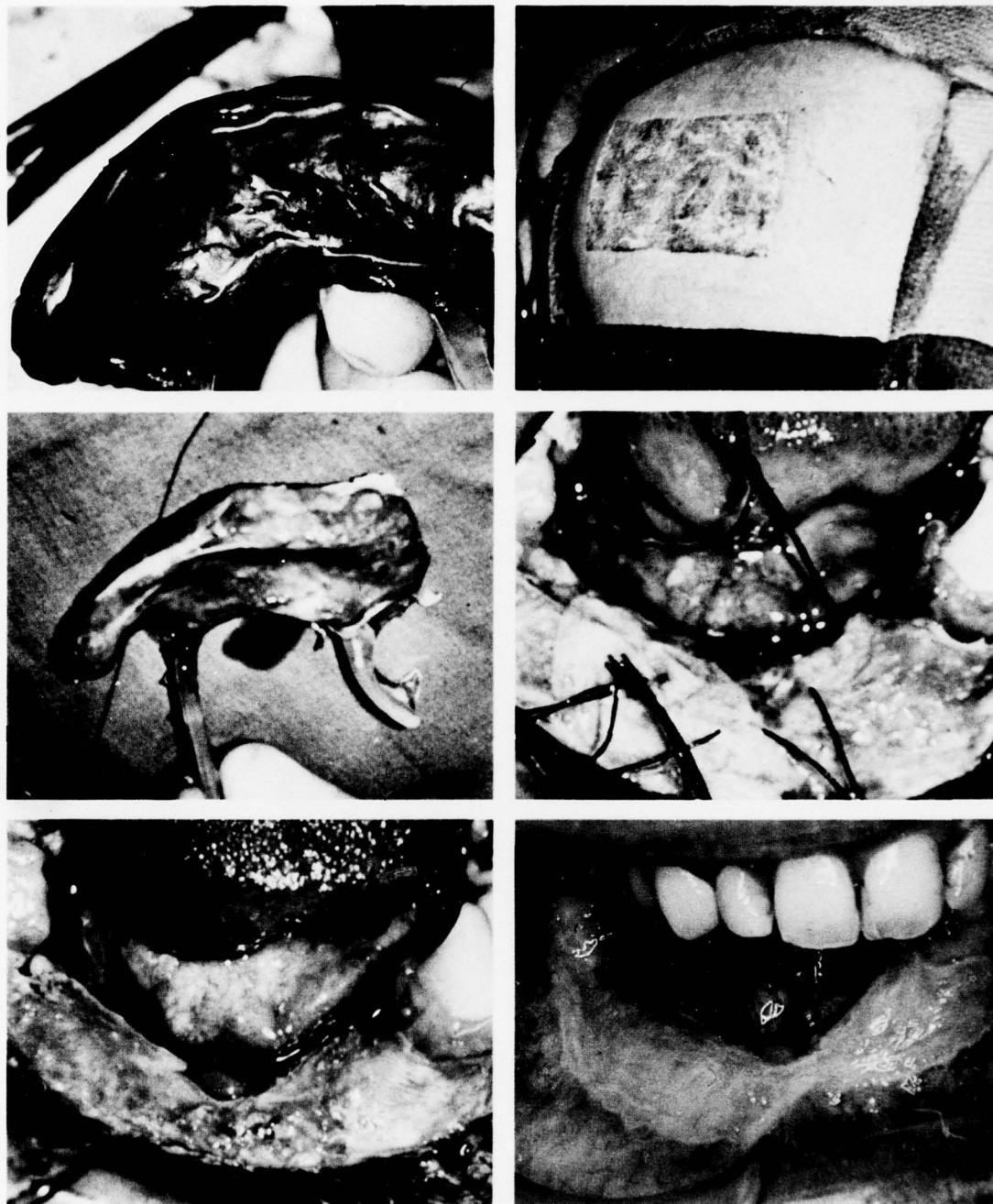


*Upper left:* Appearance of 23-year-old casualty when admitted to a late care facility 3 weeks after a high-velocity missile wound to the face and jaw. An external skeletal fixation device had been placed as an adjunct to intermaxillary fixation and open fracture reduction to help control the mandibular fragments. *Upper right:* Panoramic radiograph at time of admission to late care facility 3 weeks after wounding. The mandibular first molar (#30) was projecting into the avulsive mandibular defect without bony covering over the apex. *Middle left:* Panoramic radiograph 4 months after injury. Tooth #30 was removed 7 weeks post injury. *Middle right:* Panoramic radiograph 10 months post injury and 5 months after removal of external skeletal fixation. The mandible had consolidated although a large osseous defect of the dentoalveolar process existed in the right body region. *Lower left:* Study model appearance of dentoalveolar defect that existed 11 months after injury just before augmentation bone grafting. The soft tissues of the cheek and the floor of the mouth, which were continuous with one another, formed a mobile tentlike sheet overlying the mandibular defect which did not afford a stable tissue base to support a prosthesis. *Lower right:* Metallic crib lined with a microporous filter that was used to conform the particulate graft material in the defect.

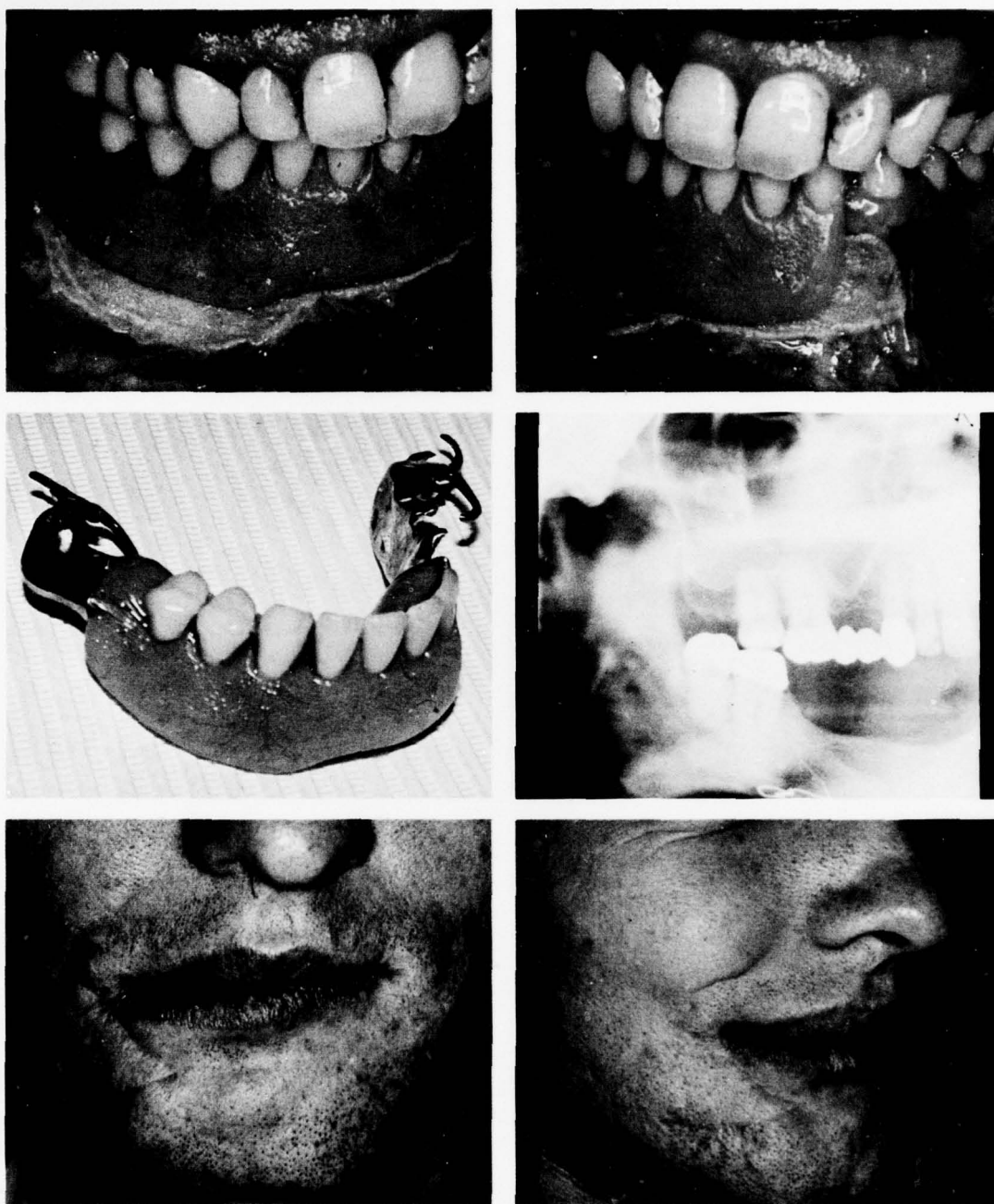


*Upper left:* Autogenous, particulate, cancellous marrow graft material from the ilium. *Upper right:* Metallic crib, microporous filter, and particulate graft material in place across the dentoalveolar defect. *Middle left:* Mucosal dehiscence that developed over the PCM graft 2 weeks post grafting. Frequent irrigations and vaseline packing over the defect controlled the extent of the breakdown. *Middle right:* Panoramic radiograph 8 weeks following augmentation bone grafting just prior to metallic crib removal. Evidence of osseous repair is seen below the level of the crib. *Lower:* Panoramic radiograph 7 months following augmentation bone grafting. Increased alveolar height is evident at the graft site.

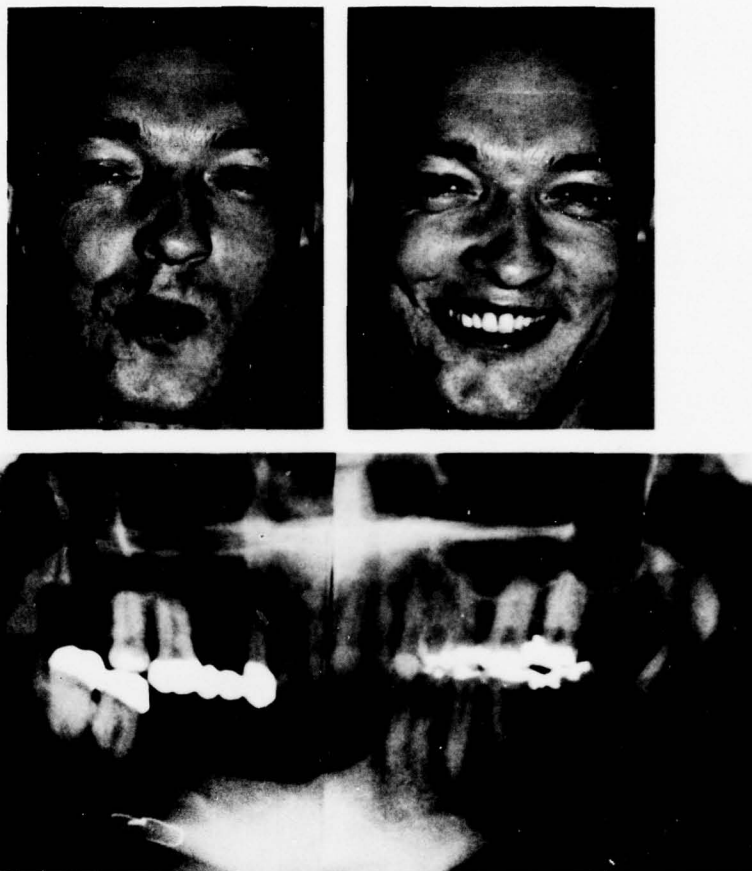




*Upper left:* Guttaform lined compound impression that was made of the bone graft reconstructed alveolar ridge following flap dissection. *Upper right:* Appearance of donor site on buttocks following dermatome excision of split-thickness skin graft at time of vestibuloplasty 12 months after augmentation bone grafting. *Middle left:* Skin graft adapted to impression prior to securing of stent over alveolar ridge. *Middle right:* Appearance of skin graft—vestibuloplasty site at time of stent removal 8 days following surgery. *Lower left:* Appearance of skin graft—vestibuloplasty site 24 days post surgery. *Lower right:* Appearance of reconstructed alveolar ridge 24 months post bone grafting and 13 months post vestibuloplasty.



*Upper left and upper right:* Appearance of prosthesis and occlusion 13 months following vestibuloplasty. Note the position of the mucosa-skin graft junction below the level of the denture flange. *Middle left:* Appearance of prosthesis that was restoring the mandibular defect. *Middle right:* Panoramic radiograph of reconstructed mandible 24 months post bone grafting. *Lower left and lower right:* Appearance of lower face 5 years after injury. Scar revision has improved esthetics as well as function of the lips and corner of the mouth.



*Upper left and upper right:* Appearance of patient, 6 years and 4 months post injury, showing acceptable esthetics and lip function. *Lower:* Panoramic radiograph, 5 years and 5 months following bone graft augmentation of the mandible, showing full maturation of the graft area, normal-appearing trabeculation, and maintenance of alveolar height obtained at time of augmentation bone grafting.



## CASE NUMBER 18

---

**Description of Injuries:** This 21-year-old casualty was injured by a rocket fragment. He sustained a large stellate laceration of the right cheek and a depressed fracture of the right zygoma. There was an avulsive, compound, comminuted fracture of the right mandibular body, lacerations of the overlying mucoperiosteum and avulsion of the right mandibular teeth and alveolus (#29-32). There was neuropathy of the marginal mandibular branch of the 7th cranial nerve and laceration of the anterior tonsillar pillar.

**Early Care:** The patient was evacuated to a 4th-echelon medical facility (hospital ship) where his wounds were debrided, and a 5-cm incision was made along the inferior border of the right mandible to facilitate the removal of a  $3 \times 4 \times 1$ -cm metallic fragment. A closed reduction of the comminuted fracture was performed, the mandible was immobilized with elastic traction, and the soft tissues were closed primarily. Postoperatively, the patient developed swelling and purulent drainage from the area overlying the right mandibular fracture. Bacteriologic testing revealed *Pseudomonas aeruginosa*, which responded to therapy with systemic antibiotics and local wound care. Twelve days after injury, swelling developed over the parotid area and 30 cc of clear fluid was obtained by aspiration. Inspection revealed that the parotid duct had been severed; therefore, a 14-gauge polyethylene catheter was passed through the oral mucosa opposite the area of pooling and sutured into place to create a fistulous tract. The cannula drained saliva immediately after placement and no further soft tissue pooling occurred. The patient was released to the medical evacuation system 6 weeks following initial injury.

**Late Care:** There was no intermediate care admission and the patient entered a late care hospital after 5 days in transit. At the late care facility the parotid catheter was removed. The fistulous parotid opening was functioning satisfactorily. Intermaxillary fixation was removed 10 weeks after injury, at which time limited stability was present. Eight months following injury, a PCM graft was performed because continued instability did not permit normal function. At the same time, a solid, one-piece, onlay graft of iliac corticocancellous bone was placed over the right zygomatic depression to restore facial symmetry. Intermaxillary fixation was discontinued after 5 weeks, at which time the mandible was clinically stable. Twelve weeks post grafting the metallic crib and filter were removed via an intraoral approach. At last follow, 7 years and 7 months post injury, both grafts were well healed. Periodontal pathosis was affecting the remaining dentition. The patient was not able to wear a prosthesis over the right mandible because of an insufficient alveolar process and improperly positioned vestibular soft tissues.

---

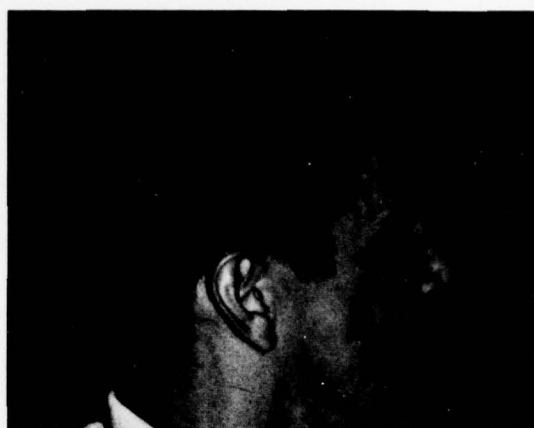
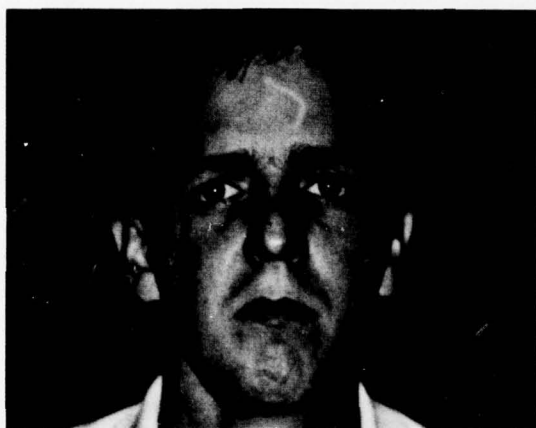


*Upper left:* Appearance of a 23-year-old casualty at triage, several hours following injury, showing a stellate laceration overlying the right zygomatic area. *Upper right:* Posteroanterior radiograph showing the very large metallic fragment lateral and inferior to the border of the right mandible. The fragment had caused a compound, comminuted, avulsive injury to the right mandible. *Middle left:* Appearance of metallic fragment after recovery from the right cheek. *Middle right:* Posteroanterior radiograph taken following closed reduction of the mandibular fracture showing the position of the reduced fragments. *Lower left:* Lateral radiograph showing the fracture comminution of the right mandibular body and angle after closed reduction. *Lower right:* Panoramic radiograph of right mandible, 1 month post injury, showing evidence of some consolidation.



*Upper left:* Panoramic radiograph 10 months post injury. The fracture was clinically mobile at this time although there was osseous consolidation and remodeling. *Upper right:* Panoramic radiograph 5 days following PCM bone grafting to establish mandibular stability. *Middle left:* Panoramic radiograph, 7 weeks post grafting, showing osseous regeneration in the region of the graft particularly above the level of the crib. *Middle right:* Lateral oblique radiograph, 26 months post grafting, showing restoration of continuity. *Lower:* Panoramic radiograph 5 years post grafting. Although continuity has been restored, there remains limited vertical height of the mandible.





*Upper left and upper right:* Clinical appearance of the patient 6 years post injury. *Lower left and lower right:* Appearance of the occlusion and intraoral appearance of the right mandibular alveolar process. At last follow the patient was not wearing a prosthesis. Periodontal pathosis was extensive and the fate of several critical teeth was questionable. Loss of additional mandibular teeth would further preclude construction of a prosthesis without preprosthetic surgery including bone graft augmentation plus vestibuloplasty.

## CASE NUMBER 19

---

**Description of Injuries:** A 20-year-old casualty sustained a missile injury to the left maxillary alveolus and posterior teeth during combat in the Korean conflict. A mortar fragment entered his opened mouth fracturing and avulsing the maxillary left bicuspid and molar teeth and associated alveolar process. There were no significant external injuries.

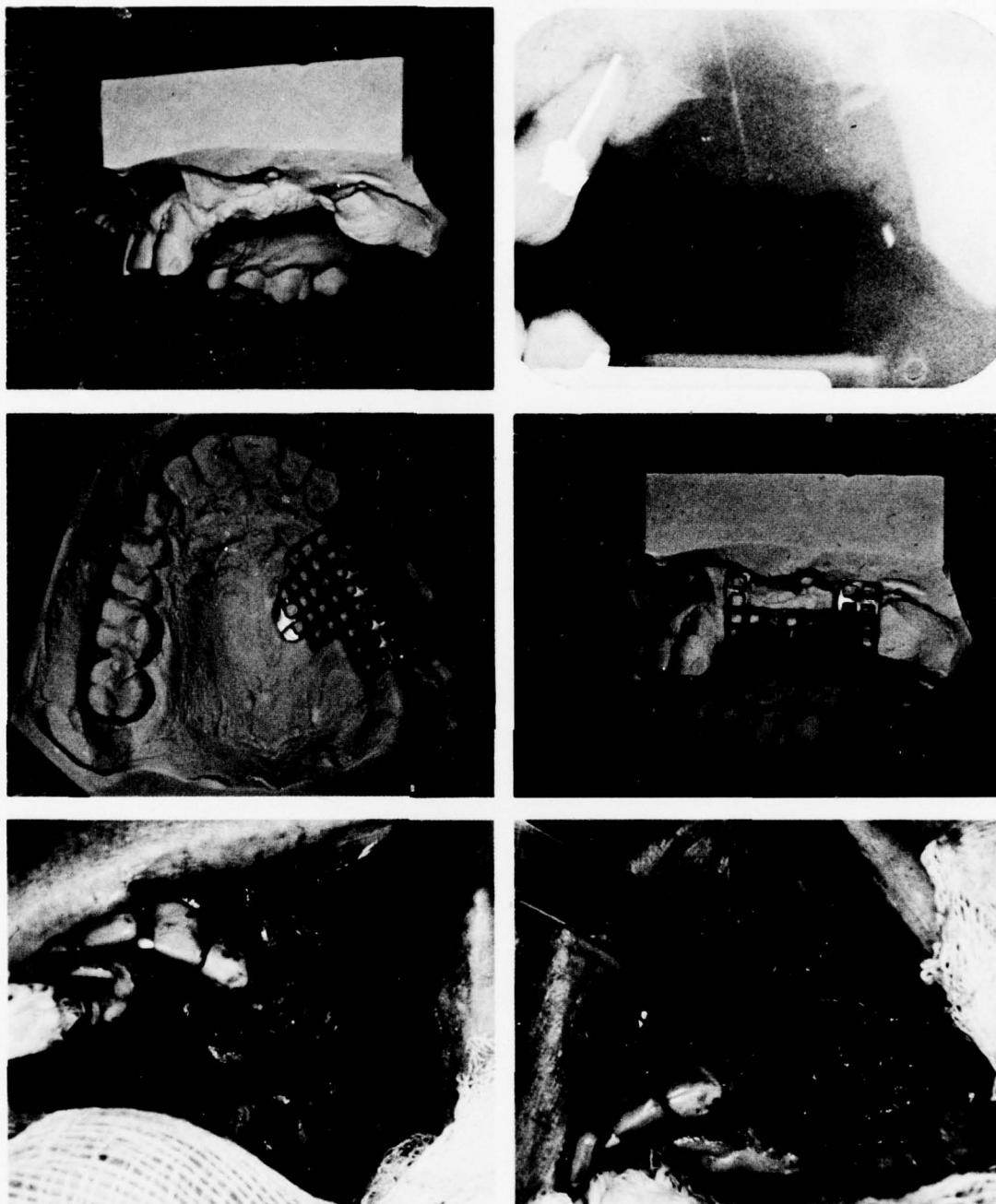
**Early Care:** The patient was taken to a mobile hospital treatment unit where the wound was initially debrided.

**Intermediate Care:** The patient was immediately evacuated to an intermediate hospital where a large oral-antral opening was noted and additional debridement was carried out which included removal of the remaining tooth and free-bone fragments. The patient was evacuated to a CONUS hospital for continued care.

**Late Care:** At the CONUS facility the oral-antral opening was successfully closed utilizing a soft tissue buccal flap procedure. Other treatment included endodontic therapy on the maxillary left cuspid tooth which had become devital following the injury. There was excellent occlusion and satisfactory masticatory function with the remaining teeth; therefore, prosthetic restoration of the left maxillary defect was not attempted and the patient was returned to active military duty. Five years following the injury, a prosthesis was fabricated but was unsatisfactory because the vestibule and denture support area were inadequate.

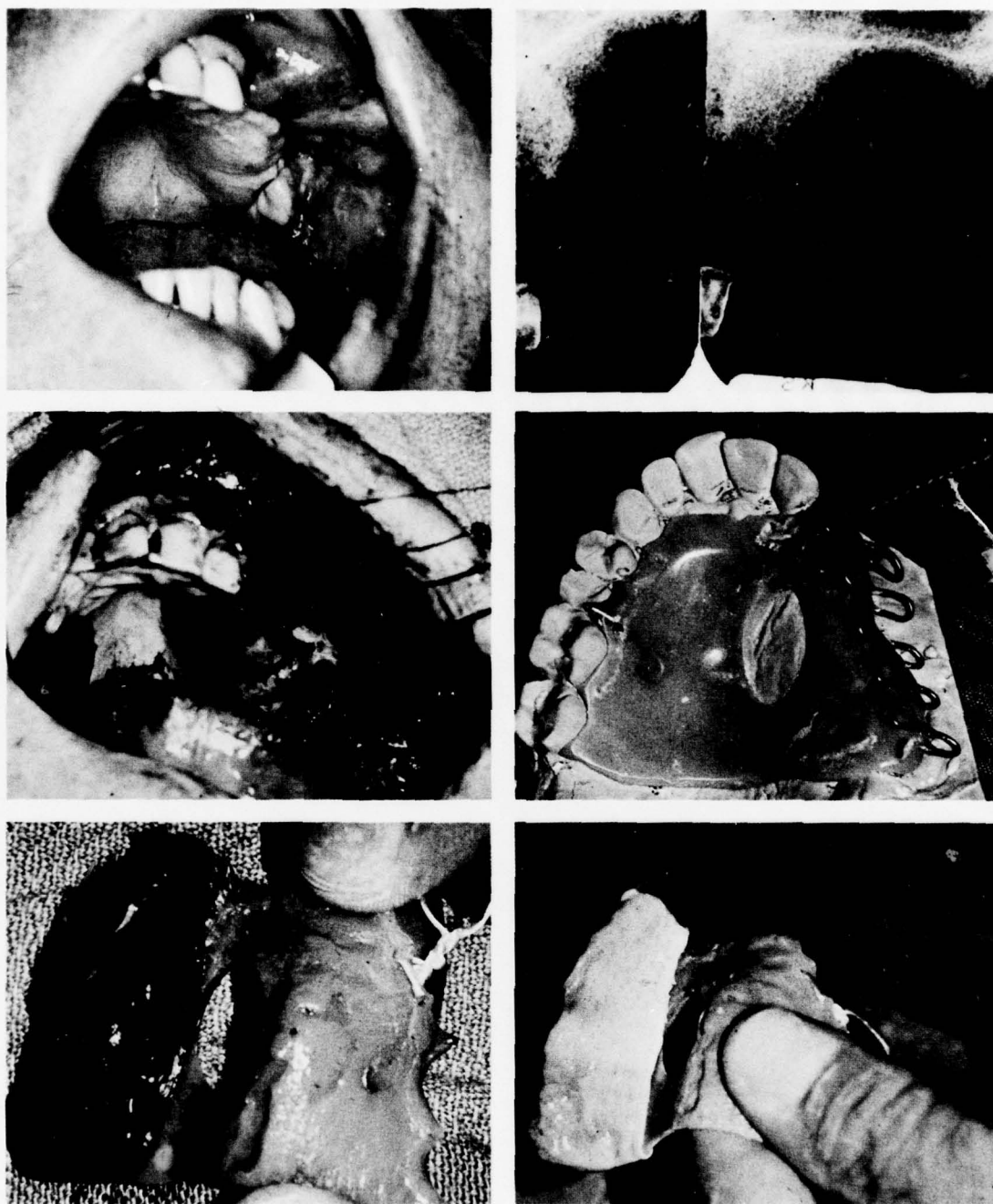
Nineteen years following injury the patient had developed moderate periodontal disease. Bone loss around the left maxillary cuspid was extensive necessitating its removal. To facilitate construction of a prosthesis for the left maxilla, bone graft augmentation followed by vestibuloplasty was required. A PCM bone graft was performed 19½ years after injury, followed by vestibuloplasty with split-thickness skin grafting 6 months later. At last examination, 5 years post grafting and 25 years following injury, the patient was wearing a functional prosthesis over a stable reconstructed alveolar ridge.

---

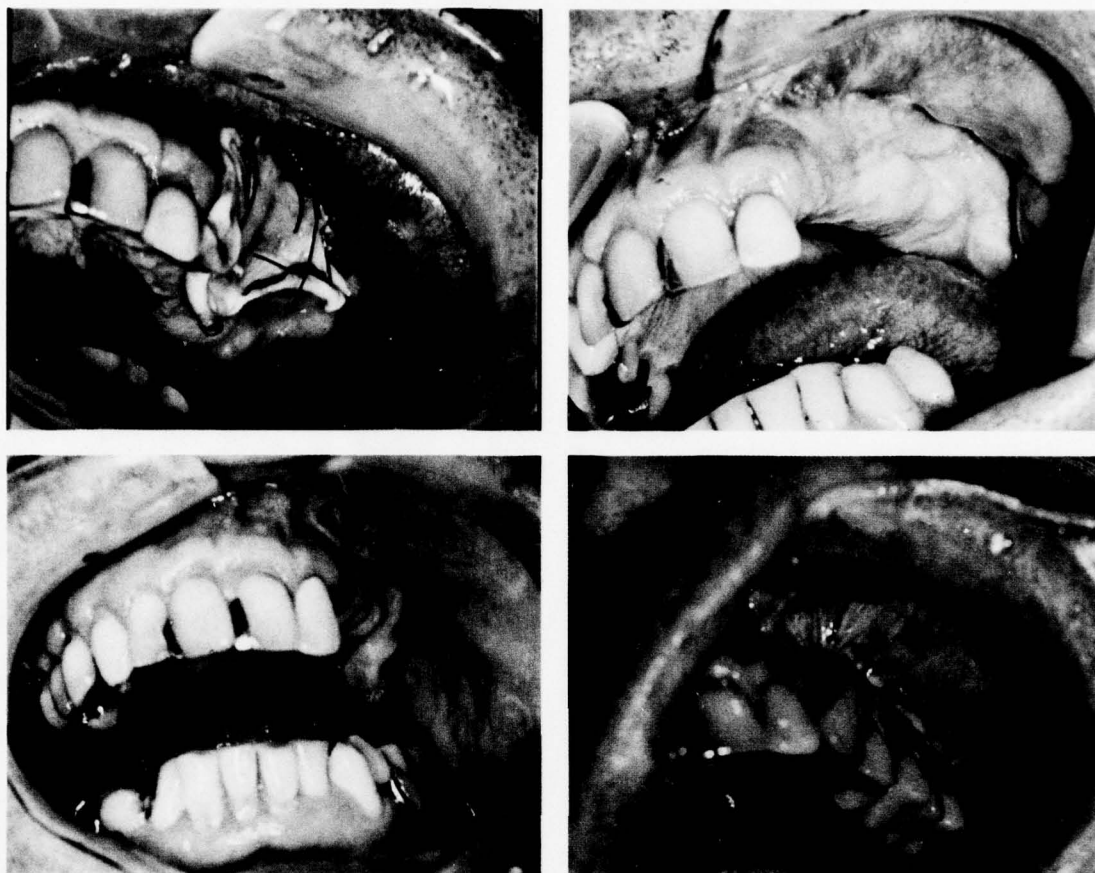


*Upper left:* Study cast of maxilla for a 39-year-old casualty illustrating a deficient alveolar ridge and abnormal vestibule that had resulted from a fragmentation wound 19½ years previously. *Upper right:* Periapical radiographs of left maxilla showing the osseous maxillary defect. *Middle left and middle right:* Study casts on which had been formed a metal mesh crib that was used to support an autogenous particulate cancellous marrow bone graft. *Lower left:* PCM graft system in place in left maxilla. *Lower right:* Reconstructed left maxillary alveolar ridge at time of crib removal 8 weeks post grafting.





*Upper left:* Area of bone graft reconstruction in left maxilla several weeks post grafting. *Upper right:* Radiographs of left maxilla showing the area of osseous reconstruction 9 weeks post grafting. *Middle left:* Maxillary left alveolar ridge, 6 months post bone grafting, at time of vestibuloplasty. Flap dissection had been completed and stay sutures placed. *Middle right:* Specially designed acrylic stent, which had been modified by incorporation of malleable wire loops that extended over the buccal area to support the thermoplastic material. *Lower left:* Impression of the grafted area that had been modified with a soft thermoplastic material for recording finer detail. *Lower right:* Autogenous skin graft from left buttock attached to the modified stent with dermatome glue.



*Upper left:* Area of vestibuloplasty at time of stent removal, 8 days post grafting. *Upper right:* Reconstructed alveolar ridge, 8 weeks following vestibuloplasty. *Lower left:* Reconstructed alveolar ridge, 5 years and 8 months following bone graft reconstruction. *Lower right:* Prosthesis in place over reconstructed alveolar ridge, 5 years post bone grafting.

## *Appendix*

---

### **ACKNOWLEDGMENTS**

This Appendix, which assesses research on acquired craniofacial disfigurement, was compiled by the National Institute of Dental Research with the assistance of the following consultants: Ralph W. Phillips (Ed.), Indianapolis, Indiana; Joseph B. Drane, Houston, Texas; Fred Leonard, Washington, D.C.; William R. Proffit, Chapel Hill, North Carolina; Marvin E. Revzin,

Kansas City, Missouri; Robert V. Walker, Dallas, Texas; and Bernd Weinberg, West Lafayette, Indiana.

The following pages cite some specific areas of research need, including such topics as wound healing, growth aberration, infection, psychosocial impact, communicative disorders, biomaterials, and prostheses.



# *Research in Acquired Craniofacial Disfigurement*

*Edited by* RALPH W. PHILLIPS, B.S., D.SC.

## INTRODUCTION

This book represents careful documentation of the management of oral and maxillofacial injuries incurred in the tragic act of war. It is hoped that the material contained in this text will also help prepare health professionals to treat patients who have suffered severe craniofacial trauma from whatever source.

As the opportunity developed to assist the U.S.

Navy in the production of this book, it became increasingly apparent that acquired craniofacial disfigurement is a major health problem to the American people. In recognition of this problem, this Appendix is written to identify selected areas where knowledge is needed to reduce the impact of the acquired disfigurement on the afflicted individual, his family, and society.

## THE NATURE AND EXTENT OF THE PROBLEM

Trauma is the principal cause of acquired disfigurement. Trauma can be defined as the change in morphology or function produced by the application of an external energy source on the body. The reaction to injury or transfer of energy may be of an acute or a chronic nature (Narasimhan and Day, 1975). Gross trauma from such causes as vehicular or athletic accidents, combat, burns, falls, ablative surgery, and radiation will be considered in this Appendix.

Trauma is the fourth leading cause of death in the United States and ranks first in cause of death between 1 and 37 years of age. Although there is increasing concern for this health problem, it is still among the most neglected medical problems in society (Mullen, 1976; Touloukian and Krizek, 1974). Some of this neglect arises from the fact that other health problems which seemingly pose a greater intellectual challenge

are highlighted. Yet, there are reported to be more than 55 million accidental injuries in the United States every year, and 11 million of them are disabling to some degree. Hospitalization of trauma patients exceeds 22 million days annually, a figure substantially above that for other serious diseases of man, including cardiovascular disease and cancer (Mattson, 1975).

The incidence of craniofacial injuries is still largely unknown. A report on injuries from automobile accidents indicated that 70% involved head structures. Facial soft tissue wounds were incurred in 60% of the cases, and associated facial skeletal tissue lesions were present in 7.6% of the cases (Converse, 1974). The causes of 1,042 cases of facial injury were: automobile 54%, home 17%, athletic 11%, animal bite 6%, other 5%, intended 4%, and work 3% (Schultz, 1970). A study of injuries resulting from falls indicated that 8% of

the fractures involved the teeth and jaws, whereas 21% were of the craniofacial structures (Smith, Burrington, and Woolf, 1975).

Data reveal a seventeenfold increase in the risk of fatality in motorcycle accidents over automobile accidents. Admissions to hospitals for treatment of motorcycle injuries have increased fivefold in the past 5 years. Of 240 fractures caused by motorcycle accidents, 11% involved facial bones and 8% were skull fractures (Deaner and Fitchett, 1975).

The psychologic response to trauma has received limited attention by researchers. This neglect may be due to the complexity of the issue. Psychologic response to trauma is assumed to incorporate the emotions of fear, relief, distress, blame, shame, the desire to dismiss unpleasant experiences, and the urge to hide deformed humans from society (Mattson, 1975). Disfigurement resulting from ablative surgery is, by its very nature, a preplanned injury differing from other types of trauma. In this case, the psychologic impact and necessary personal adjustment of the patient, his family, and others must be dealt with even before the trauma has occurred. How this emotional impact differs from that caused by sudden, unexpected accidents is not known.

The varied nature of the problem points up one of the first tasks to be faced in addressing this important health issue. Innumerable classifications of trauma exist, each based on variable

criteria such as anatomic site, regional classification, extent and impairment of physiology, and other listings based on clinical symptomatology, with or without pertinent biologic correlations. Future classification schemes might benefit from the inclusion of molecular considerations and help reduce the confusion frequently found in complex clinical trauma cases (Narasimhan and Day, 1975). Improved methods of data classification might also facilitate the obtainment of more reliable information concerning incidence, morbidity, and mortality.

Treatment of trauma requires that primary attention be directed to the total patient. For example, multiple system injuries resulting from automobile accidents necessitate multidisciplinary management. The experience of military combat as exemplified in this book highlights the need for a sizable biomedical team and a team leader to assure that serious injuries will not be overlooked (Touloukian and Krizek, 1974). Orofacial trauma usually can be managed after the life-threatening aspects of the injury are attended.

The training of dental, medical, and allied health professionals in trauma care has historically received a low priority in the total biomedical curriculum (Watkins, Metcalf, and Audette, 1975). Through improved training of the health professionals, more complete knowledge will be developed and better care made available on these variegated injuries.

## PREVENTIVE PROGRAMS

For many types of traumatic disfigurement, prevention represents a logical and realistic goal. Hence the improved design and control of man's personal environment identify a major effort to achieve prevention. Great strides have been made in such areas as occupational safety, protective sporting equipment, and improved automobile safety features. However, prevention is a continuing process and as industrialized society becomes more automated and complex, environmental control also becomes more complex and difficult to manage. It is important to note that successful prevention of fatalities may result in a marked increase in craniofacial injuries. For

example, many accident victims who now survive previously fatal auto crashes still sustain head and neck injury. Through a reduction in the time elapsing between reception of the wound and definitive hospital treatment, mortality prevention may be associated with increased morbidity. During World War I overall mortality was about 10% while intervening time was about 1 hour. Mortality was 75% when intervening time was 10 hours (Hardaway, 1975).

The behavioral and motivational dimensions of man's response to impairment from trauma must be studied in conjunction with environmental research designed to prevent injury. Man



must have the motivation to preserve himself and others, to recognize danger, and to avoid unnecessary risk. Behavioral studies must also ad-

dress the problem of self-inflicted injury to better understand the dilemma that these individuals are experiencing.

## NATURAL HISTORY OF ACQUIRED DISFIGUREMENT

### SPECIAL IMPACT ON CHILDREN

Acquired deformities of the dentofacial area may be divided into two groups: 1) those due to the loss of stimulus to normal growth, and 2) those due to mechanical restrictions on growth. The problem of acquired disfigurement relates to both missing or displaced tissue. This results in localized deficits—almost never excesses—with the localized deficits frequently influencing a larger area of morphology through mechanical restriction of growth.

In a child, a blow to the lower jaw often causes damage to the joint, since the condylar neck represents the most vulnerable part of the mandible at early ages. A unilateral fracture of the body of the mandible will usually be associated with a fractured condyle on the contralateral side. Jaw fractures in children below the age of 3 years are likely to lead to severe deformity, while fractures beyond the age of 6 years will be less disfiguring (Rowe, 1969). In young children surgery tends to aggravate the problem. Thus, a closed reduction approach is advocated (Waite, 1973).

*Loss of Mandibular Condyle and Nasal Cartilage:* Growth failure after injury to the face at an early age relates, in part, to loss of growth stimulation provided by the cartilages of the nasal septum and, perhaps, by the mandibular condyle. The extent to which cartilages in the cranium and face serve as primary growth centers is highly controversial. The cartilages of the cranial base, the nasal septum, and mandibular condyle can be ordered in terms of their similarity to epiphyseal plate cartilages. The latter group of cartilages is known to have a primary role in growth of the long bones. Cranial base cartilages are rarely damaged by trauma because of their protected location. However, the cartilaginous nasal septum is vulnerable to injury and animal experiments indicate that loss of the septal cartilage does have an impact on growth (Sarnat and Wex-

ler, 1967). Despite controversy about the mechanisms underlying this type of growth disturbance, injury to the nasal septum apparently does result in maxillary hypoplasia and orofacial dysfunction.

### Loss of Stimulus to Normal Growth

*The Battered Child Syndrome.* Violent abuse or neglect of children has been a problem since the beginning of recorded time (Ten Bensel, 1975). The battered child syndrome applies to the child who has received repetitive, severe injuries. Such injuries frequently result in bone fractures, internal injuries, severe skin injuries, or damage of the central nervous system (Gregg and Elmer, 1969). Conservative estimates indicate that 200,000 to 250,000 children in the United States are maltreated annually (Solomon, 1973). Recent Congressional testimony suggests that 6,000 children die annually from child abuse (Congressional Record, 1973).

The percentage of young children who receive abuse-related injuries leading to later orofacial disfigurement is not known. However, child abuse is unquestionably more common than many people think. Children who are physically abused by the parents often receive head injuries. In a study of 134 children known to have been assaulted by parents, 37 had skull fractures, and another 15 had evidence of intracranial hemorrhage without skull fracture (Cohen, 1975). Since jaw fractures are less common in children than in adults, it is not surprising that 57% of all children with a fractured mandible or maxilla also have multiple fractures elsewhere (Waite, 1973).

In the case of the mandibular condyle, the cartilage apparently grows more in reaction to other growth, rather than serving as a primary growth center. Mandibular fractures are known to exert a deleterious effect on growth if they occur at an



early age. A major question concerns whether the deleterious effect is due to loss of the condylar cartilage or to restriction of growth related to loss of the normal joint. Most investigators agree that growth continues after a condylar fracture provided the joint capsule and disc are not injured (Rowe, 1969).

*Nerve Damage:* Injury to motor nerves leads to loss of the associated muscles as well. Muscle loss produces soft tissue asymmetry, which in turn, may lead to hard tissue asymmetry as growth proceeds. Trauma as well as developmental disturbances produce asymmetry.

*Tongue Injury:* Damage to the tongue can occur from mechanical trauma, infection, or electrical burns. One of the strongest arguments for viewing the importance of the tongue as a stimulator of mandibular development is the tendency for mandibular underdevelopment to occur in patients with tongue injury. As was the case in condylar cartilage loss, it is difficult to separate the effects of lack of growth stimulation from mechanical restriction on growth in such cases.

#### **Mechanical Restrictions on Growth**

Mechanical restriction of mandibular growth is primarily due to ankylosis. Fixation can occur as a secondary response to trauma or infection, or may be related to rheumatoid arthritis. Ankylosis is usually seen at the temporomandibular joint, but ankylosis of the coronoid process also has been reported subsequent to accidental injury with depression of the zygomatic arch (Findlay, 1972). Release of ankylosis is essential to the prevention of increasing mandibular underdevelopment and severe facial disfigurement. Once disproportionate mandibular growth has been observed, release of the ankylosis is not likely to produce catch-up growth that will effect correction of the distortion. Normal growth will often resume following release and such growth is expected to limit the severity of the ultimate result but not preclude the need for surgical rehabilitation.

The second major cause of mechanical restriction of growth is nongrowing or contracting scar tissue. This is a particular problem following extensive burns. Even after excellent cosmetic repair of a burned area in a growing individual, facial asymmetry and other evidence of growth distortion frequently appear (Masson and Jamines, 1972). Interestingly, psychologic trauma

from such burns is reported to affect the parents more than the burned child (Wright and Fulwiler, 1974). Growth deficits secondary to surgery also can result from mechanical restriction due to scar tissue.

#### **RESEARCH NEEDS**

As with all problems of orofacial deformity, a primary need for research relates to our present lack of understanding of the direct and indirect influences on growth. An improved understanding of the precise role of surrounding soft tissues on growth of the facial skeleton certainly could be exploited therapeutically in the management of acquired disfigurement. Animal model systems commonly used in growth studies could be adapted to simulate tissue loss associated with acquired disfigurement. In addition, human subjects with acquired disfigurement represent "experiments in nature." More precise documentation of these cases should provide a promising field of clinical research. For example, the placement of metallic implants into the jaws of young children with fractures would provide a method of assessing growth patterns subsequent to injury (Bjork and Skieller, 1972). This information has direct application to improved therapy in the individual patient. When nerve injury and loss of muscle tissue are suspected, evaluation of sensory innervation, nerve conduction, and blood flow, coupled with electromyography and studies of muscle function, could also be considered.

#### **GENERAL IMPACT ON PATIENTS**

Facial injuries and fractures of the facial bones have increased in severity as the speed of vehicles has increased. Such fractures frequently involve the middle third of the facial skeleton and occasionally the anterior cranial fossa and brain.

In oral and maxillofacial injuries, emergency management considerations involve the maintenance of an adequate airway and the control of hemorrhage. Tracheostomy may be required if the injury is severe. Antibiotic therapy should be instituted as soon as possible (NATO, 1975). The basic principle of definitive treatment is restoration of skeletal integrity in relation to sound dental occlusion.

## Infections

Infections involving fractured facial bones often result in a loss of hard tissue. This loss produces a defect or deformity which is proportional to the amount of bone destruction. Following the control of infection, the soft tissue covering infected fractures may be scarred and tightly bound to adjacent structures. The mandible is most often involved, but the maxilla, zygoma, and septum are also implicated. Clinical studies to determine the unique characteristics of infections associated with fractures of facial bones are expected to provide helpful information concerning the prevention of such distinctive complications. Such studies should consider: patient age, type of fracture, time lapse between injury and fracture fixation, type of fixation appliance, involvement of teeth within fracture lines, and the locations of such teeth within the dental arch, infecting organisms, presence, absence, and persistence or duration of associated hematomas, use and timing of antibiotic therapy, involvement of the sinuses, dietary status of the patient, and presence or absence of significant associated injuries.

## Severe Trauma with Secondary Sequelae

Significant secondary sequelae to severe trauma of the maxillofacial area frequently result from malunion of bony parts in an abnormal position. The mandible and maxilla are large enough to be repositioned for correct alignment and permit the retainment of sufficient soft tissue pedicles for adequate vascular perfusion. The zygoma can be united, particularly if it has healed in a downward or inward position. Freeing of the zygoma by cutting it from its healed attachment to adjacent bony parts can be accomplished, at which time a gap of variable size occurs in the floor of the lateral wall of the orbit or along the infraorbital margin. Bone grafts may be required to span the gap and are used to hold or fix the repositioned zygoma. Dense scarring of the temporal side of the zygoma, i.e., between the bone and temporal fascia or temporalis muscle, may preclude the necessary repositioning of tissues. Research on animal models is needed to address

malunion problems of this type. Studies of fixation methodology should also be included in future investigations.

Extensive comminution and fracturing in the naso-orbital-ethmoidal area pose a particular challenge in terms of avoiding disfigurement. Bony repair, positioning and anchorage of canthal tendons, and reestablishing functional nasolacrimal drainage are important objectives. Accurate and stable repair of this morphologic complex is best achieved relatively soon after injury, because the tissues are still free and pliable. Animal studies designed to examine the optimal methods of manipulation, healing, and postoperative evaluation of small facial tendons are indicated. Malunion of the bones and malfunction of the nasolacrimal system are exceedingly difficult problems to correct at a later time—since the bones are small, lifting and repositioning them often leaves dead space between the undersurface of the bones and the deeply healed soft tissues. Dead space surrounding free bone grafts adds significantly to the problem of healing.

Damage to the contents of the superior orbital fissure can result although secondary complications are infrequent. Fractures of the zygomaticomaxillary complex may produce injury within the bounds of the superior orbital fissure and may damage the oculomotor, trochlear, and abducent nerves. Damage may be caused by actual disruption of the bony margins of the fissure or by the formation of a hematoma or aneurysm within its boundaries. Clinically, damage to the 3rd, 4th, and 6th cranial nerves may produce ophthalmoplegia, ptosis, proptosis, or a fixed dilated pupil. The latter is thought to be due to parasympathetic block. In addition, fractures of the zygomaticomaxillary complex may produce sensory disturbance to the ophthalmic division of the trigeminal nerve. Such disturbance may produce retro-orbital pain and neuralgia. The prognosis for complete resolution is poor if the nerves have been severed or severely damaged. The incidence and nature of this injury need to be better elucidated and less empiric treatment regimens devised. Incorporating neurophysiologic studies in investigations of wound healing appear promising.



## WOUND HEALING

Trauma frequently distorts and twists flaps of soft tissue. Such tissues should immediately be unraveled and tacked with sutures so that the patient can be transported to a health care facility for definitive treatment. Improved knowledge about initial tissue management, debridement, and infection control, and methods to reduce complications is urgently needed.

Prompt coordination of treatment depends on early recognition of the extent of the injuries. Specialized care in such areas as neurosurgery, ophthalmology, oral surgery, plastic surgery, and otolaryngology is frequently necessary.

### COLLAGEN METABOLISM

Collagen plays a crucial role in the healing process. Identification of the precise role of collagen in wound healing requires information concerning the rate at which collagen is synthesized, deposited, and resorbed. The mechanism of healing of cutaneous wounds is similar regardless of the etiologic agent.

As a result of advances that have clarified the role of collagen metabolism in wound healing, it is now known that wounds may continue to gain tensile strength for at least 1 year. However, wound-collagen content and tensile strength do not show a correlation after early stages of healing. Prolonged remodeling of wounds occurs with continuing synthesis, deposition, and resorption of scar collagen. A correlation does exist between wound strength and the rate of collagen turnover and deposition for extended periods after net accumulation of wound collagen has

ceased. Studies are needed to explain the observation that healing of dehiscent and resutured wounds gains strength more rapidly than that of primary wounds during the first few days. The rate of collagen synthesis and deposition apparently is not changed by dehiscence and resuture. Collagen synthesized during primary healing does not contribute to the burst strength of resutured wounds. Thus, the rapid gain in tensile strength during secondary wound healing is apparently not the result of cross-linking or reutilization of collagen synthesized during the primary healing process.

It is not known why large quantities of new collagen are synthesized and deposited during normal healing of skin grafts without excessive scarring. More studies need to be directed toward elucidating the processes in biosynthesis and degradation of wound collagen. The enzyme which hydroxylates proline to hydroxyproline increases in wounds of both man and experimental animals. Similarly, collagenase, an enzyme which may be essential for degradation of wound collagen, increases in wound edges of human and experimental subjects.

Studies of wound healing have been of continuing interest to the clinician and the experimental biologist. In such studies they have sought to devise ways of accelerating wound healing, but have met with little success. The increasing pool of detailed knowledge on the role of collagen in wound healing may give rise either to new techniques to accelerate wound healing or to the recognition that nature already accomplishes the process with maximum efficiency (Smith, 1975).

## MICROBIOLOGY OF TRAUMA

Because trauma deranges host defense mechanisms and provides an opportunity for infection to begin, understanding the microbiology of trauma requires a review of opportunistic microorganisms. Normal anatomic barriers, such as skin and mucosal membranes, serve as obstacles to invasion by microorganisms. Disruption of them by trauma provides an entry for micro-

organisms that may serve as a nidus for infection. Infection is five times as frequent in contaminated wounds as in clean wounds. Whether or not infection develops in a contaminated wound depends on the following factors: the number and pathogenicity of the contaminating organisms; the amount of devitalized tissue in the wound; the presence of foreign material; the



nature, location, and duration of the wound; the status of the body's defense mechanisms; the type of treatment administered; and the general condition and nutrition of the patient. Beyond the primary microbial contamination, an injured patient who is taken to a hospital is subject to contamination and infection from an enormous variety and number of sources. Control of hospital-acquired infection represents an exceedingly complex problem.

Except for rabies, the primary microbiology of trauma is bacterial and fungal. An almost infinite number of species of bacteria and fungi are in-

involved. Primary contamination and infection are frequently due to mixtures of microorganisms of either endogenous or exogenous origin. Many new causes of posttraumatic infection are being recognized with obvious implications for needed research in their management and control (Washington, 1975). The use of hyperbaric oxygen as a treatment modality has received recent attention as an investigative tool and preliminary reports are encouraging. Further clinical and laboratory studies are needed in this direction to enhance management of chronic infection.

## ENDOCRINE ASPECTS OF TRAUMA

Trauma has generalized effects on the whole patient, in addition to direct effects on specific tissues. The nervous and endocrine systems coordinate and integrate the organism's responses to these generalized effects. The responses represent an effort to give the patient protection, stabilization, and adaptation to environmental change.

The nervous and endocrine systems have many similarities, but the primary difference is that the nervous system transfers its signal by a network of neurons with synaptic linkage. The end organ must be intact with this neuron linkage for a response. The endocrine systems elaborate a hormone that is transported by the systemic blood circulatory system to distant target sites. The hormone receptor sites may be common to all cells of the organism or may involve only specific cells with specific receptor sites for a specific hormone. The nervous system response is immediate and the hormone system response is slower and more sustained. Specific aspects of the role that the endocrine system plays in trauma will be divided into primary and secondary and interrelated aspects.

The major primary endocrine responses to trauma include such areas as 1) hypothalamic-pituitary system, 2) ACTH and vasopressin, 3) sympathetic adrenal medulla system, and 4) renin-angiotensin-aldosterone system. The hormone system facilitates the patient's adaptation

to the new demands of trauma. The nervous system is an integral part of many of these hormonal responses as a sensor, integrator, and neuroendocrine mediator, particularly in the hypothalamic and sympathetic system. Vasopressin, cortisol, aldosterone, and catecholamines are of primary importance in responses geared to main cardiovascular circulatory adequacy, particularly for vital organs. These are closely related to conservation of fluid and electrolytes by antidiuresis, sodium retention, and modification of the inflammatory reaction. ACTH, glucocorticoids, growth hormone, and glucagon all may play a role in cellular metabolism to facilitate the conservation of energy sources and activation of alternate metabolic pathways for energy. The basic site of action of hormones is on the cellular level. Other complex effects of hormones may be of selective benefit in the adaptive response to trauma, and these aspects need investigation (Jacobson, 1975).

## PROSTAGLANDINS

Prostaglandins are currently receiving the attention of research scientists. These derivatives of fatty acids are ubiquitous in the human body and act as local hormones which mediate events that are important in inflammation, trauma, and a variety of clinical disorders. Prostaglandins modulate local arterial blood flow and capillary

permeability in trauma and are thought to play a role in the pathophysiology of shock. Because the synthesis can be blocked by available drugs, possibilities exist of positively controlling the local

response to inflammation and trauma by controlling the synthesis of these fatty acids (Fletcher, 1973).

## PSYCHOSOCIAL IMPACT

Facial disfigurement is among the most handicapping human afflictions. Facial disfigurement is not considered by some to be a physical disability since some normal activities may still be realized. Yet facial disfigurement represents a constellation of disabilities with broad ramifications in nearly all social interactions (Converse, 1974). Psychosocial research in acquired facial disfigurement has received little attention. This neglect may be related to the complexity of the problem and to the difficulty of approaching the subject in terms of rigorous scientific methodology. There is a great need to frame critical questions and to initiate the investigative process.

The major questions might center on three basic issues:

1. The descriptive aspects of inquiry
  - a. What kinds of psychologic processes follow facial trauma?
  - b. What systemic interactions are involved? What psychologic mechanisms are activated, when, why, and to what extent?
  - c. What is the usual course of events?
2. The predictive aspect of the inquiry
  - a. What types of psychologic processes lead to what kinds of immediate, short-term, and long-term outcomes?
3. The suggestive aspect of the inquiry
  - a. What should or should not be done psychologically in the course of the events (Mattson, 1975).

The most noteworthy principle is the commonsense observation that victims of facial injury undergo extreme psychologic suffering. The victim of facial injury is initially frightened and helpless. The distress is typically followed by emotional numbness, profound depression, and the feeling that "This is a terrible situation."

The immediate danger is followed by a feeling of enormous relief, gratitude, joy, and a feeling of being fortunate to be alive. This relief soon gives way to feelings of angry frustration: "Why

should anything like this happen to me?" If the fault is the victim's, his hatred turns to himself. If the fault lies elsewhere, the victim will focus the blame on another person, object, or institution. Finally, even when the injury is rapidly resolved with satisfactory recovery, the traumatic emotional experience may continue (Mattson, 1975). These reactions and others reveal the extensive psychosocial problems associated with the injury (Ablon, 1973; Andreason, Norris, and Hartford, 1971; Ross, 1966; O'Connor, 1970).

Several factors have been suggested as having clinical significance in understanding the psychosocial reaction to injury (Mattson, 1975).

- Characteristics of the injury, its nature, location, severity, extent, and reversibility.
- Characteristics of the impact agent, human or inanimate, instantaneous or prolonged, and preventable or unpreventable.
- Nature and adequacy of immediate care and treatment.
- Rate and extent of recovery.
- Previous health and health care experiences.
- General personality characteristics and past life experiences, especially in dealing with previous emergencies.

## RESEARCH NEEDS

Care of an injured person involves an effort to restore or repair his self-image, self-identity, and self-integrity. The individual tries to reestablish his psychologic balance and normal activities.

- Most studies of psychosocial injury have been retrospective in nature. It is now timely to prospectively study the psychosocial course of events following facial disfigurement using scientific protocol.
- Information on the psychologic consequences of trauma should be developed on a broad scale, as compared to the case-report type of information



which is presently available.

- Long-term effects of trauma should be studied, since many psychoses and neuroses have been traced to physical injury. Long-term and multi-stage procedures can be very demoralizing to the patient.
- Future investigations should include studies cor-

relating the degrees of success of the treatment with the psychological state.

- Increased knowledge should lead to the incorporation of psychologic aid into the early and total care procedures of trauma teams (Mattson, 1975).

## COMMUNICATION SCIENCE

### RATIONALE AND ASSUMPTIONS

Current information about the effects of acquired craniofacial defects on speech is largely limited to small sample case reports and clinical observation. Probably there is only a small number of practicing speech pathologists who devote a sizable percentage of their clinical service time to the management of patients with acquired head and neck defects. An even smaller number of communication scientists engage in either basic or applied research in this important area. Little is known about *a*) the effects of specific types of acquired craniofacial defects on speech, *b*) the prevalence or number of patients with dis-

figurement and associated speech disability, *c*) the rationale for or the effects of remedial speech programs for patients with various types of defects, or *d*) the costs of acquired impairments.

There probably is a marked discrepancy between the total number of patients with acquired defects and the number of such patients who are referred for diagnostic and therapeutic services by speech pathologists. Identification of the factors that give rise to this discrepancy merits systematic study. Finally, research in this area will be rewarding because of its applied or clinical relevance and its basic or theoretical challenge to current models of speech production and perception.

## SELECTED TYPES OF ACQUIRED CRANIOFACIAL DEFECTS

### ACQUIRED LARYNGEAL DEFECTS

The larynx, together with the respiratory system, provides the voicing source of oral communication. Various injuries may affect laryngeal function and produce vocal disturbance. Laryngeal destruction resulting from injuries to the neck in automobile accidents has been reported to be on the increase (National Institutes of Health, 1969). Unfortunately, little is known about *a*) the effects of such destruction on phonatory function, *b*) the effects of surgical laryngeal reconstruction on phonatory function or voice disturbance, or *c*) the feasibility, rationale, and effects of voice therapy for patients with such acquired defects.

By contrast, a number of speech pathologists have devoted a sizable portion of their clinical and research efforts to the voice and speech problems of laryngectomized patients. The most frequently used method of speech after laryngectomy is called esophageal speech. Although much is known about the physical, perceptual, and physiologic correlates of esophageal speech, a sizable number of laryngectomy patients (20–40%) fail to develop functionally useful esophageal speech (Diedrich and Youngstrom, 1966; Sniedecor, 1974). The factors which account for this substantial rate of failure among laryngectomized patients learning esophageal speech warrant study. The rate of persons developing functionally serviceable esophageal speech has not



appreciably increased but apparently has remained constant during the last two decades.

Patients with acquired laryngeal defects also rely upon various prosthetic devices to provide a voicing source for speech. Although a number of electronic or pneumatic devices or artificial larynxes are available (Lebrun, 1974), most of them produce speech quality that is characterized as abnormal, monotonous, or mechanical (Bennett and Weinberg, 1974). Thus, a primary research need in this area is the continued development of more normal-sounding voice prosthesis.

Recently several alternative surgical-prosthetic approaches to speech restoration for laryngeal-deficient patients have been developed, and research in this area deserves support and expansion (Komorn, 1974; Miller, 1967; Shedd, Bakamjian, Sako, Mann, Barba, and Schaaf, 1972; Taub, 1974; Taub and Bergner, 1973; Taub and Sprio, 1972). There is a critical need to obtain information about the ultimate speech proficiency levels achieved by users of these newly developed techniques.

Speech pathologists do not routinely see patients who have sustained partial loss of the larynx. Research is needed to answer such questions as: What is the prevalence of patients with partial laryngeal defects? Do these patients require speech rehabilitation? Is speech rehabilitation effective?

### ACQUIRED NONLARYNGEAL DEFECTS

Information on how acquired disfigurement and impairment of nonlaryngeal craniofacial structures and systems affect speech is even more limited. Little clinical or research effort has been given to the speech and voice problems of patients with such problems. Although disturbance in voice and speech represents one of the primary problems following ablative surgery for craniofacial neoplasms, little is known about the speech characteristics of persons who have undergone such treatment. Clinical and research experience with patients who have undergone total excision of the tongue has been extensively reviewed (Moore, 1974). Reports are available regarding one area of speech following prosthetic obturation of surgically acquired maxillary defects (Skelly, 1973; Stoicheff, 1975). However, broad-scale, systematic observations on the effects of

traumatic and/or surgically induced craniofacial defects on speech have not been reported.

### RESEARCH NEEDS

Although a larger number of persons become victims of craniofacial disfigurement and impairment each year (Kipfmüller and Lang, 1972), there is a marked discrepancy between the total number of such patients and the number who have diagnostic or therapeutic services provided by speech pathology and audiology. Two broad areas of research are suggested.

1. *Prevalence-Oriented Research.* It is necessary to determine the prevalence of patients with acquired defects who have speech and voice disorders and to specify, in as much detail as possible, the nature and types of speech disturbance in this group of patients. Systematic information is needed on the number of patients with acquired craniofacial defects who are receiving diagnostic and therapeutic speech pathology/audiology services, on the nature of services delivered, and on the efficacy of such services.

2. *Management-Related Research.* As noted earlier, speech studies represent a powerful approach to evaluate important functional changes associated with acquired deformity and subsequent reconstruction of the craniofacial complex. Hence, a primary research need must be the evaluation of currently used medical-dental reconstructive approaches by speech specialists.

If it is assumed that a sizable number of patients have acquired defects of the craniofacial complex that include speech disturbances, there is a critical need to evaluate the objectives of current speech and hearing diagnostic and therapy programs and to assess their efficacy. In view of the limited involvement that speech pathology has had with such patients, it is likely that innovative clinical research or demonstration projects need to be initiated to develop new approaches to speech rehabilitation for specific types of patients.

Finally, there are the factors of manpower and qualifications. In view of the limited involvement that speech pathology has had in this area of study and clinical service, specialized training opportunities will probably need to be developed so that speech and hearing specialists can learn skills which will enable them to provide appropriate clinical service and conduct specialized research.

## PROSTHETIC REHABILITATION

Prosthetic procedures used in the rehabilitation of patients with acquired craniofacial defects are varied and often complicated. This is because most craniofacial defects are visually obvious, and such disfigurements may disrupt such functions as speech, vision, hearing, mastication, and deglutition. Rehabilitation in this highly functional complex is made difficult because such defects frequently involve bony, cartilaginous, and soft tissue.

Surgical treatment of diseased tissue may result in profound defects coupled with scarring and fibrosis in the operative site. Accidental trauma of craniofacial tissues is generally managed by surgery or by a combined surgical and prosthetic approach. Therapeutic radiation renders surrounding hard and soft tissues permanently vulnerable to breakdown from the additional stress of a prosthesis.

An overall treatment plan should guide all phases of rehabilitation. This planning should be a part of early management since prevention is often the best form of rehabilitation. In addition to correctly performed surgery, early management may involve the use of such treatment prosthesis as surgical and radiation stents and splints for facial bone fractures or defects, immediate obturators for closing palatal defects at the time of surgery, and tongue and buccal mucosa guards to aid in wound healing and to prevent undue irritation to the remaining soft tissues.

More definitive prosthetic procedures are implemented in later stages of management. These procedures include replacing facial parts with alloplastic materials when the defects are not suitable for surgical repair, using removal or fixed prostheses to correct defects and restore function in the oral cavity, and fabricating implant prostheses to correct skeletal defects and reestablish function in the temporomandibular joint. Prosthetic care must address both the esthetic and functional needs of the patient. Artificial replacement may be needed for soft tissue loss of the external ear or nose, contents of the orbits, and portions of the cheeks and lips. Skeletal replacement is most frequently needed for the mandible, midface and zygoma, and cranium and scalp. Prosthetic restoration of function may involve vision, hearing, speech, mastication, and

deglutition.

Tissues which surround the facial defects may have altered blood supply and thus increased susceptibility to infection and trauma. Additionally, these distorted structures have modified function. These factors indicate the necessity for paying special attention to the types of materials used, the types of retention for prostheses, and the amount of additional trauma to which these tissues are subjected in supporting the prostheses.

### RESEARCH NEEDS

Research that is needed to advance the prosthetic contribution to the rehabilitation of patients with acquired craniofacial defects includes development of the following:

1. Techniques for the use of presently available materials.
2. New implant materials for replacement of both hard and soft tissues.
3. New materials for use in facial or extraoral prostheses.
4. Improved artificial saliva for use following destruction of salivary glands.
5. Guidelines for use of protective prostheses for life activity when there is risk of injury.
6. Studies on biomaterials and tissue tolerance.

### Development of Biomaterials for Maxillofacial Prostheses

The fabrication of extraoral maxillofacial prostheses poses various problems. First, there is the difficulty in obtaining impressions and constructing molds for the complex shapes encountered. In addition, the heterogeneity of tones and shades, the illusion of depth, and the varying degrees of translucency present in the human skin require the prosthodontist to develop special techniques in tinting and coloring. Further, the degree of permanence (resistance to aging and irreversible staining) required in the materials and the necessity for providing flexible materials, which can be fabricated to produce tear-resistant feather edges, present a most difficult challenge to the materials scientist.



**Fabrication.** For the fabrication of maxillofacial prosthesis, the materials developed must be in liquid form suitable for dip-casting, casting in a female mold, or slush casting so that cheap plaster of paris, stone, or plastic molds may be used. This is necessary because of the variety, complexity, and long-term instability of the shapes required. Thus, nondispersed polymeric materials requiring expensive permanent tooling to be utilized for injection or compression molding are contraindicated. Materials for maxillofacial prostheses have been used as solutions of polymers in a solvent, emulsions, organosols, and plastisols.

Solutions of polymers in solvents are generally used in dip-casting procedures. Polymer emulsions have decided advantages over solutions of polymers. Organosols and plastisols have been tried as materials for preparing maxillofacial and other body cosmetic prostheses. The main disadvantage to the organosols and plastisols is the presence of plasticizers, which are used to disperse polymers and modify their physical properties.

**Coloring Constraints.** In the design of a maxillofacial prosthesis the material must accept a proper tint. Initial color and translucency are only one aspect of the problem; unless the material retains its proper color when exposed to a reasonable period of wear, it does not merit serious consideration.

**Stability:** Several factors related to the chemical and physical nature of organic polymers contribute to the rate of their degradation under the influence of these conditions.

1. The chemical nature of polymers' stability is affected by the presence and frequency of chemical bonds which may react with attacking reagents.
2. The supramolecular character of the polymer is of importance in relation to the rate of polymer degradation.

**Stain Resistance.** Maxillofacial prostheses are susceptible to staining from ordinary day-to-day stainants such as grease, nicotine, and ink. From the viewpoint of stain resistance, an improved material for maxillofacial prostheses should possess an optimum hydrophilicity.

**Mechanical Properties.** Because the material should be as flexible as the surrounding living skin, soft and flexible elastomeric type materials are indicated, particularly to achieve a cosmetic

blend into surrounding tissues.

For use in maxillofacial prosthetics, flexible translucent material is required that is latex dispersed, dip castable or castable in a female mold, and is of high strength and tear-resistant. In addition, the materials should have outstanding resistance to oxidative and hydrolytic degradation and be resistant to irreversible staining by water-soluble and oil-soluble stainants.

No material embodying all these qualities is available. To bring about improvements in the materials required for maxillofacial prostheses, organic, inorganic, and physical chemists need to work in close association with the mechanical engineers and clinicians.

### Bioengineering and Healing Tissues

Our understanding of the physical-mechanical components of healing tissue lags far behind our understanding of the chemical components. Bioengineering analysis of healing tissues has brought to light several important problems.

1. Different components of the mechanical properties of healing tissues return to normal at different rates.
2. The result obtained by engineering tests varies with the rate of the stress or strain applied.
3. The healing rate is different in different animal species. It varies in different tissues and at different sites in the same tissue.
4. Engineering tests give reliable results only when carried out under strictly controlled conditions.

Therefore, extrapolation from data from excised rat skin to a healing wound in a patient after trauma or operation is risky. The healing of wounds is a prolonged process. The conditions which allow this process to proceed at an optimal rate are not adequately defined, nor can we accurately describe the optimal activities during the healing period (Zingg, 1975).

**Stretching Increases Range of Motion.** Connective tissue has a very high resistance to tension of short duration. Mechanical devices have been developed to stretch burned oral structures in the treatment of microstomia and thus restore function of the mouth to near normal.

A combination of heat at the therapeutic level in conjunction with prolonged stretch is more



effective than stretch at room temperature. Numerous exercise techniques have been advocated to rebuild weakened muscles in various regions of the body. Investigations are indicated to determine the most appropriate method of restoring the muscles of the orofacial tissues.

### General Summary

Rehabilitation of the disfigured person must begin when the patient enters the hospital. The biomedical team is indeed interdisciplinary and includes many dental, medical, communicative, behavioral, and vocational specialists. The goal is to return the patient to his family, job, and society as rapidly and completely as possible. The treatment regimen includes primary and frequently secondary procedures which may extend for months or years.

*Problems of Rehabilitation.* The professional specialists' definitions and interpretations of "success" and "failure" may differ from those of the injured. Function must be restored, enabling him to eat, or to speak, and cosmetic results must restore his self-image and provide him with the anonymity he craves if "success" from the patient's frame of reference is to be achieved. To the degree that he evokes negative reactions from others he remains stigmatized. The path to rehabilitation is often complicated. Results are still difficult to predict, which illustrates the need of refining our knowledge of diagnostic methods, treatment planning, and wound healing.

After each phase of the overall plan of reconstruction, time is required for healing before progress can be evaluated and further steps planned. During these waiting periods, which can last for weeks or months, the patient alternates between hope and despair.

The interaction between doctor and patient is important because the patient who is given a thorough explanation throughout the stages of his treatment not only tends to participate more effectively in the rehabilitation but is also more likely to accept the plans and goals for treatment. The patient's concept of a successful outcome

should be ascertained, since his expectations may be quite different from what the clinician assumes. It is particularly important during the long and often arduous course of multiple procedures to consistently allow the patient to express himself freely (Ozel and Kottke, 1975).

The following recommendations apply, in a general sense, to the overall challenge of improving the care of the patients with craniofacial injuries:

- The fibrosis and contracture of scar tissue which result from injury pose a major problem which should be examined on a molecular basis. Basic collagen research has advanced rapidly and this knowledge must now be directed toward the clinical problems of healing soft tissue.
- Osseous research, particularly as it involves the role of the periosteum in growth and healing, should prove of great benefit to the convalescing patient. Increased knowledge of the biochemistry of bone induction should lead to practical application in the healing of fractures and osseous grafts (Terashima and Urist, 1974; Urist, Iwata, Boyd, and Ceccoti, 1974).
- Principles of biomechanics and bioengineering have been receiving some attention in the traumatic injury field. Additional studies on animal models will promote the scientific basis of surgical rehabilitation.
- A real need exists to develop improved biomaterials to be used in craniofacial rehabilitation prostheses. The currently used polymeric materials do not meet the requirements for a cosmetic, durable, and easily fabricated appliance. Research in this area requires an intimate relationship between scientists of diverse disciplines.
- It is necessary to train a new type of researcher to address all these problems. Clinical investigators must be trained in interdisciplinary orientation including psychology and basic science.
- Information is needed on the reasons why some patients respond negatively to therapy when they are otherwise improving. Are the fantasies of death derived from real or fancied guilt for the accident? Of secondary importance to psychological therapy for the trauma patient is the need to investigate any emotional problems that may have contributed to the accident (Schnaper, 1975).

## **SPECIAL RESEARCH RECOMMENDATIONS**

Although it is widely recognized that trauma is one of the most common causes of disfigurement in the United States, additional data are needed to improve our understanding of the magnitude of long-term craniofacial disabilities caused by such injuries.

### **GROWTH AND DEVELOPMENT**

A primary need for research relates to our present lack of understanding of the direct and indirect influences of trauma on growth. An understanding of the role of surrounding soft tissues on growth of the facial skeleton should be explored in the management of acquired disfigurement. Animal model systems which are used in growth studies could be adapted to simulate tissue loss associated with acquired disfigurement. More precise documentation of subjects with acquired disfigurement should provide a promising field of clinical research. For example, the placement of metallic implants into the jaws of children with fractures would provide a method of assessing growth patterns subsequent to injury. When nerve injury and loss of muscle tissue are suspected, evaluation of sensory innervation, nerve conduction, and blood flow, coupled with electromyography and studies of muscle function, could also be considered.

### **PSYCHOSOCIAL**

Most studies of psychosocial injury have been retrospective in nature. It is timely to prospectively study the psychosocial course of events following facial disfigurement using scientific protocol. Information on the psychologic consequences of trauma should be developed on a broad scale, as compared to the case-report type of information which is presently available. Long-term effects of trauma should be studied, as many psychoses and neuroses have been traced to physical injury. Long-term treatment can be very demoralizing to the patient. Future investigations should include studies correlating the degrees of success of the treatment with the psychologic state.

### **WOUND HEALING**

Mechanism of soft and hard tissue healing must be explored in greater depth in the future. The role of oxygen tension needs to be further clarified and the efficacy of hyperbaric therapy delineated in order to create the most favorable condition for wound healing. Recent advances in microvascular surgery may be beneficial in creating a more favorable environment for the healing of wounded tissues.

### **COMMUNICATION SCIENCES**

It is necessary to determine the prevalence of patients with acquired defects who have speech and voice disorders and to specify the nature and types of speech disturbance. Speech studies represent a powerful approach to evaluate important functional changes associated with surgery and subsequent reconstruction of the craniofacial complex. Hence, a primary research need must be the evaluation of currently used medical-dental reconstructive approaches by speech specialists. In view of the limited involvement that speech pathology has had with such patients, it is likely that innovative clinical research or demonstration projects need to be initiated to develop new approaches to speech rehabilitation for specific types of patients. Specialized training opportunities will probably need to be developed so that speech and hearing specialists can learn skills which will enable them to conduct clinical service and specialized research.

### **BIOMATERIALS AND PROSTHETICS**

For use in maxillofacial prosthetics flexible translucent material is required. In addition, the materials should have outstanding resistance to degradation and be resistant to irreversible staining. No material embodying all these qualities is available. To bring about improvements in the materials required for maxillofacial prostheses, organic, inorganic, and physical chemists need to work in close association with the mechanical engineers and clinicians. New materials are



needed for use in facial or extra-oral prostheses for replacement of both hard and soft tissues. Artificial saliva needs to be fully developed for use following destruction of salivary glands. Ad-

ditionally, research is necessary to improve protective prostheses for life activity when there is risk of injury.

## COST OF CRANIOFACIAL IMPAIRMENT AND DISFIGUREMENT

The cost of craniofacial disfigurement and impairment represents both tangible and intangible realities about which little is known. Certain types of acquired craniofacial defects might be expected to bring about a diminution in inter- and intrapersonal experiences. Although such costs may not be measured in dollars, the price in terms of these elements of human behavior is real and merits systematic study. On the tangible side, information is needed concerning the costs of deformity and impairment in terms of reduced earning power of those afflicted. There is also the need to determine the costs of direct expenditures for matters such as therapy services, preparing specialists to provide such services, etc.

The problems inherent in research to improve management and treatment procedures are difficult. Treatment must be evaluated over long

periods and numerous factors interacting in a complex manner must be considered. Such research is likely to be both demanding and expensive. Even with care, evaluation based on comparisons of patients will be difficult, and a large subjective factor is inevitable in such research.

Nevertheless, such research is necessary if we are to progress beyond a gross clinical impression. There is now a trend toward the establishment of rehabilitation facilities at health science centers which specialize in various types of problems. A center focusing on craniofacial deformity would have sufficient patient flow with acquired disfigurement problems to make such research feasible. It would be appropriate to consider support for such a center in the near future.

## BIBLIOGRAPHY

- 
- |  |   |
|--|---|
| <p>Ablon, J.: Reactions of samoan burn patients and families to severe burns. <i>Soc Sci Med</i> 7:167-178, 1973.</p> <p>Andreasen, N.J., Norris, A.S., and Hartford, C.E.: Incidence of long-term psychiatric complications in severely burned adults. <i>Ann Surg</i> 174: 785-793, 1971.</p> <p>Bennett, S., and Weinberg, B.: Acceptability ratings of normal esophageal and alaryngeal larynx speech. <i>J Sp Hear Res</i> 16:608-615, 1974.</p> <p>Bjork, A., and Skieller, V.: Facial development and tooth eruption, an implant study at the age of puberty. <i>Am J Orthod</i> 62:339-383, 1972.</p> <p>Cohen, M.M.: Cogenital, genetic and endocrinologic influences on dental occlusion. <i>Dent Clin North Am</i> 19:499-514, 1975.</p> <p>Congressional Record—Proceedings and Debates of the 93rd Congress, First Session (Senate), United States of America, 119(39):S4444. Washington, D.C., 1973, pp 1-9.</p> | <p>Converse, J.M.: <i>Kazanjan and Converse's Surgical Treatment of Facial Injuries</i>, Vol. 1. Baltimore, The Williams and Wilkins Co., 1974.</p> <p>Deaner, R.M., and Fitchett, V.H.: Motorcycle trauma. <i>J Trauma</i> 15: 678-681, 1975.</p> <p>Diedrich, W., and Youngstrom, K.: <i>Alaryngeal Speech</i>. Springfield, Ill., Charles C Thomas, 1966.</p> <p>Findlay, I.A.: Ankylosis of the coronoid to the zygomatic bone. <i>Br J Oral Surg</i> 10:30-34, 1972.</p> <p>Fletcher, J.R.: Prostaglandins. Presented at Medical Grand Rounds, National Naval Medical Center, Bethesda, January 1973.</p> <p>Gregg, G.S., and Elmer, E.: Infant injuries: Accident or abuse? <i>Pediatrics</i> 44:434-439, 1969.</p> <p>Hardaway, III, R.M.: The problem of acute severe trauma and shock. In <i>Trauma, Clinical and Biological Aspects</i> (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 85-105.</p> |
|--|---|



- Jacobson, M.E.: Endocrine aspects of trauma. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 107-122.
- Kipfmüller, L.J., and Lang, B.R.: Presurgical maxillary prosthesis: An analysis of speech intelligibility. *J Prosthet Dent* 28:620-624, 1972.
- Komorn, R.M.: Vocal rehabilitation in the laryngectomized patient with a tracheoesophageal shunt. *Ann Otol* 83:445-452, 1974.
- Lebrun, Y.: *The Artificial Larynx*. Amsterdam, Swets and Zeitlinger, 1974.
- Masson, C.L., and Jamines, H.: Dento-maxillo-facial deformities resulting from scar contractures of the neck developing after burns sustained in childhood. *Ann Clin Plast* 17:254-259, 1972.
- Mattson, E.I.: Psychological aspects of severe physical injury and its treatment. *J Trauma* 15:217-234, 1975.
- Miller, A.: First experiences with the Asai technique for vocal rehabilitation. *Ann Otol Phonol Laryngol* 76:829-837, 1967.
- Moore, G.P.: Voice problems following limited surgical excision. *Laryngoscope* 104:619-625, 1974.
- Mullen, J.T.: Treatment of trauma. *US Med* 12:3 and 21, 1976.
- Narasimhan, M.J., and Day, S.B.: Biological perspectives of some trauma injuries. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 1-23.
- National Institutes of Health: *Human Communication and its Disorders—An Overview*. Bethesda, Maryland, US Dept Health, Education, and Welfare, 1969.
- NATO Handbook. *Emergency War Surgery (First US Revision)*. Washington, D.C., US Gov Print Off, 1975.
- O'Connor, G.: Psychiatric changes in the acutely injured. *Postgrad Med* 48:210-214, 1970.
- Ozel, A.T., and Kottke, F.J.: Problems in rehabilitation following trauma. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 329-359.
- Ross, W.D.: Neuroses following trauma and their relation to compensation. In *American Handbook of Psychiatry*, Vol. III (Arieti, S., ed.). New York, Basic Books, 1966, pp 131-147.
- Rowe, N.L.: Fracture of jaws of children. *J Oral Surg* 27:497, 1969.
- Sarnat, B.G., and Wexler, M.R.: The snout after resection of nasal septum in adult rabbits. *Arch Otolaryng* 86:463-6, 1967.
- Schnaper, N.: The psychological implications of severe trauma: Emotional sequelae to unconsciousness. *J Trauma* 15:94-98, 1975.
- Schultz, R.C.: *Facial Injuries*. Chicago, Yearbook Medical Publishers, 1970.
- Shedd, D., Bakamjian, V., Sako, K., Mann, M., Barba, S., and Schaaf, N.: Reed fistula methods of speech rehabilitation after laryngectomy. *Am J Surg* 124:510-514, 1972.
- Skelly, M.: *Glossectomy Speech Rehabilitation*. Springfield, Ill., Charles C Thomas, 1973.
- Smith, M.D., Burrington, J.D., and Woolf, A.D.: Injuries in children sustained in free falls: An analysis of 66 cases. *J Trauma* 15:987-991, 1975.
- Smith, Q.T.: Collagen metabolism in wound healing. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 31-45.
- Snidecor, J.C.: *Speech Rehabilitation of the Laryngectomized*. Springfield, Ill., Charles C Thomas, 1974.
- Solomon, T.: History and demography of child abuse. *Pediatrics* 51:773-776, 1973.
- Stoicheff, M.L.: Voice following radiotherapy. *Laryngoscope* 104:408-618, 1975.
- Taub, S.: Voice prostheses for speech restoration in laryngectomees. *Trans AAOO* 78:280-287, 1974.
- Taub, S., and Bergner, L.H.: Air by-pass voice prosthesis for vocal and rehabilitation of laryngectomees. *Am J Surg* 125:748-754, 1973.
- Taub, S., and Sprio, R.H.: Vocal rehabilitation of laryngectomees. *Am J Surg* 124:87-92, 1972.
- Ten Bensel, R.W.: Physical maltreatment of children. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 1-23.
- Terashima, Y., and Urist, M.R.: Bromodeoxyuridine-inhibition of substratum-controlled chondrogenesis. *Proc Soc Exp Biol Med* 146:855-858, 1974.
- Touloukian, R.J., and Krizek, T.J.: *Diagnosis and Early Management of Trauma Emergencies*. Springfield, Ill., Charles C Thomas, 1974.
- Waite, D.E.: Pediatric fracture of jaw and facial bones. *Pediatrics* 51:551-559, 1973.
- Washington, J.A.: Microbiology of trauma. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 123-169.
- Watkins, G.M., Metcalf, G.N., and Audette, L.G.: Emergency medical technician training in a medical school environment. *J Trauma* 15:772-778, 1975.
- Wright, L., and Fulwiler, R.: Long range emotional sequelae of bones: Effects on children and their mothers. *Pediatr Res* 8:931-934, 1974.
- Urist, M.R., Iwata, H., Boyd, S.D., and Ceccoti, P.L.: Observations implicating an extracellular enzymatic mechanism of control of bone morphogenesis. *J Histochem Cytochem* 22:88-103, 1974.
- Zingg, W.: Bioengineering analysis of healing tissues. In *Trauma, Clinical and Biological Aspects* (Day, S.B., ed.). New York, Plenum Medical Book Co., 1975, pp 47-48.

## Subject Index

---

### A

- Abrasion, corneal, 86
- Abscess, limited effect of systemic antibiotics, 71
- Acidosis, 52
- Aerobacter aerogenes*, contamination of wounds by, 70, 72
- Airway
  - artificial assistance, types of in early care, 44, 47, 48
  - assessment and management during late care, 106
  - buccal, 106
  - care of, in patients with altered consciousness, 47
  - complications of, noted at intermediate facilities, 97
  - cricothyrotomy, for obstruction of, 47
  - effect of facial fractures on, 48
  - emergency airway splint, World War I, 3
  - management of in early care, 44-49
  - monitoring of, after surgery, 87
  - presurgical evaluation and care of, 56
  - respiratory diagnosis, 47, 48
  - supraglottic, 91
- Alignment and stabilization, of osseous fragments, 109, 110
- Alloplastic implants *see* Implants
- Alveolar ridge, reconstruction of, 231, 241
- Ambulation, beneficial for maxillofacial patients, 103, 104
- Amebiasis, 103
- 9-Aminoacridine, for irrigating oral wounds, 101
- Anatomy, of oral and maxillofacial area, 23-31
- Anemia of trauma, 115
- Anesthesia
  - Korean war, 12
  - management of, Vietnam war, 68, 69
  - World War I, 5, 6
  - World War II, 8
- Ankylosis, temporomandibular *see* Temporomandibular ankylosis
- Antibiotic therapy
  - availability of antiinfective agents in World War II, 11
  - caution in use of, 101
  - early use of antiinfective agents, 1
  - selection, in wound treatment, 97, 98
  - in wound preparation, 70
- Antimicrobial agents
  - daily doses and routes of administration, 75
  - suggested choices of, 72, 73
- Appendix, 245
- Asphyxia, death from in World War II, 11
- Avulsion
  - of anterior portion of mandible, 187
  - of hard and soft tissue, 166
  - of mandibular symphysis, 162, 179
  - of mandibular teeth and alveolus, 231
  - partial, of mandible, 201
  - of right mandibular ramus, 155
  - from missiles, 44
  - of soft tissue of lip, 158
  - of teeth, 158

### B

- Bacteria
  - assessment of, in biopsied tissue, 83
  - isolated from culture, 98
  - wounds contaminated by, 70
- Ballistics *see also* Gunshot wounds, Case reports during World War I, 2
  - types of, 35-44
- Betadine®, use as antiseptic, 68, 70, 101, 102
- Biochemical changes, with onset of shock, 52
- Biomedical scientific progress, phases of during war, 1
- Bone
  - conservation of, 74, 108

- fragments, alignment and stabilization of, 109, 110
  - loss of, in World War I patients, 3
  - methods of immobilizing fragments, 100
  - surgical evaluation of, 103
  - types of mandibular injury, 42
  - Bone grafts *see also* Case reports
    - analysis of MFCS cases, 118-121
    - augmentation for continuity, 119, 120, 123
    - augmentation procedures, 148-151
    - autogenous grafts, 116
    - cancellous chips, 116, 117, 134
    - complications, 140-144
    - dental prosthetic appliances following, 144, 145
    - dentures required following, 120, 124
    - fixation appliances for, 131-133
    - ilium, as donor site, 11, 116, 117, 133-136, 140, 155, 163, 169, 195, 207, 215, 221, 237
    - infection
      - in patients requiring, 124, 126
      - postoperative, 141
  - Bone grafts (cont.)
    - inlay grafts, 134, 135
    - for reconstruction of mandible
      - anatomic location, 122
      - criteria of success, 117
      - illustration of method, 7
      - incidence of type, 122
      - long-term results, 119
      - mean length of follow-up, 119
      - restoration of continuity, 6
      - success, by anatomic site, 123
      - technical management, 121-133
      - in World War I, 6, 7
      - in World Wars I and II, 116, 117
    - for reconstruction of maxillofacial injuries, 11
    - metallic cribs, use and techniques of application, 138, 139
    - methods and basic principles of, in World War I, 6
    - methods of graft recovery
      - chip grafts, 134
      - iliac crest grafts, 133, 134
      - PCM grafts, 136, 140
      - rib grafts, 136
    - onlay grafts
      - for restoration of mandible, 134, 135
      - for restoration of morphology, 116
    - preoperative inflammatory conditions, 143
    - procedures for reconstruction-rehabilitation, 117, 118
    - soft-tissue procedures, 130-133
    - types of
      - block, 6, 11, 134-136
      - cancellous chip, 11
      - corticancellous, 11
      - local pedicle, 116
      - mandibular pedicle, 6
      - osteoperiosteal, 6, 116
      - ramus sliding, 116
  - Bone grafts (cont.)
    - unsuccessful, 144
    - rib, as donor site, 116
    - lateral approach methods, 136
    - tibia, as donor site, 116
  - Buccal circatrix *see* Scar bands
- C**
- Caldwell-Luc procedure, 155
  - Canaliculus, destruction, 87
  - Cancellous bone chips, removal for bone grafts, 134
  - Cancellous chip grafts, introduction of, in World War II, 11
  - Case reports, 155-244
  - Cerebrospinal fluid
    - rhinorrhea, 61, 91
  - Cheeks
    - deformities of
      - closure of defects, 195
      - stellate laceration by rocket fragment, 237
    - mucosa graft from, 227
    - repair
      - after soft tissue loss, 179
      - exit wound, 207
      - lacerations from gunshot, 173
      - mouth opening restriction, after scarring, 113
      - zygomaticomaxillary injuries, 60
  - Chin, repair, after fragment wounds, 207
  - Clinical evaluation
    - at early facilities, 49
    - at intermediate facilities, 97-99
    - at late facilities, 105-110
    - preoperative, of patients receiving bone grafts, 123, 124
  - Combat surgeon, desirable characteristics of, 33, 34
  - Communication
    - interdisciplinary
      - need for evident in Korean war, 13
      - need for recognized in World War II, 11
  - Conjunctiva, treatment of lacerations, 86
  - Contamination
    - effective principles for control of, 71
    - fecal, 70, 98
  - Cornea, abrasion, 86
  - Coronoid process
    - fractures, 112
    - section to permit realignment of ramus, 131



Cranial nerves, 99  
 neuropathy of by rocket fragment, 237  
 Cranium, surgical exploration, 73, 80  
 Craniotomy, 111  
 Cricothyrotomy, for airway obstruction, 47  
 Crimean War, debridement of wounds, 2

## D

Debridement  
 during early care, 48  
 early practices, 1, 2  
 hydrodynamic, 69, 70  
 improvements in during World War I, 3  
 in Korean war, 11  
 tooth and root fragments, 103, 108  
 in World War II, 9  
 Defects  
 avulsive  
 of mandible, 7  
 one-piece splints for, 132  
 in patients requiring bone grafts, 124  
 of symphysis, 163  
 discontinuity  
 mandibular ramus-angle, 155  
 rib grafts for reconstruction, 122, 136, 138  
 inlay-onlay grafts for, 134, 135  
 soft tissue, 169  
 Deformities *see also* Specific sites  
 of canthal area, 60  
 dentoalveolar, 231  
 Dentures, artificial  
 increasing masticatory efficiency of, 201  
 mandibular, 159  
 maxillary partial and mandibular full, 169  
 required after bone grafting, 145  
 surgical preparation for, 163, 173, 179, 187, 191, 207, 231  
 Dextran, allergic reactions and clotting defects produced, 53  
 Diarrheal diseases, in U.S. troops, 103  
 Diplopia, management of, 60  
 Disease(s)  
 and concomitant injuries, 114-116  
 in army personnel in Vietnam, 103  
 Drains, removal and care, after surgery, 88, 89  
 Drugs, for maxillofacial evacuees, 92  
 Ducts  
 parotid,  
 fistulization in after injury, 113, 114  
 repair, 85, 86, 113-115  
 severance of, 237  
 salivary, 99  
 technique for reconstruction, 114

## E

Ears, management of injuries, 114  
 Electrolyte needs, after surgery, 88  
 Emesis  
 release of fixation devices, 92  
 strangulation from, in World War I, 6  
 Emotional needs, of patients after surgery, 88  
 Empyema, effect on maxillofacial wound, 114  
 Endodontic therapy  
 after fragment wound, 183  
 after missile injury, 221, 241  
 before bone grafting, 126  
 Endotracheal tubes, *see* Intubation  
*Escherichia coli*, 70, 98  
 Estlander operation, for repair of lower lip, 159  
 Etiology, of injury, for MFCS patients, 42  
 Evacuation procedures  
 aeromedical, 89  
 aeromedical routes, 91  
 coordination during early phase, 34  
 effects on casualties, 90  
 hospital admission and medical evacuation, 19, 20  
 improved survival by helicopter, 34  
 improvements during World War I, 2  
 improvements during World War II, 8  
 at intermediate facilities, 95  
 in Korean war, 11, 13  
 law regarding transport by ship, 6  
 medications, evacuation tag used for, 90  
 selection, preparation, timing, and in-flight management of evacuees, 90  
 in World War II, 10, 11  
 Evacuation time *see also* Case reports  
 from each facility, 90  
 mean time to, of transfer, 18  
 Eyelids  
 examination and surgical repair, 60  
 Eyes  
 conjunctiva, treatment of lacerations, 86  
 cornea, abrasion of epithelium, 86  
 examination of, before surgery, 60  
 management of injuries, 86, 87, 114

## F

Face  
 anatomy, 29  
 deformities of, 1, 4  
 repair of fragmentation wounds, 163, 183, 191, 207  
 repair of missile wounds, 169, 179, 221, 227, 231  
 repair of orofacial wounds, 183

- Facial nerves, decompression of, for motor function, 221
- Fever, management of, 102-104
- Fistula
- arteriovenous, 98
  - extraoral, after salivary gland injury, 113, 114
  - pleural cutaneous, in neck, 195
  - salivary-cutaneous, prevention of, 86
- Fixation
- acrylic splints, 9
  - appliances for bone grafting, 131-133
  - arch bars, 129
  - bandages
    - Barton type, 4
    - four-tailed, 4
  - biphasic external skeletal-pin, 12
  - British metal cap splints, 9
  - continuous loop wiring with elastic traction, 129
  - Crawford metal head appliance, 9, 10
  - custom cast cribs, use in bone grafting, 138
  - direct osseous wiring, 12
  - Gunning splint, 9
  - Gunning open-bite splint, 4
  - Hullihen capped splint, 4
  - improvements, in World War II, 11
  - interdental splints, 4, 5, 9
  - internal suspension wiring, 9, 10
  - intermaxillary, period for bone grafting, 131
  - intermaxillary fixation, 80, 82, 155, 195, 207, 231, 237
    - with custom splints, 227
  - Kingsley splint secured to head cap, 9, 10
- mandibular
- analysis of in Federal facilities, 66
  - and body regions, 179
  - arch bars and biphasic external skeletal fixation, 231
  - arch bars and intermaxillary fixation,
    - with circumzygomatic suspension wiring, 221
  - arch bars and intermaxillary elastic fixation, 191, 207
  - arch bars and intermaxillary fixation, 159, 173, 179, 187, 215
  - arch bars and intermaxillary wire fixation, 183
  - bandages, 4
    - four-tailed, 5
  - biphase external skeletal-pin fixation, 163, 195
  - cast metal lingual appliances, 110
  - cast splint fixation, 207
  - circumdental intermaxillary wire fixation, 169
  - metal crib, use in bone grafting, 136, 138, 139
  - metallic crib, 227
  - monoarch fixation, 179
  - plaster or strap headcap, 9
  - Roger Anderson external skeletal-pin, 10
  - stabilization
    - of mandibular grafts, 6
    - of skeletal fractures, 80, 82
  - vulcanite splints, 9
- Flaps *see* Skin flaps
- Fluid
- blood
    - replacement after hypovolemic shock, 53
    - transfusions, 5
  - blood and crystalloid solutions, for hypovolemic shock, 53
  - colloid solutions, use in hypovolemic shock, 53
  - crystalloid solutions
    - limited use in World War I, 5
    - replacement, during presurgical period, 57
    - treatment of hypovolemic shock, 53
  - replacement, 53, 88
- Foreign bodies
- fibrosis and/or bony consolidation accentuated by, 112
  - procedures followed in late care, 108
  - removal before bone grafting, 124
  - retention of, 101
- Fractures
- alignment and stabilization of bony fragments, 109
  - analysis of reduction in MFCS patients, 82
  - comminuted
    - arch bar fixation, 100, 110
    - external skeletal-pin fixation, 100
    - operative treatment of, 101
    - period of intermaxillary fixation after early care, 110
    - splints, 100, 110
    - wire fixation, 100
  - compound, closed reduction, 101
  - compound, comminuted, avulsive, 179
  - condylar, from indirect source, 111
  - endentulous, external skeletal-pin fixation, 82, 133
- mandibular
- clinical examination of, 61, 62
  - comminuted, surgical management of, 74, 78, 79
  - compound, comminuted, 163, 173, 187, 201, 207, 211
  - compound, comminuted, 163, 173, 187, 201, 207, 211
  - compound, comminuted, avulsive, 159, 187, 191, 193, 195, 215, 227, 231
  - incidence of mandibular fixation, 82
  - incidence of type of reduction, 82
  - reduction of
    - at intermediate facilities, 100
    - at late care facilities, 110

temporary immobilization of, 48, 67

maxillary

- analysis of in Federal facilities, 66
- gunshot wounds and, 2, 155
- Le Forte I, II, III, 67-78, 215
- teeth, 241

midfacial

- clinical examination of, 60
- craniofacial head frame fixation, 82, 101
- internal suspension wiring, 9, 10, 82
- Kingsley splint fixation, secured to head cap, 9, 10
- in MFCS study group, 66
- reduction of
  - at intermediate facility, 100
  - at late care facilities, 109, 110

naso-orbital

- clinical examination of, 60
- in association with Le Forte I, II, and III, 61

orbital

- clinical examination of, 60
- surgical management of, 78
- treatment, 78

orbital floor

- analysis of, in Federal facilities, 66
- surgical management of, 78, 79
- treatment, 80

stabilization of, 80, 82

sternoclavicular joint, compound, 195

thyroid cartilage

- compound, 195
- tracheal stent, 195

teeth

- and hard palate, 221
- incidence in MFCS patients, 67
- retention of, 101
- types of, in MFCS patients, incidence of reduction, 82

zygomatic

- anatomy, 24
- analysis of, in Federal facilities, 66
- clinical examination, 60
- restriction from, 112
- surgical management of, 78
- treatment, 78

## G

Genitourinary tract, fever in conjunction with, 103

Genial muscle, 159

Gingiva, lacerations, 78

Glands

- parotid, repair, 85, 86

salivary, 99

- early care, 85, 86
- fistula after injury to, 113
- submaxillary, 86

Grafts *see* Bone grafts and Skin grafts

Gunshot wounds *see also* Ballistics and Wounds

- to face and neck, 173
- to mid and lower face and extremities, 155
- World War I, 2

## H

Hard tissue

- avulsive wounds from fragments, 215
- early care of, 73-82
- principles guiding surgical care, 73, 74

Head, management of injuries to, 114

Helicopter

- evacuation, in Korean war, 11, 12
- injury from rotor blades of, 159

Hematoma, formation, 141

Hemorrhage, control of before surgery, 57

Hepatitis, 103, 169

Hernia, after graft removal, 147

History

- evolution of mandibular bone grafting, 116, 117
- of management of oral and maxillofacial injuries during war, 1-15
- medical, of casualties before surgery, 58

Hospitalization time

- reduced overseas, in Korean war, 13
- of Vietnam casualties, 19-21

Hyphema

- ophthalmologic evaluation of before surgery, 60

Hypovolemic shock

- classification of, 52
- clinical manifestations of, 52, 53
- management of, 53
- mechanisms and physiologic manifestations, 52

Hypoxemia, during aeromedical evacuation, 91

## I

Ileus, postoperative, development of, 140

Ilium, donor site for bone grafts, 11, 116, 117, 133-136, 140, 155, 163, 169, 195, 207, 215, 237

Implants

- alloplastic
  - for mandibular repair, 77, 80, 187, 201
  - as source of infection, 124
  - for space or reduction of fragments, 101



- for orbital floor, 80
- silastic, for mandibular repair, 163
- Titanium, for bone grafting, 138, 139
- Vitallium®, for bone grafting, 138, 139
- Infection
  - after alloplastic implants, 101, 187, 201
  - antibiotic treatment of, 155
  - bacterial, 70
  - cause of restrictive lesions, 112
  - chemotherapy for, in World War II, 9
  - chronic, at iliac crest donor site, 169
  - control of before bone grafting, 124–126
  - fibrosis and/or bony consolidation accentuated by, 112
  - from foreign bodies, 70, 141
  - of iliac crest block grafts, 136
  - from inadequate seating of biphasic pins, 133
  - from oral mucosa and wound dehiscence in bone grafting, 141–143
  - late, from teeth, 126, 141
  - rarely from missile fragments, 124
  - of urinary tract, 103
  - in wounded patients, 69, 107, 124, 195, 207, 211, 222
- Inflammation, after bone grafting, 143
- Infraglottic obstruction, compromise of respiration, 48
- Injuries *see* Specific anatomical site
- Inlay grafts, skin, for bone grafting, 134, 135
- Intravenous catheters, replacement of before evacuation, 91
- Intravenous infusion, during presurgical period, 57
- Intubation
  - endotracheal, 50, 68
    - establishment of, in World War II, 8
    - for airway obstruction during early care, 47
    - removal of before evacuation, 91
  - nasogastric, to evacuate stomach contents, 87
  - nasotracheal, 68, 106
    - development of, in World War II, 8
    - use of, in Korean war, 12
- Irrigation, with various solutions, 101

## J

- Jaw deformities, evolution of surgical therapy for, 1
- Jaw exercisers, 111–113
- Jaws *see also* Fractures
  - anatomic locations of restriction, 111, 112
  - prevention of aspiration after immobilization during evacuation, 92
  - procedures for release of supporting devices during evacuation, 92

- restrictive function of, 110–113
- Joints, sternoclavicular, compound fracture of, 195

## K

- Korean war *see also* Anesthesia, Debridement, Fixation, Management
  - case report of patient injured by mortar fragment, 241
  - logistics, 11, 12
  - surgical research efforts during, 1
  - wound management, 12, 13

## L

- Laboratory examination
  - at intermediate facilities, 99
  - presurgical, at early facilities, 57, 58
- Larynx
  - injury of, 59
  - mortar fragment wounds in, 195
- Lingual mucosa, closure of lacerations, 78
- Lip,
  - commisure, scar revision of, 130, 231
  - laceration of, 173
  - repair of
    - after fragmentation wounds, 62, 63
    - exit wound, 187
  - soft tissue avulsion of, 159
  - soft tissue loss, 130, 179
  - vermillion border used
    - for repositioning, 63, 68
- Logistics
  - consideration of, 17–21
  - in Korean war, 11, 12
  - in World War I, 6
- Lung
  - complications in, as cause of fever, 102
  - progressive pulmonary insufficiency (shock lung), 88
  - pulmonary atelectasis after early surgery, 89
  - pulmonary pathology, as respiratory obstruction, 48

## M

- Malaria
  - Plasmodium falciparum*, 103
  - Plasmodium vivax*, 103
- Management *see also* Team Management
  - of anesthetics, 8, 12, 68
  - clinical goals of, 19
  - of mass casualties, 56

- patient  
   initial overall, 56-69  
   in Korean war, 12, 13  
   at treatment facilities of Vietnam war  
     early care  
       fragment wounds, 183, 191, 195, 207, 215, 237  
       gunshot wounds, 155, 173  
       helicopter wounds, 159  
       hypovolemic shock, 53-55  
       missile wounds, 169, 179, 207, 221, 227, 231, 241  
       postsurgical, 87  
       review of, 33-94  
       small arms fire, 183  
       surgical, 69-84  
       in triage area, 50, 51  
     intermediate care  
       fragment wounds, 183, 191, 195, 215  
       gunshot wounds, 155, 173  
       helicopter wounds, 159  
       of fever, 101  
       of fluid therapy, 102  
       missile wounds, 169, 221, 227, 231, 241  
       protocol, 97  
       rationale of, 96  
       review of, 95-104  
     late care  
       fragment wounds, 183, 191, 195, 207, 215, 237  
       gunshot wounds, 155, 173  
       helicopter wounds, 159  
       missile wounds, 169, 179, 221, 227, 231, 241  
       preprosthetic surgery, 144-151  
       review of, 105-153  
       small arms fire, 183  
       technical, 121-133  
     in World War I, 18  
     in World War II, advances of, 8-11  
 Mandible *see also* Fractures  
   anatomy, 24  
   prosthetics reconstruction, 6, 7, 113, 116, 147, 148  
   roentgenographic examination, 65, 82, 123  
 Mastication, maintenance of ability, 20  
 Mastication muscles, 111  
 Maxilla *see also* Fractures  
   anatomy, 26  
   Le Forte I, II, III, description of, 61  
   Le Forte type, 78  
   management of in World War II, 9-11  
   prosthetics, 148  
   rentgenographic examination, 65, 82, 123  
 Maxillary tuberosity, and extra-articular restrictions, 112  
 Maxillofacial Casualty Study Patients (MFCS),  
   basis for analysis of Vietnam experience, 18, 19, 23, 42, 59, 65-69, 73, 82, 100, 103, 110, 119, 124, 149, 150  
 Methicillin, effective against *Staphylococcus aureus*, 98  
 Mouth  
   anatomy, 27, 28  
   floor of  
     closure of lacerations, 78  
     mortar fragment wounds, 195  
     presurgical examination, 63  
     release of adhesions in, 227  
   restriction of opening, 110, 113  
 Muscles  
   buccinator, 114  
   genial, 159  
   masseter, 113, 114  
   mastication, 111  
   orbicularis, 62  
   pterygomasseteric, 112  
   temporal, 111, 112  
  
 N  
 Narcotics, for pain in hypovolemic shock patients, 54  
 Nasal cavity, presurgical examination of, 63  
 Nasal packs, removal of after surgery, 89  
 Nasolabial fold area, missile wound in, 221  
 Nasolacrimal apparatus, severance of canaliculi, 87  
 Naso-orbital-ethmoidal complex, treatment of injuries to, 80  
 Neck  
   exploration for repair of missile damage, 73  
   management of injuries to, 114  
   wounds in from  
     fragments, 163  
     gunshot, 155, 173  
     missiles, 169, 227  
 Nerve(s) *see also* Names of  
   facial, procedures for treatment of, 86  
   management of injuries to, 114  
 Nose  
   depression over bridge of, 60  
   management of injuries to, 114  
 Nutrition, after surgery, 88  
  
 O  
 Orbicularis muscle, 62  
 Odontoma, removal of after missile injury, 221

Ophthalmologic examination, facial injuries and, 60, 80  
 Oral-antral opening, closure by soft tissue buccal flap procedure, 241  
 Oral hygiene  
   problem during evacuation, 92  
   regimen for wound cleanliness, 107  
 Orofacial lacerations, closure of, 68  
 Oxygen support, for hypovolemic shock patients, 54  
 Orbit *see also* Fractures  
   injuries to, 78, 80, 86  
 Orbital floor *see also* Fractures  
   examination of, 80  
 Osteolysis, around fixation pins, 10

## P

Palate  
   hard, fracture of, 221  
   presurgical examination of, 63  
 Parotid duct, 85, 86, 113-115, 237  
 Parotid gland, 85, 86  
 Particulate cancellous marrow (PCM)  
   for bone grafting, 136-140  
   long-span, 139, 140  
   techniques of application, 139  
 Pathology, peridental and periapical, 108  
 Penicillin, 1, 70  
 Peridental disease, 241  
 Pharynx  
   anatomy, 26-28  
   closure of wounds in, 78  
   presurgical examination of, 63  
 Phlebitis, 102, 103  
 Physical examination, of battle casualties, 58  
 Physical therapy  
   conservative use by patients, 111, 112  
   for extensive fibrosis, 113  
 Pneumothorax, in rib resection, 140  
 Postsurgical considerations, in early care, 87-92  
 Preprosthetic surgery, 144-151  
   mandibular, 113, 147, 221  
   maxillary, 148  
   recent reemphasis of, 117  
   rationale for, 146  
 Pressure dressings, removal after surgery, 88  
 Presurgical examination, documentation of, 65  
 Prosthesis  
   cantilever-like, 201  
   fixed-bar, 207  
   for missile injury, 241  
*Proteus*, contamination of wounds by, 70  
*Pseudomonas aeruginosa*  
   antibiotic therapy for, 237  
   contamination of wounds by, 70

infection, 100  
 isolation, from wounds, 98  
 Psychologic aspects of war injuries, 19

## R

Radiographic evaluation  
   at intermediate facilities, 99  
   limits of in World War I, 5  
   preoperative evaluation, 64, 65  
   preoperative, of teeth and supporting bone, 123  
   of presurgical patients, 59  
 Reconstructive surgery *see also* Case reports  
   challenges of, 5, 20  
   criteria for, 117  
   at late care facility, 20, 21  
   mandibular bone grafting, 6, 7, 116-144  
   methods in World War I, 5-7  
   methods and improvements in World War II, 11  
   procedural format for, 117, 118  
   repair of parotid duct, 114  
 Reduction  
   closed  
     of comminuted fracture, 237  
     of mandibular fracture, 183, 207, 237  
   delayed, in facial fracture, 68  
   of fractures in MFCS patients, 82  
   of fractures, incidence at intermediate care, 100  
   of fragments, 76  
   of midfacial fracture, 109, 110  
   open  
     direct, 77  
     of compound fractures, theories on, 3  
     of fractures in Korean war, 12  
     of mandibular fracture, 231  
     of maxillary fracture, 215  
     extra- and intra-oral, 101  
 Rehabilitation  
   at late care facility, 21  
   of patients at intermediate facilities, 103, 104  
   procedural format for after reconstruction, 117  
   prosthetic, cooperative therapy necessary, 146  
 Respiration  
   diagnosis, 47, 48  
   monitoring of, after surgery, 87  
 Resuscitation  
   criteria for success of, 54, 55  
   development of methods, 8  
   improvements in methods, 2  
 Restriction  
   anatomic locations of, 111-113  
   of mandibular function from scarring, 111, 112



Rib grafts, lateral approach methods, 136

## S

Salivary duct, 98

Salivary gland

early care, 85, 86

fistula after injury to, 113

*Salmonella*, 103

Scar

contraction of, 3, 85

excision, 113

prevention, by scrubbing, 70

revision, 159, 163, 169, 179, 215, 231

Scar bands, Buccal circumferential

management of, 113

prevention of, 131

Z-plasty for, 113

Scar tissue

malalignment consideration before bone

grafting, 130, 131

softening of, 113

Sepsis

control, before bone graft, 6, 124-126

in World War I casualties, 3

*Shigella*, 103

Shock *see* Hypovolemic shock

Sinus cavity, presurgical examination of, 63

Skin, scrubbing of, before surgery, 70

Skin flap(s)

designs, introduction of, 7

distal, 169

Estlander, for lower lip repair, 159

local, 83, 169

repositioning of, for information on closure, 63

rotation, 221

tube pedicle, 169

Skin grafts

Escher epithelial inlay

for relieving scar bands, 113

for replacing lost mucous membrane, 7

to floor of mouth, 215

and mandibular vestibuloplasty, 231

scar excision by Thiersch type, 113

split-thickness, 83, 163, 173, 241

with vestibuloplasty, 241

Soft tissue

avulsive injury of, from fragments, 215

conservation of, 74

early care of, 82-85

evaluation of, before bone grafting, 130-133

management at intermediate facilities, 101, 102

principles of primary and secondary closure, 82, 83

procedures, in World War I, 6, 7

for repair of lower lip, 159

to improve facial appearance, 179

presurgical examination of, 62, 63

Solutions, *see also* Fluids: Crystalloid solutions

use in World War I for severely injured, 5

Spine, cervical, radiographic survey of, 65

*Staphylococcus aureus*, isolation from wounds, 98

*Staphylococcus epidermis*, contamination of wounds by, 70

Streptomycin, therapy against organisms, 70, 71

Study casts, before bone grafting, 124

Sulfonamide, 1

Surgical therapy

advances in, for maxillofacial war injuries, 13, 14

evolution of, 1, 2

Sutures

removal after surgery, 88

soft tissue, 83

## T

Team cooperation

evident need for in Korean war, 13

in late care, 21

Team management, in handling severe and multiply traumatized patients, 55, 56

Teeth

avulsion of, 179, 231

fractures, 159, 163, 183, 241

preoperative evaluation, 123

removal of, 163, 169, 173, 195, 207, 215, 231

retention of, after fracture, 101

root fragments

care of, 74, 103

removal of, 179

selection of, before bone grafting, 126, 130

source of late infection, 126

Temporal muscle, 111, 112

Temporomandibular ankylosis, unlikely as cause of jaw restriction, 111

Throat, management of injuries to, 114

Thrombophlebitis, development of, after phlebitis, 102, 103

Tongue

adhesions of, 227

avulsion of, 221

types of injury, 63

Tracheostomy

evaluation of, at late care, 106

management of, at intermediate facilities, 97

- in MFCS patients, 68, 69
- use of during
  - early care, 47
  - evacuation, 90
  - World War I, 5
  - World War II, 8
- Transient cavitation space, 36
- Transmastoid, extratemporal exploration, 221
- Transportation *see* Evacuation procedures
- Trauma
  - anemia of, 115
  - cause of restrictive lesion, 112
  - effect of mandibular function, 112
- Treatment
  - at base hospitals during World War I, 3
  - at early facilities, 33-94
  - early, intermediate, and late care of casualties with
    - fragmentation wounds, 183, 191, 193, 195
    - gunshot wounds, 155, 173
    - helicopter blade wounds, 159
    - missile wounds, 169, 179, 221, 227, 241
  - early and late care of casualties with
    - fragmentation wounds, 207, 237
    - missile wounds, 201
    - small arms fire, 187
    - priority of, 51
  - echelon of patient care, 19
  - at intermediate facilities, 20, 95, 104
  - at late facilities, 20, 105-153
    - goals, 18-21
    - factors influencing, 33
    - of hypovolemic shock, 53
  - surgical
    - advance for maxillofacial war injuries, 13, 14
    - evolution of, 1, 2
- Treatment facilities in Vietnam
  - fixed complete (hospital), 35
  - minimal (temporary and mobile), 34
  - mobile complete (hospital ship), 35
  - mobile limited (surface vessel), 34, 35
- Triage, procedures followed and evaluation of patients, 49, 50
- Trismus, 111

## U

- Urinary catheter
  - for patients with major injuries, 54
  - after surgery, 87
- Urinary tract infection, 103

## V

- Vestibuloplasty
  - after bone graft augmentation, 150, 151
  - procedures for, 146-148
- Vietnam war
  - case reports on casualties, 155
  - combat troop strength, 17
  - treatment
    - goals, 18-21
    - at early facilities, 33-94
    - at intermediate facilities, 95-104
    - at late facilities, 105-153
- Vision, 60, 61
- Vitallium® crib, for graft system, 173
- Vocal cord, lacerations, 195

## W

- Waters radiograph, 65, 99
- Wounding agents, ballistics, 35, 36
- Wounds *see also* Ballistics, Case reports, Gunshot wounds, and Specific sites
  - avulsive, from missiles or missile fragments, 44-47
  - classification of, 38-44
  - clinical evaluation and treatment, 105-110
  - closure, 9, 12, 83-85
  - dehiscence, in bone grafting, 143
  - evaluation, at intermediate facilities, 97-99
  - extraoral, 107
  - infection, 70, 107
  - intraoral, 107
  - management of
    - in Korean war, 12, 13
    - objectives of in late care, 106
    - principles for
      - inside out-bottom-up, 71
      - neck exploration, 73
      - recovery of foreign material, 71, 73
    - and special problems in late care, 105-115
  - maxillofacial
    - complications
      - during World War I, 3
      - effect of concomitant injuries on, 114
      - treatment of, in World War II, 9
    - penetrating, from missiles, 38-42
    - perforating, from missiles, 42-44
    - physiologic status of resuscitated casualties before surgery, 54, 55
    - preliminary care, 66-68

presurgical aseptic technique and debridement, 69  
surgical exploration of, 73  
types and patterns of injury, 36, 37

**XYZ**

**Zygoma**

fractures, 112, 231  
Zygoma-coronoid process-maxillary turbidity, 112  
Zygomaticomaxillary area wounds, 78-80  
Zygomaticomaxillary cheek injuries, 60  
Z-plasty, for scar bands, 113



ED  
78