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DENTAL CARIES INCREMENTS EVALUATED BY USE OF BITE-WING ROENTGENOGRAMS

by

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SUMMARY PAGE

THE PROBLEM

A clinical caries study in the United States Navy is extremely difficult to conduct because the subjects must be re-examined over a long period of time to note any reduction in the caries attack rate. It is desirable to discover if any examination technique other than the usual complete clinicai examination would suffice in these studies.

FINDINGS

Routinely exposed posterior bite-wing X-rays were used in this study. The subjects were those in a clinical study for the evaluation of stannous fluoride applications. About the same degree of agent effectiveness was demonstrated when using X-ray evaluations alone as was seen with the usual complete clinical examination.

APPLICATION

The use of this technique in Navy Dental Corps caries studies will enable these studies to be done with less expenditure of effort than was previously possible. In addition, much more latitude in the selection of study subjects is possible since the exposure of X-rays can be performed at any activity and mailed to the principle investigator of the project.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit MR005.19-6042 - Study of Preventive Dentistry Principles and Methods in Military Populations. The manuscript was approved for publication on 24 October 1966, and submitted to Military Medicine. It was subsequently published in that journal - Vol. 132, No. 4, April 1967. This reprint has been designated as SubMedResLab Report No. 495 under date of 15 May 1967. It is the second report on the Work Unit shown above.

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Dental Caries Increments Evaluated by Use of Bite-Wing Roentgenograms

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THE ASSESSMENT of dental caries increments has always been a difficult task. The very slow rate of change when compared with other disease processes and the many changes in tooth status brought about by treatment have contributed to make this disease one of the most difficult to study in a population.

Various indices have been devised to be used as tools in caries assessment. All of these, with the possible exception of Knutson's index of caries prevalence in children,[1] are in some manner based upon enumeration of carious lesions and on some manner of including treated lesions in the count.

The DMF (decayed, missing and filled) surfaces and the DMF teeth indices have been the two most widely used methods of caries assessment. Bodecker[2] and Klein and Palmer[3] developed the DMF surfaces index to the form that it is essentially used today. Each tooth is considered to have five surfaces which may become involved with caries. An enumeration of the involved surfaces becomes the DMFS score. The DMF teeth index was described by Klein and Palmer[4] as being simply the total number of teeth in the mouth involved by caries (decayed, missing or filled).

The other indices, such as Mellanby's "Average Caries Figure" (ACF),[5] Richardson's Caries Susceptibility Index,[6] and the Relative Increment of Decay (RID) index of Porter and Dudman[7] represent very useful variations on the handling of decayed, missing or filled tooth or surface counts.

The subject of caries testing was studied extensively by a conference convened by the American Dental Association in 1955. The committee on types of indices[8] concluded that, generally, the DMFS index is to be recommended. It was pointed out, however, that the choice of the index to be used depends upon the objective of the study.

Caries studies have routinely involved two types of examinations: A visual evaluation of the subject's teeth by the examiner and evaluation of roentgenograms. The x-rays have usually been used to supplement the data obtained in the clinical examination and have largely been concerned only with the posterior interproximal surfaces. The use of the clinical examination has been beset with three main difficulties. The fact that the examiner himself must actually look in the subject's mouth often makes transportation a problem. Thus, a study involving subjects in different areas often becomes quite complicated. The fact that the examiner must be closely associated with the subject, leads to some question of examiner bias entering into the study. Thus, caries comparison between subjects of two areas such as in water fluoridation studies compels a stern attention to objectivity on the part of the examiner. Finally, some agents used as caries preventives may as a side effect, so mark the subject that examiner bias could lead to a type I or just as importantly a type II experimental error. Stannous fluoride application has been reported to cause a characteristic stain on certain surfaces[9,10,11] which may mark the subjects.

Experience with Navy preventive dentistry studies has certainly demonstrated the presence of the first objection to the use of clinical examination; i.e., transportation problem. The modern highly mobile Navy is a tremendous asset to the defense of our country but this same mobility and fluidity of personnel is a bane to the clinical epidemiologist. The Navy's preventive dentistry program current-

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ly includes the use of stannous fluoride as a caries preventive agent. The assertion by some investigators that a truly blind evaluation is impossible when doing clinical examinations in a stannous fluoride topical application study certainly does concern the Navy Dental Corps. An additional problem has become evident in Navy caries preventive studies. Every man now receives caries preventive measures in recruit training. There is, therefore, literally no control groups available outside of recruit centers with which to compare experimental groups.

The presence of these problems prompted a search for a more practical approach to studies of caries preventives in the Navy.

Fosdick[12] reported a caries preventive study which included subjects in several widely separated localities. The data from this study were presented from the usual clinical examination and on the basis of posterior x-ray interpretation alone. Similar conclusions were reached regardless of which method of examination was used.

Backer Dirks[13] in 1951 reported a method for positioning the x-ray film with the aid of a specially designed holder so that reproducible x-ray examinations were possible. This method was used to evaluate fluoridation effects in the Tiel/Culemborg (Netherlands) study.[14] It was possible to show a marked effect of fluoridation in reducing the incidence of interproximal caries in children.

It, therefore, appeared distinctly possible that x-ray assessment alone of caries may be a valuable tool in Navy Dental Corps caries studies.

Materials and Methods

In the initial phase of this study 34 experimental and 49 control subject x-rays were evaluated by one of the investigators (L.P.M.) during a period of two weeks reserve active duty training

The experimental group had received the standard three-agent stannous fluoride treatment one year prior to x-ray evaluation and the control subjects were given complete placebo treatment. The x-rays were exposed and developed routinely without any special positioning devices or other attempts to ensure uniformity above that found in any naval activity.

TABLE I

FATE OF INITIALLY SOUND POSTERIOR INTERPROXIMAL SURFACES (FIRST STUDY) (RESTRICTED TO THOSE SURFACES CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	Surfaces initially sound	Surfaces remaining sound after one year	Surfaces involved after one year
Control	678	615	63 (9.3%)*
Experimental	492	463	29 (5.9%)*

* Differences significant $P<.05$.

The x-rays were given to the examiner without information concerning the group to which the subject belonged. Both the initial x-rays and those after one year were evaluated blindly without comparison and the findings were so recorded.

The thirty-two posterior interproximal surfaces were evaluated—(first and second premolars and first and second molars).

Each surface was evaluated as being in one of six categories as follows:

1. Sound (no evidence of caries involvement)
2. Filled
3. Missing
4. Decayed (incipient)—There is obvious decalcification of enamel but the area of involvement does not extend beyond the dentinoenamel junction.
5. Decayed—There is carious involvement extending beyond the dentinoenamel junction.
6. Not evaluated. The surface was not clearly visible either because of overlapping, improper film placement, or for other reasons.

The data were analyzed simply on the basis of occurrence or nonoccurrence of decay in initially sound surfaces (Table I). Chi square analysis revealed statistically significant differences between the experimental and control groups.

The promising outcome of this inital modest survey prompted an expanded analysis of 90 experimental and 115 control subjects. This evaluation was performed by another of the authors (J.C.D.). Again, the examiner did not know the group to which the x-rays be-

TABLE II

EXPERIMENTAL AFTER TWO YEARS

INITIAL	Sound	Filled	Missing	Decayed	Incipient Decay	Surface not Clearly Visible	Total (Initial)
Sound	1083	14	2	12	42	162	1315 (1153)*
Filled	1	653					654
Missing			240				240
Decayed	13	97	3	129	11	11	264 (255)
Incipient Decay	38	17		41	72	32	200 (168)
Surface not Clearly Visible	110	8	1	8	13	77	217
Total (after two) years	1245 (1135)*	789 (781)	246 (245)	190 (182)	138 (125)	282	2890 (2468)*

*Omitting The Surfaces Not Clearly Visible in Both Examinations

longed. This time, however, initial and final x-rays were compared. This was done primarily to avoid some errors of recording which resulted in apparent but impossible reversals of filled surfaces in the initial phase. The time period of the second phase was also different from the first phase. The subjects had been in the study for two years instead of one.

Findings

The incidences of surface categories are shown in Table II (Experimental) and Table III (Control). An identical table was derived for each of the thirty-two surfaces. These individual tables were then used to make up the composite tables shown here. These tables are almost identical to those developed by Porter and Dudman (7) except that two additional categories (incipient decay and non-evaluated) are added.

TABLE III

CONTROL AFTER TWO YEARS

INITIAL	Sound	Filled	Missing	Decayed	Incipient Decay	Surface not Clearly Visible	Total (Initial)
Sound	1040	19	1	25	81	216	1382 (1166)*
Filled		957	6		1	19	983 (964)
Missing			262				262
Decayed	6	89	9	122	14	32	272 (240)
Incipient Decay	45	23		82	155	64	369 (305)
Surface not Clearly Visible	170	28	13	22	41	141	415
Total (after two) years	1261 (1091)*	1116 (1088)	291 (278)	251 (229)	292 (251)	472	3683 (2937)*

*Omitting The Surfaces Not Clearly Visible In Both Examinations

The categories "surface not clearly visible" are cross hatched for both examinations to indicate that these are omitted from most subsequent analyses. Thus, for the experimental group it is seen that 422 or 15% of the surfaces under study were not clearly visible in one or both of the examinations. This is unfortunate but is not considered a fatal defect. These lost surfaces (lost to the study) were randomized between the groups, so from a statistical viewpoint a comparative study evaluating the effect of some agent on caries should not be adversely effected. It is assumed that most clinical studies utilize x-ray detected caries to add to the score obtained by first doing a visual examination. In those cases, then, a similar rate of non-visible surfaces would also be present and these surfaces would be judged caries free if nothing was seen on them in the visual examination.

A very low rate of obvious recording errors can be detected in Tables II and III. The criteria used dictate that a surface can not go from a filled category to a sound or carious one. There is, however, one such entry in each of the two tables. It is also obviously impossible to have an odd number of missing surfaces, yet this occurred in each of the two second examination totals. The very low rate of these obvious recording errors is considered scant cause for concern.

It is readily apparent that the data in Tables II and III are arranged for relatively easy statistical analysis based on the binomial distribution or by chi square analysis.

Table IV and Table V summarize the findings in a more usually presented form. In table V it can be seen that an additional 75 posterior interproximal surfaces become involved in the control group in two years versus only 18 in the experimental group. Chi square analysis reveals the difference in these

TABLE IV

GENERAL FINDINGS OF POSTERIOR INTERPROXIMAL SURFACES

	N	Sound	Filled	Missing	Decayed	Couldn't evaluate
Beginning:						
Control	3683	1382 (38%)	983 (27%)	262 (7%)	641 (17%)	415 (11%)
Experimental	2890	1315 (45%)	654 (23%)	240 (8%)	464 (16%)	217 (8%)
After two years:						
Control	3683	1261 (34%)	1116 (30%)	291 (8%)	543 (15%)	472 (13%)
Experimental	2890	1245 (43%)	789 (27%)	246 (9%)	328 (8%)	282 (13%)

TABLE V

STATUS OF POSTERIOR INTERPROXIMAL SURFACES (RESTRICTED TO SURFACE CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	N	Sound	Filled	Missing	Decayed
Beginning:					
Control	2937	1166 (40%)	964 (33%)	262 (9%)	545 (18%)
Experimental	2468	1153 (47%)	654 (26%)	240 (10%)	421 (17%)
After two years:					
Control	2937	1091 (37%)	1088 (37%)	278 (9%)	480 (17%)
Experimental	2468	1135 (46%)	781 (32%)	245 (10%)	307 (12%)

decay rates to be significant ($P < .001$). Perhaps these same facts can be stated more succintly as a 2.4% increase in DMF surfaces in the control group versus a .7% increase in the experimental group. Reversals in diagnosis are included in the values of Tables IV and V.

The data in Table VI omit reversals in diagnosis. Only the initially sound surfaces are considered. A significantly lesser number of the experimental sound surfaces become cariously involved in the two years than did the control surfaces.

The diagnostic reversals of initially decayed surfaces are examined in Table VII. A greater percentage of the experimental groups decayed surfaces were diagnosed as reversals. The difference between the two groups was not statistically significant, however. In Table VIII the incipient lesions are examined for reversal rates. In this case the experimental group does present significantly more diagnostic reversals. These results prompted an evaluation of reversal data in the first study (49 control and 33 experimental subjects). Here the first and second x-rays were not compared; it was felt that this fact might lead to a greater diagnostic reversal rate than in

TABLE VI

FATE OF INITIALLY SOUND POSTERIOR INTERPROXIMAL SURFACES (RESTRICTED TO SURFACES CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	Surfaces initially sound	Surfaces remaining sound after two years	Surfaces involved in two years
Control	1166	1040	126 (10.8%)
Experimental	1153	1083	70 (6.1%)*

* Null hypothesis rejected ($P < .001$).

TABLE VII

FATE OF INITIALLY DECAYED SURFACES (RESTRICTED TO THOSE SURFACES CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	N	Diagnosed as sound after two years	Diagnosed as involved after two years
Control	545	51 (9.4%)*	494 (90.6%)
Experimental	421	51 (12.1%)*	370 (87.9%)

* Difference not significant.

TABLE VIII

FATE OF SURFACES INITIALLY DIAGNOSED WITH INCIPIENT DECAY (RESTRICTED TO THOSE SURFACES CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	N	Diagnosed as sound after two years	Diagnosed as involved after two years
Control	305	45 (14.7%)*	260 (85.3%)
Experimental	168	38 (22.6%)*	130 (77.4%)

* Differences statistically significant $P<.05$.

the second study when comparisons were made. It is seen that a significantly greater number of reversals occurred in the experimental group both in initially decayed teeth (Table IX) and in those teeth with incipient decay (Table X). It is not necessarily implied that true reversals of interproximal carious lesions have occurred. It is apparent that the incipient lesions are somewhat inconstant findings when special precautions are not taken in the exposing and developing of the x-rays. The greater rate of reversals in the experimental group could be the result of arrestment of the carious process and the prevention of a more readily visualized lesion. Even if this is the case, these findings are still considered quite interesting.

In Table XI an attempt is made to present a parametric analysis of the data. A DMFS (interproximal posterior) score is computed for each individual by counting the number of involved surfaces out of those considered in this study. Obviously the maximum score is 32. This analysis demonstrates a 70 per cent reduction in decay in the experimental group. It must be understood that the data had to be modified to an extent in order to compute these DMFS (IP) scores. Some consideration of those surfaces not clearly visible had to be included. It was, therefore, assumed for convenience that if the surface was clearly visible in one examination, that its condition was the same in the other examination; and if the surface was not clearly visible in either examination, that it was sound. It is recognized that these assumptions may not be valid in each case; however, since the surfaces in question were almost equally distributed between the experimental and the control groups (Table IV) a comparative analysis should not be jeopardized.

The relationship between the DMFS (IP) scores and DMFS and DMFT scores are illustrated by scattergrams (Fig. 1, 2). The linear least square regression lines are computed from the formula $\hat{y} = \bar{y} + b\ (x - \bar{x})$, where $\hat{y}$ is the expected value of the dependent variable (DMFS or DMFT) at any given value of x, the independent variable [DMFS (IP)], and b is the regression coefficient. The regression line for values of DMFS (Fig. 1) is computed as $\hat{y} = 1.66x + 11.26$ and values of DMFT (Fig. 2) as $\hat{y} = .404x + 8.33$. The plotted values on the scattergrams are only those from cases in which all surfaces were clearly visible in the x-rays.

Product moment correlation coefficients were also computed for the values in Figs. 1 and 2. For DMFS vs. DMFS (IP), $r = +.79$; for DMFT vs. DMFS (IP), $r = +.68$ and for DMFS vs. DMFT, $r = +.88$. A lowered degree of correlation is seen when

TABLE IX

FATE OF INITIALLY DECAYED SURFACES (FIRST STUDY) (RESTRICTED TO THOSE SURFACES CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	N	Diagnosed as sound after one year	Diagnosed as involved after one year
Control	223	13 (5.8%)*	210 (94.2%)
Experimental	179	18 (10%)*	161 (90%)

* Differences statistically significant $P<.05$.

TABLE X

FATE OF SURFACES INITIALLY DIAGNOSED WITH INCIPIENT DECAY (FIRST STUDY) (RESTRICTED TO THOSE SURFACES CLEARLY VISIBLE IN BOTH EXAMINATIONS)

	N	Diagnosed as sound after one year	Diagnosed as involved after one year
Control	63	7 (11%)*	56 (89%)
Experimental	52	16 (31%)*	36 (69%)

* Differences statistically significant $P<.001$.

TABLE XI
DMFS (IP)
(ALL SURFACES)

	N	Initial	After two years	Mean change	Percent reduction
Control	115	17.3* ±.54**	17.96 ±.53	+.66	—
Experimental	90	15.42 ±.77	15.62 ±.77	+.2	70%

* Mean.
** Standard error of the mean.

scores from x-ray evaluations alone are compared with the complete examination scores. This is not altogether an indictment of the method, for some of this lack of correlation may be the result of traumatic non-professional extractions of anterior teeth not being counted in the x-ray study.

Discussion

Objections have been voiced against too great a reliance on x-rays in clinical studies. The objections most frequently heard are that beam angulations and exposure characteristics are too variable to yield results that are accurate enough for such studies. Backer Dirks[13,14] overcame these objections by employing a film positioning device which would allow exact duplication of the angulation. By stern attention to exposure he was able to obtain a high degree of accuracy. The use of such a system in the United States Navy, however, would still mean that the subject would have to be seen by a certain examiner for each examination and/or would have to be transported to a definite examination center. The transportation problem as stated in the introduction would not be solved.

Any clinical investigator realizes that some examiner error is present in any caries study. The real criterion for a satisfactory evaluation is the keeping of the error incidence low enough and randomizing it between the

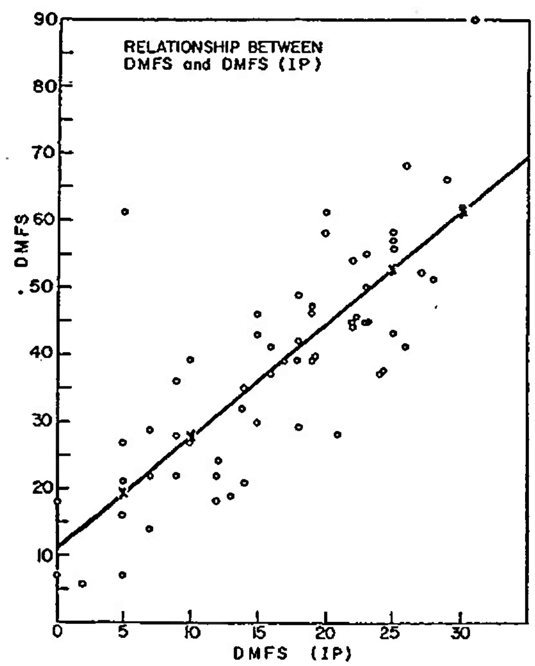

Fig. 1.

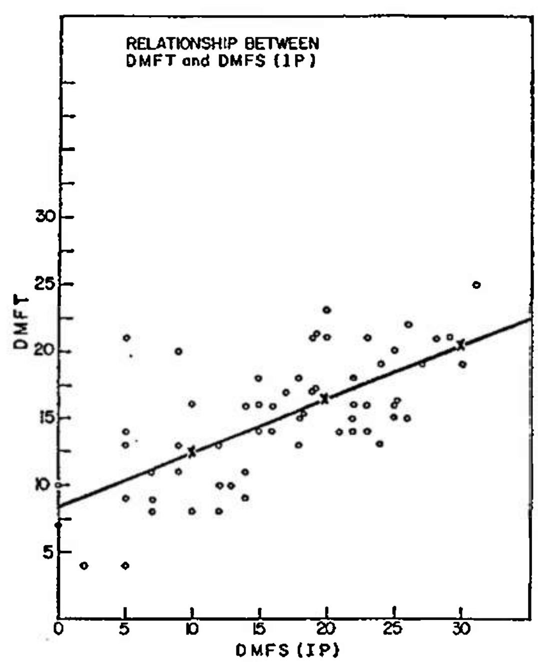

Fig. 2.

groups being studied so that any real difference in treatment effects can be detected. It is felt that this criterion was met in the studies presented in this paper. Approximately the same level of effectiveness of stannous fluoride applications was demonstrated by these studies of x-rays as was demonstrated by the usual complete clinical examinations.[15]

The advantages from the Navy Dental Corps' use of roentgenogram evaluation are quite apparent. Subject transfers and mobility of units to which subjects are attached have made long term clinical studies almost impossible in the Navy. If roentgenogram evaluation only were used, the examinations could be performed wherever the subject might be. It is recognized that variability of x-ray techniques is present between dental activities, but in the presence of random distribution a sufficient number of cases should overcome this difficulty.

The use of roentgenogram alone would enable an investigator to have almost unlimited access to any desired military population for his study. Thus, if a broad random population was desired, he could begin his study at a recruit training command. If only men of a certain intelligence was desired, he could begin his study at a school command.

Bias is of constant concern to the clinical investigator. The use of x-rays could completely eliminate the chance of bias influencing the results of a caries study. There are no distinguishing features which would yield clues concerning the treatment course when considering x-rays alone.

The chief drawback to the use of x-rays alone in a caries study is the fact that many surfaces are omitted from the study. It may, therefore, be argued that some beneficial effect may be overlooked if all the surfaces are not evaluated. The validity of this argument is admitted to a degree, however, the choice of posterior interproximal surfaces for evaluation does have certain distinct arguments to recommend it.

1. The posterior interproximal surfaces are almost never involved in a restoration unless they are carious. This may be contrasted to the occlusal surfaces which become involved whenever an interproximal lesion is restored. Thus, a caries score based on interproximal lesion is actually a more "pure" score than is a total caries score.

2. The posterior interproximal lesions are the most time consuming to the dental officer who restores them. A demonstrated reduction in posterior interproximal caries then really represents a greater saving of Dental Corps man hours than would a comparable reduction of caries in any other surface.

The practical nature of this reported study is seen in the fact that approximately fifty Class II carious lesions were prevented per 100 men by using the stannous fluoride treatment. A group this size would be approximately representative of one submarine crew.

Summary

1. Effectiveness of a proven preventive dentistry measure can be demonstrated by the use of routinely exposed posterior bite-wing roentgenograms alone.

2. It is recommended that the method described be used in caries studies in the United States Navy.

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