# Rehabilitation of the Burned Hand

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**KEYWORDS**

- Burn hand deformities • Burn scar contracture
- Burn rehabilitation • Splinting the burned hand
- Range of motion • Hand therapy • Hand function

Hands are the most frequent sites of burn injury,[1] and proper management is essential to assure that optimal functional recovery is achieved. Although each hand represents less than 3% of the total body surface area, burns to the hand are considered serious injuries and should be referred to a burn center.[2] The thin, highly mobile dorsal skin, the sensory-enriched palmar skin, and the delicately balanced musculotendinous systems are all at risk with a hand burn. Successful management of the burned hand does not result simply from closing the wound. The hand is ranked as one of the three most frequent sites of burn scar contracture deformity.[3–5] The resulting loss of function from burns that include or are specific to the hands can have a devastating effect on the numerous life roles of the patient at any age.

When possible, burned hands are best treated by the entire burn center team, including physical and occupational therapists, with knowledge of burn wound healing and the potential problems that can be anticipated. This article outlines the principles of burn rehabilitation generally accepted in current burn center practice and is based more on the experience of the authors than on controlled comparative studies.

## PROBLEMS TO ANTICIPATE

A thorough understanding of the effect of thermal injury on the structures of the hand can minimize or even avoid many burn-related problems. Some of the more commonly encountered complications after thermal hand injury include postburn edema, scar contracture, joint deformities, sensory impairment, loss of skin stability, and restricted functional use of the hand. A brief overview is given in this article. Other complications of thermal injury to the upper extremity that ultimately affect hand function are also considered.

### *Postburn Edema*

An increase in vascular permeability coupled with a shift of fluids to the extravascular space should be anticipated following thermal injury. In superficial partial-thickness burns, minimal fluid is leaked into the extravascular space, and edema is minor and transient. In deep partial-thickness and full-thickness burns, edema is more severe (**Fig. 1**) and prolonged.[6] As edema increases during the first 72 hours postburn, so may the pressure within the compartments of the hand. Consequently, excessive intracompartmental hand and forearm pressures will impair arteriovenous and lymphatic function.[7]

### *Hand Deformities*

There are several common burn hand deformities that can result from injury itself or the sequelae of injury.

#### *Claw hand deformity*

Claw hand can occur in the early postinjury period as a result of edema, tendon injury, or scar contracture. An immediate consequence of

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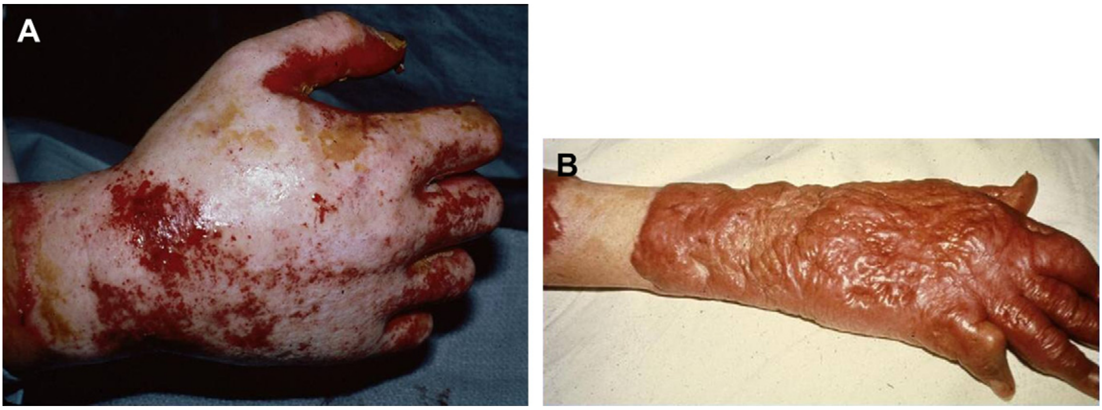

**Fig. 1.** Two complications of deep burn injury that can be minimized with intensive rehabilitation therapy include edema and scar. (*A*) Significant unresolved edema may result in limited mobility and chronic joint deformity. (*B*) Long-term hypertrophic scar that has not been molded and elongated to maximum length during its development is devastating, with permanent shortening of structures and joint deformity.

postburn edema can be hyperextension of the metacarpophalangeal (MP) joints and flexion of the interphalangeal (IP) joints, which is commonly referred to as a claw hand deformity (**Fig. 2**A). The severity of these deformities seems to be edema-dependent. Hyperextension of the MP joints occurs as the dorsal skin is drawn taut by the fluid shift into the extravascular tissues and as the palmar arches flatten. Flexion of the proximal interphalangeal (PIP) joints follows as a result of this edema-imposed tension on the common digital extensor tendon system and concurrent hyperextension of the MP joints.[8,9] The predisposition for MP joint hyperextension deformity to occur is intensified when the dorsal surface of the hand is also burned. Hyperextension


**Fig. 2.** Joint deformities can occur with tendon disruption, either from the original injury or from stretch or compression of damaged tendons. (*A*) Clawed hands with multiple deformities, including MP hyperextension, IP flexion, and thumb radial adduction. (*B*) Note boutonnière deformity of middle digit. (*C*) Palmar cupping deformity is frequently associated with hyperextension of the MP joint of the thumb, with loss of the grasping surface of the hand.

contractures of the MP joints may develop despite early surgical and well-planned therapy intervention, particularly in the presence of long-standing edema. The ring and little fingers account for 65% of problem digits, as studied by Graham and associates.[10]

#### *Boutonnière deformity*

The potential for this deformity is more likely with a deep burn involving the dorsum of the hand, fingers, or thumb. Boutonnière deformity in the fingers (see **Fig. 2**B) involves the extensor apparatus at the PIP joint level. This problem can be the result of direct thermal injury or of tendon ischemia. Tendon ischemia can result when the injured tendon is compressed between the eschar and the head of the proximal phalanx as the PIP joint is flexed.[11] The extent of damage to the extensor apparatus often is not known until inspected surgically.[12] In all deep partial-thickness and full-thickness burns involving the fingers and dorsal hand, because immediate surgery may not be feasible, involvement of the extensor apparatus should be assumed, and it should be protected until viability of the tendon system is known. An exposed tendon is at risk of desiccation and subsequent rupture, which will also result in a boutonnière deformity if it is located over the dorsal PIP joint. Therefore, it is recommended that all exposed tendons be kept moist and exposed tendons over the dorsal PIP joint be immobilized in extension until the tendon is no longer exposed. However, the distal interphalangeal (DIP) joint can be mobilized to allow lengthening of the oblique retinacular ligament (ORL). Later causes of a boutonnière deformity include flexion of the PIP joint secondary to scar banding in combination with a shortened ORL.[13]

#### *Mallet and swan-neck deformities*

Thermal injury to the terminal slip of the extensor tendon can result in loss of DIP joint extension or mallet deformity. Injury to the terminal slip can be a result of direct thermal injury or tendon ischemia induced as the injured tendon is compressed between the eschar and the base of the distal phalanx as the DIP joint is flexed.[14]

The swan-neck or PIP hyperextension deformity is characterized by hyperextension of the PIP joint and flexion of the DIP joint. The incidence of swan-neck deformity is most prominent in the middle finger.[15] Several causes for PIP joint hyperextension following burn injury have been hypothesized, including extensor digitorum communis tendon adherence, ischemic contracture of intrinsic muscles, joint stiffness from improper immobilization, and burn scar contracture.[15]

#### *Palmar cupping deformity*

The concavity of the hand's transverse and longitudinal palmar arches is accentuated in cupping-of-the-palm deformity (see **Fig. 2**C). Cupping of the palm can be anticipated when a burn is on the palmar surface of the hand, usually as a result of a contact burn. Precise evaluation of the depth of a palm burn in children is often difficult because the epidermis is very thin compared with the thickened calloused hand of an adult. Frequently the cupping deformity has a biomechanically associated hyperextension of the MP joint of the thumb. In addition to these deformities, sensory deficits and loss of the stable grasping surface of the palm should be anticipated. Palmar burns often require extensive therapy and multiple reconstructive efforts to yield functional results.[16]

#### *Scar-band deformities*

Scar bands develop when wounds cross lines of tension and run perpendicular to the axis of joint motion. These bands frequently cross multiple adjacent joints and are found at the borders of skin grafts and in areas that healed by secondary intention. Examples of common scar bands include the dorsal web spaces, the dorsal-lateral surfaces of the thumb and little finger, and the palmar surface of the fingers (**Fig. 3**). Loss of web space expansion creates considerable functional impairment. When the span of the first dorsal web space is shortened, thumb palmar abduction and circumduction are limited, and the thumb cannot be positioned away from the plane of the palm for grasp. When the span of the web spaces between the fingers is decreased, finger abduction can be severely restricted. If the width of the transverse volar arch is reduced, MP joint extension can be restricted. Functionally, placement of the hand around objects that require spherical grasp and any activities that require a flattened hand are impaired. Thumb radial abduction can be affected if scar bands are present on the thenar region of the palm.

#### *Loss of skin sensation*

Permanent sensory deficits following thermal injury should be anticipated, with limited potential for improvement, in all hand burns involving the dermis. Hermanson and colleagues[17] studied recovery of sensation in the grafted hand for 2 to 3 years postburn and found the final quality of sensation to be established at 1 month postgrafting. Sensory loss may also occur with neurologic damage to the upper extremity from multiple causes, such as electrical injury, tension or compression to peripheral nerves from edema, or improper positioning. These sensory deficits can

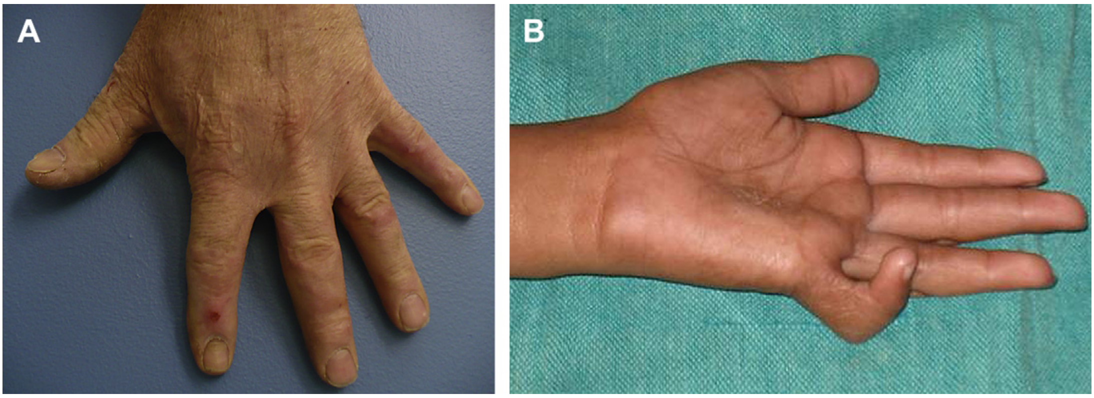


**Fig. 3.** (*A*) Scar bands of dorsal web spaces with resultant loss of web-space expansion may create functional impairment. (*B*) Palmar and lateral banding of the fifth digit results in flexion and ulnar deviation and places the distorted digit in the way of most hand activities.

affect overall hand function, including fine motor skills.

### *Fingernail deformities*

Because dorsal hand burns are common, fingernails are involved and damaged frequently. Functionally, the fingernail acts as a rigid support against which the fleshy pulp of the finger can stabilize. This stability aids in sensation during pinch activities. Complete or partial loss of a fingernail is cosmetically disabling, and it may interfere with the stability of the fingertip. A burn that involves the surface of the fingertip often limits range of motion (ROM) of the DIP joint secondary to wound contraction.[18] These factors may contribute to problems with fine motor dexterity.

### *Peripheral nerve injuries*

Peripheral nerve injuries tend to occur in association with high-voltage electrical injuries.[19–21] Neural tissue has a very low resistance to electric current and is particularly susceptible to injury. Hand function can be affected by both spinal cord injuries from current passing between contact sites around the spine and local nerve damage. Peripheral nerve damage is caused by direct influence of the current on the nerve and surrounding tissues and by swelling of an individual muscle compartment. Permanent damage to peripheral nerves, due to heat generated by current flow and immediate or delayed thrombosis of local vessels, is limited to the area of local tissue damage. The median and ulnar nerves are the most frequently injured nerves in electrical burns, reflecting the greater frequency of hand involvement in such injuries.[22,23]

### *Heterotopic ossification*

Although heterotopic ossification (HO) is rarely seen in the hand, it is commonly seen at the elbow[24] in burn patients and can severely affect upper extremity function. This formation of new bone may occur in soft tissue surrounding the joint (**Fig. 4**) or within the joint capsule or ligaments, or it may form a bony bridge across the joint.[25] In some instances, this abnormal deposition of bone resolves spontaneously. In other cases, the continuous presence of HO limits the functional abilities of a patient so severely that surgical excision is necessary. HO is found more commonly in patients with a greater than 20% full-thickness burn and in patients whose wounds remain ungrafted for long periods of time.[26,27]

## THERAPY MANAGEMENT GUIDELINES

Burn rehabilitation should be initiated within the first 24 hours of admission of a burn patient to establish an individualized positioning, splinting, exercise, and functional activity plan. Many of the complications previously described can be minimized with early and ongoing therapy. Patients with severe hand burns may require several years of scar management and reconstructive procedures that typically involve long-term rehabilitation. General guidelines for burn therapy approaches are outlined in the following sections.

### *Positioning*

Specific positioning of the burned hand is crucial to healing with optimal results. Key components of positioning include elevating the distal extremity to facilitate venous blood flow, placing an elongation force on healing tissue, and protecting viable joint and soft tissue structures from additional trauma such as rupture or excessive pressure.

Fig. 4. HO is a common problematic complication in burn survivors. Although HO is not directly related to the hand burn injury, hand function can be greatly affected. (*A*) The elbow is the most frequent site of HO. (*B*) Although rare, bony deposits can occur at the small joints of the hand.

***Edema management***

Elevation of the hand and upper extremity is crucial to absorption of developing edema fluid. The hand should be elevated above heart level as much as possible. It is also critical to extend the elbow sufficiently to promote venous drainage. Various devices can be used to elevate the upper extremity, including pillows, foam wedges/troughs, or slings, all supported on bedside attachments, intravenous poles, or furniture.

Secondly, a patient who is alert and able to participate should be instructed in active exercise to activate the muscle pump to decrease edema. The technique used to reduce edema should be selected carefully to avoid potential injury of fragile tissues. For example, frequent episodes of active composite finger flexion and extension can be encouraged safely in superficial partial-thickness hand burns. However, there is a risk of extensor tendon damage with passive composite flexion in deeper hand burns. In these cases, exercises for isolated active or passive MP joint flexion, combined with active or passive IP joint extension, will impose less stress on this fragile extensor tendon system.[28] Repetitive finger abduction and adduction requires contraction of the dorsal and palmar interosseous muscles, which assists in edema reduction and is generally indicated for burns of all depths.[15] Edema control following the initial 72 hours should remain a priority to minimize stiffening of the soft tissue and loss of tendon glide and joint mobility.

Finally, edema control through externally applied pressure is frequently used in burn centers and thought to be clinically useful. Self-adherent elastic wraps have been proved to be effective on acutely burned and postoperative skin-grafted hands to control edema.[29] Hand edema measurements can be used to document improvement with elevation, motion, and compression. The figure-of-eight technique has proven to be a reliable and valid tool for measuring hand edema in patients with burns.[30] This technique is a more clinically feasible tool than water volumetry, which is considered the gold standard for hand edema assessment.[30]

***Anticontracture positioning***

As with any burned body part, the position of comfort for the patient becomes the position of contracture formation due to edema organization, wound bed contraction, and ultimate scar formation. The forearm frequently assumes a pronated position with the wrist in flexion when a patient elevates the forearm and hand or rests the segment on a pillow. If wrist ROM becomes limited in a specific direction, splinting the wrist in the opposite direction would be indicated. Circumferential forearm burns usually require the wrist to be positioned in slight extension due to the effects of gravity and the strength of the flexor muscles.

Positioning of the hand may vary from one therapist to another, but generally the antideformity position of the hand with a dorsal burn is an intrinsic plus position, consisting of wrist extension, MP joint flexion, PIP and DIP joint extension, and thumb palmar abduction.[31] This position combination can only be achieved by applying a custom-fit splint. If the IP joints are not deeply burned, wrapping a gauze roll or piece of foam into the palm and extending it through the thumb web space may provide adequate positioning. There is some controversy about whether the thumb should be positioned in radial or palmar abduction.[32] Whichever position is used, the objective is to preserve the thumb web space.

With deep palmar burns, the hand is usually positioned with all the finger joints extended and the volar thumb web space under stress to preserve finger extension and thumb radial abduction, respectively. These palmar burns need to be positioned by a splint. Following re-epithelialization, silicone elastomer may be added to the splint to provide positioning and scar management. With circumferential hand burns, the positioning program will need to be modified and alternated based on burn depth of each surface and the likelihood of scar contracture development.

### Neuropathy prevention

The development of neuropathy is a common problem in patients with burns.[33] Specific areas that must be managed carefully to prevent nerve injury in the upper extremity are the shoulder for brachial plexus injuries, the elbow for ulnar nerve lesions, and the wrist for injuries to the ulnar or median nerves. A brachial plexus injury may result from improper positioning of the shoulder for prolonged periods of time. Shoulder abduction greater than 90° combined with external rotation decreases the distance between the clavicle and the first rib, which may result in compression of the plexus. This position, when combined with posterior displacement of the shoulder, may also cause stretching of the brachial plexus.[33] Placing the arm in scaption position, that is, midway between shoulder abduction and forward flexion and in neutral shoulder rotation, may relieve this compression.[34] Compression of the posterior cord of the brachial plexus by a splint or positioning device may result in a motor neuropathy in the radial nerve distribution.

Certain arm positions put the ulnar nerve at risk of compression as the nerve runs through the cubital tunnel at the elbow. When the elbow is flexed to 90°, the ulnar nerve is susceptible to pressure exerted by the arcuate ligament. When the forearm is pronated, the ulnar nerve is susceptible to an external compression force created by the surface on which the nerve lies.[33] The combination of these 2 positions puts the nerve doubly at risk. Ulnar neuropathy can be prevented by positioning the elbow in extension with the forearm supinated and positions alternated for comfort. Ulnar and median nerve involvement may be a result of compression at the wrist caused by extreme positions or excessive pressure.

## Exercise and Activities of Daily Living

### Skin biomechanics

Skin is a highly extensible tissue when compared with burn scar.[35] The skin overlying the dorsum of the hand and fingers is especially flexible with reservoirs of skin overlying the IP joints.[36] When making a fist, skin is recruited in a distal to proximal direction. Researchers have documented a 30% increase in finger length when moving from a position of total finger extension to complete fisting.[36] The joints of the fingers do not move like a door hinge; rather, the phalanx articulates around the head of the antecedent segment to account for the increase in finger length.

### Range of motion

Emphasis is placed on the movements that oppose the development of contractures. The choice of exercise should be tailored to the individual needs of the patient. Active ROM is preferred to passive ROM (PROM); however, if patients are unable to achieve full ROM or participate with maximum effort, active-assisted movement or passive movement of the hand needs to be implemented. Alert patients can be taught self-range to ensure full combined tissue elongation (**Fig. 5**). PROM in the operating room, before excision and grafting procedures, enables the therapist to assess ROM restrictions and perform pain-free lengthening of tight structures.

The presence of multiple articulations within the hand makes it particularly susceptible to joint and scar contractures. To avoid joint contracture, it is recommended that ROM be performed to isolated joints before composite ROM. Composite ROM is required to provide maximal tissue elongation and prevent scar contracture of the hand.

Frequent exercise, performed multiple times throughout the day, is considered more beneficial than one intense session. Wound and scar contraction is a process that is ongoing throughout the day and night and this process needs to be treated constantly. Repeated ROM is helpful in mobilizing edema and preconditioning the tissue,[37,38] followed by sustained stress to elongate the scar as described later. Evaluations should be performed with the wound and scar tissue exposed, so appropriate exercise programs can be determined. When possible, ROM should also be performed in the absence of dressings so that the tissue can be observed during exercise, and treatment intensity can be adjusted appropriately. Strengthening and conditioning programs should be implemented, along with specific ROM exercises, as soon as the patient is able to participate actively.

Following tissue preconditioning, splints (static, static-progressive, or dynamic) or casts can be used to positively influence further gains in scar tissue length and subsequent ROM. Static devices demonstrate the biomechanical principle of tissue

**Fig. 5.** ROM should be performed for maximum elongation of the healing skin or developing scar. (*A*) This can be achieved with active ROM in motivated alert patients. (*B*) Note blanching over thumb joints as opposition to the tip of the fifth digit is achieved, indicating maximum elongation of the scar. (*C*) It is difficult to obtain a full palmar expansion actively in the presence of developed scar. (*D*) Because this is a frequent injury in children, it is essential to instruct the child's parent/caregiver in appropriate techniques for passive ROM.

relaxation whereby tissue adapts to the stress applied. Dynamic interventions cause tissue to elongate over time.[38] By applying a constant load, tissue responds by increasing its length, which translates into increases in ROM.

### *Modalities*

When the burn is closed and skin grafts are stable, modalities may be beneficial.

1. One recommended modality is paraffin, which provides moist heat and seems to soften skin/scar to promote increased ROM when used before exercise.[39] It is effective at lower temperatures, so it can be allowed to cool before applying to healed burn/scarred skin.
2. Scar massage may be helpful in reducing hypersensitivity, itch, and pain, and in moisturizing and softening of the scar for the duration of a treatment session, allowing easier and greater extensibility with ROM exercises and functional skills training.[40]
3. In addition to scar massage, other desensitization treatment is recommended when healed or scarred areas of the hand are hypersensitive, as evidenced by extreme discomfort or irritability in response to normally non-noxious tactile stimulation.[9] Desensitization techniques may include (1) dowel textures, with different textures of material glued onto dowel sticks; (2) contact, with use of particles such as rice and beans; and (3) vibration, with use of battery-operated vibrators.
4. The use of ultrasound has been reported in treating burn scar with limited success.[40]

### *Assistive devices*

Age-appropriate self-care activities such as feeding, helping with dressing changes, bathing, applying moisturizing cream, and dressing are ways to increase physical activity.

Provision of simple aids such as built-up or extended handles and universal cuffs can facilitate independence; however, they should be implemented only if the patient has extraordinary edema or complicating comorbidities, as using regular utensils and self-care items can promote ROM, strength, and normalization of movement.

## *Splinting*

Many splints have been described to treat hand burns based on the customized need of each patient.[41] Basic splinting principles should be directed toward elongation of tissue against normal wound contraction. Guidelines directing the use of splints related to the hand are based on burn depth, skin surface involved, burn rehabilitation phase, and patient considerations.[40] It is generally accepted that no splint is needed to treat hand burns of superficial partial-thickness depth or if a patient is able to maintain full active ROM. Prophylactic antideformity splinting of the hand at night may be helpful to prevent contracture following deep partial-thickness and full-thickness burns. Splinting or other means of positioning after skin grafting to the hands is strongly recommended. A splint is also highly recommended for patients who are unable to actively maintain their own ROM, have a decreased level of consciousness, or are deemed uncooperative with treatment.[40]

The antideformity splint (**Fig. 6**) positions the wrist in extension, the MP joints in greater than 60° of flexion, and the IP joints in full extension.[42] This splint is recommended for any acute and post-acute burned hand that assumes the edema-imposed claw hand posture or has involvement of the common extensor tendons or extensor apparatus or has a burned area that includes the dorsum of the hand and digits. When skin coverage has been achieved, additional forms of splinting can be used to provide sustained stress across multiple joints. A composite flexion wrap (see **Fig. 6**) places

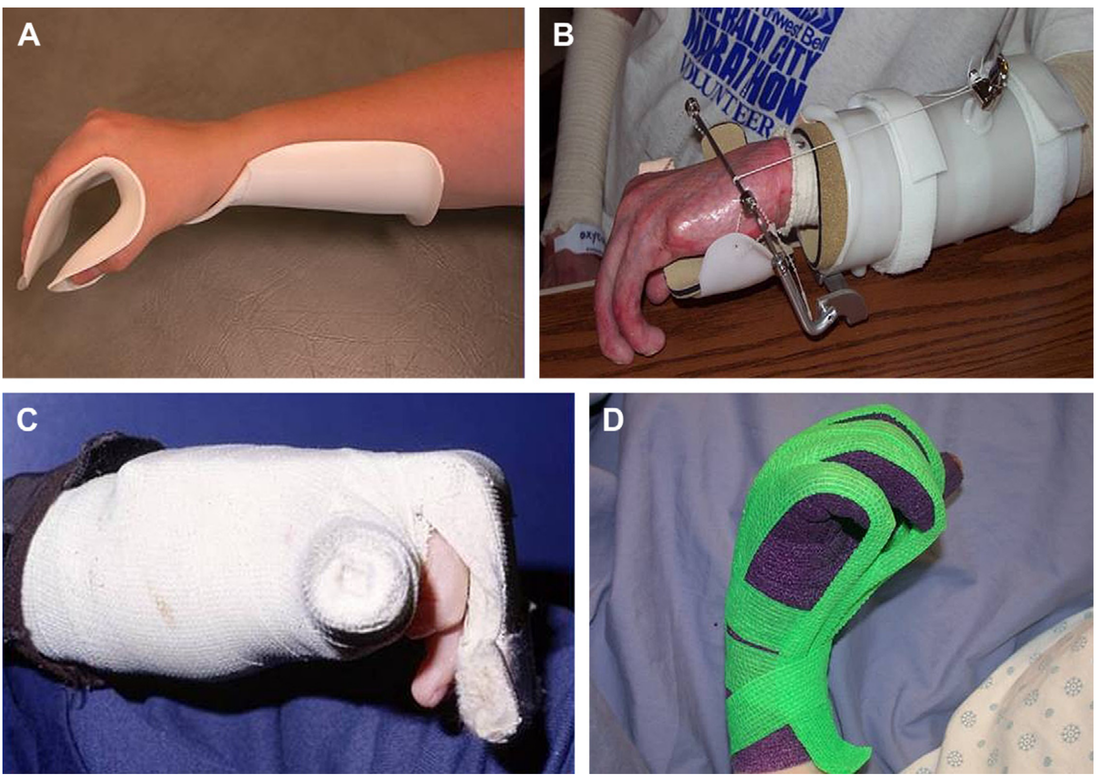


**Fig. 6.** Splinting can take many forms, indicated by individual patient need and stage of recovery. (*A*) A resting hand splint may provide adequate support for positioning the hand in the emergent and postgrafting period. If the extensor tendons are considered to be at risk, the IP joints are placed in full extension. (*B*) An example of dynamic wrist extension splint. (*C*) Casting may be required to fully hold joint position. This MCP block cast was aptly named the "shovel cast" by the 4-year-old patient, as he could still play in his sandbox while his new fifth finger dorsal graft healed. (*D*) Flexion wraps or straps can be useful in elongating dorsal skin/scar over IP joints or a combination of MP and IP joints. Strips of self-adherent wrap of a different color are applied over the wrapped hand, as tolerated for short intervals throughout the day.

maximum stress on the finger extensor mechanism, so it should be used only when the tendons are able to tolerate this force.

To successfully apply a sustained stress when the burn involves the palm and volar wrist, a splint should flatten the palmar arches and extend the digits. This position, however, places the MP joint collateral ligaments at their shortest length. In this situation, exercises to maintain collateral ligament length should be balanced with splinting to elongate the palmar wound or scar.

### *Pediatric considerations*

In addition to the small size of children, the therapist must consider other anatomic differences, such as thinner, more fragile skin and hypermobile joints. Unlike adults and adolescents, small children do not tend to lose strength or joint mobility when immobilized in splints for extended periods, provided the splints are removed for regular exercise or activity sessions.

Some splints that work well with larger children or adolescents are not as effective with small children. For example, dynamic splints (see **Fig. 6**) are not recommended for small children because they are often difficult to keep in place. Serial static splints or casts (see **Fig. 6**) may be more practical and effective with smaller children. Because of a young child's small size, hand splints may have to be made longer so they can be anchored to an extended wrist; otherwise the splint will tend to slide distally and actually place the extremity in a deforming position. In addition, adding extra straps or applying the splint with an elastic bandage or self-adherent wrap may be necessary. Cotton socks over the splint may prevent the child from removing the splint.

Contact burns involving the palmar surface of the hand and fingers are common in toddlers.[43] The hand should be splinted in wrist extension and finger extension and abduction, with the thumb in radial abduction (**Fig. 7**). Splints should be worn all night and at nap time unless joint ROM is decreasing. Actions that can assist with desensitization and minimize palmar contractures include placing the palm and digits into extension,

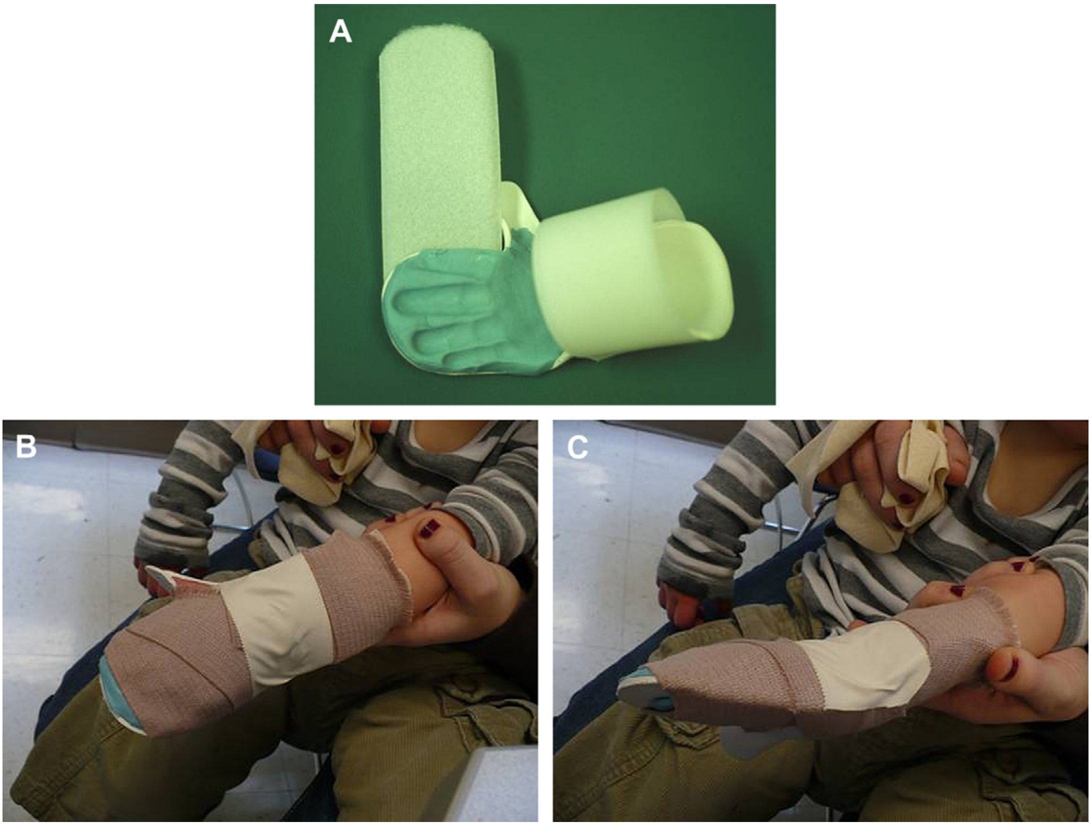


**Fig. 7.** Pan extension splint, useful in positioning palmar burns. (*A*) Elastomer putty insert can be custom molded and attached to the splint to apply pressure and full elongation within it. (*B*) and (*C*) Optimal positioning of this patient in the splint, with wrist and digit extension and thumb radial abduction. Note the need for overwrapping to keep the splint in place in a young child.

massage, and weight-bearing activities (eg, crawling on all fours or pushing a large heavy ball or toy).

## *Scar Management*

### *Interim pressure*

Early pressure application over the hand and digits can be accomplished by the use of thin, elastic self-adherent wraps (**Fig. 8**). This form of pressure aids in the early scar management of hands when the shearing force of donning a glove cannot be tolerated. Self-adherent elastic wraps may be applied over the burn dressings or directly onto digits. Before ordering custom-fit gloves, the use of prefabricated interim pressure gloves, which are made from softer materials, introduce the burn patient to circumferential pressure and allow any remaining edema to subside.

### *Custom garments and inserts*

In the intermediate and long-term phases, pressure is applied to minimize scar hypertrophy. Because scar maturation is a dynamic process, the clinician must periodically review the need for pressure therapy, the type of pressure, and the physical condition of the gloves and inserts. Pressure gloves are available commercially as either custom-made (see **Fig. 8**) or pre-sized. Ready-made tubular support or pre-sized elasticized nylon fabric gloves can be used initially. Ready-made gloves are ideal for the burned hand that does not tolerate pressure well, for use in the final phase of scar control when less pressure is required to keep the scar flat, or for the sole purpose of holding pressure inserts, such as web spacers, in position.

Pressure applied to hypertrophic scars by a garment may not be adequate because garments often do not conform or apply equal pressure to all areas.[44] Areas that most often require a pressure insert are digital web spaces (see **Fig. 8**), the palm, and volar and dorsal wrist creases. Pressure in the palm of the hand cannot be achieved adequately with only a glove or self-adherent dressing. An insert can be fashioned out of silicone elastomer or elastomer putty (see **Fig. 7**). In addition to inserts, modifications to

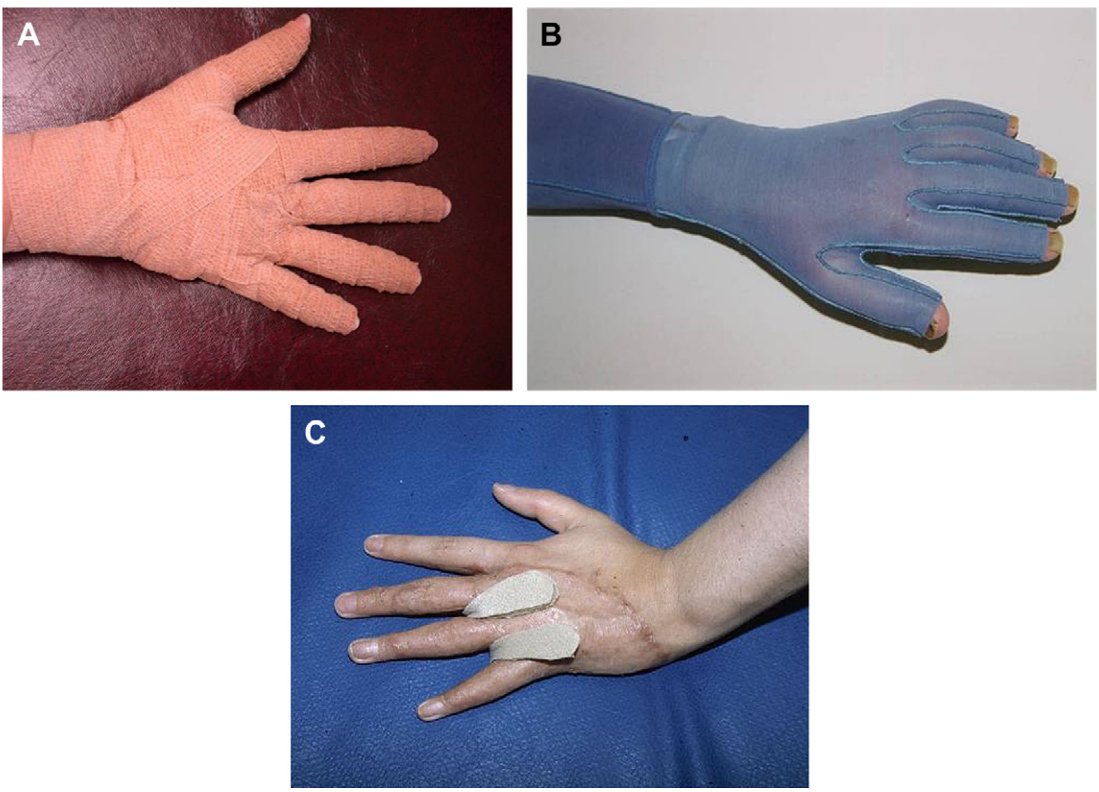


**Fig. 8.** Compression can facilitate edema reduction and scar alignment. (*A*) Self-adherent elastic wraps can be applied over dressings, providing early compression to reduce edema. (*B*) Custom-fit gloves provide long-term protection, support, and scar alignment. Note the slanted web-space design in this glove, included for specific compression of the dorsal web scars. (*C*) Further shaping and scar control is obtained with foam or inserts of other materials placed under the glove, in this case the third and fourth web-spaces.

pressure gloves can also facilitate wearing of the garment, particularly in enhancing function of the hand while wearing the glove.[45]

When compared with adults, young children appear to have a higher incidence of hypertrophic scarring and scar band formation, especially if the wound takes longer than 2 weeks to heal completely. Multiple garments should be ordered for children, and new garment measurements should be taken every 2 to 3 months or as needed to accommodate growth and development. Small hands are a challenge to measure and fit properly with pressure garments. For infants, better pressure on the hand may be achieved through the use of self-adherent elastic wraps. Narrow strips of foam padding, worn between the fingers under compression gloves, work well to preserve web spaces and do not macerate the skin or interfere with hand function. If a child's hand is burned only in the palm and does not involve the web spaces, a compression glove, used alone, is contraindicated—gloves tend to pull the thumb into adduction and fold the palm. Instead, a custom molded insert of silicone putty attached to a palmar extension splint is recommended.

## Patient and Family Education

Therapy should be constantly directed toward patients' assumption of their own care. It makes no sense for the patient to receive one session of therapy followed by 23 hours of indifference and inactivity. Therefore home programs for which directives are clearly outlined are an essential part of treatment.[9] Educating the patient and family is very important in gaining the patient's trust, which promotes compliance and motivation. Written instructions with illustrations, frequent observation of therapy sessions combined with participation, and reciprocal demonstration of rehabilitation techniques, all help to ensure successful skill acquisition by a family member. Before discharge, the patient's rehabilitation program should be well established without daily changes. Patients or caregivers should be taught independence in handling wound care, proper application of splints, pressure garments and devices, and exercise and scar massage programs. A school-aged child should be prepared for return to school and association with friends, especially if functional loss or disfigurement has occurred. In addition to specific therapy techniques, two other topics are important for the team to share with patients and families: how to manage itch and sun exposure.

Loss or damage to sebaceous glands and sweat ducts tends to leave the skin dry and itchy. Instructing the patient in alternate techniques to scratching is important; examples include applying manual spot pressure or tapping the irritated area, applying a cold wet washcloth, frequently using a perfume-free and alcohol-free moisturizer, and using mild soaps and laundry detergents. Newly healed skin is prone to hyperpigmentation, so exposed areas such as the hands and arms should be protected from direct sunlight with clothing and routine use of a sunscreen (sun protection factor $\geq$30) even under pressure garments.

## Outpatient Therapy

Frequently, patients with significant hand burns require ongoing hand therapy, following discharge from the burn center, to progress their ROM, strength, dexterity, and functional skills. The therapy needed may vary from 30- to 60-minute sessions 2 to 3 times a week to 4- to 8-hour work conditioning/hardening programs. In each case, communicating therapy outcomes and concerns with the referring burn center facilitates progression in therapy management and return to work/school/community activities.

## Functional Outcome

Many hand evaluations are available, but no consensus has been reached on a battery of tests best suited to determine outcome of the burned hand.[46–48] The traditional methods of assessment are ROM and grip strength, but it is important to assess an individual's ability to actually use their hands. The shifting focus of health care outcomes acknowledges the importance of patients' perceptions of their medical treatments and the effects on their quality of life. In a recent study,[49] the Michigan Hand Outcomes Questionnaire revealed that 68% of patients reported hand function deterioration, 65% with the nondominant hand. Activities of daily living (76%) and work (59%) were the most affected.

In a large retrospective study of acute hand burns, Sheridan and colleagues[50] reported normal function in 97% of patients with superficial injuries and 81% of patients with deep dermal and full-thickness injuries requiring surgery. Although only 9% of those with injuries involving the extensor mechanism, joint capsule, or bone had normal functional outcomes, 90% were able to perform activities of daily living independently. In a review of deep (fourth-degree) hand burns from the 1980s, Nuchtern and colleagues[51] note that it took an average time of 13.3 months to return to work, with two-thirds of the patients changing their jobs in some way because of their hand impairment.

### *Long-term Follow-up*

Most burn scars mature completely in 12 to 24 months, although skin changes can be observed for several years following a burn injury. It is possible to mold/influence scar tissue during this time, so it is helpful to provide the patient with intermittent visits to a burn specialty clinic to modify scar management techniques or plan timely surgical procedures for best outcome.

Long-term outpatient follow-up is necessary for a burned child to ensure maximum function and minimal cosmetic defect over the multiple growth periods between infancy and adulthood. Over a period of years, scars may interfere with normal growth, and a child may require additional surgery and therapy even after the scars are mature.

## SUMMARY

Rehabilitation of the burned hand is challenging but vital in minimizing functional deficits. Burn rehabilitation therapists provide ongoing assessment and management of edema, burn scar contractures, and hand function. Therapy plans include positioning, splinting, exercise, compression, and functional skills training. These efforts are facilitated by experienced burn team members working together with common goals identified by the patient or caregiver. Therapy is most beneficial when started at the time of admission and may be needed for weeks or months following discharge. This article provides an overview of the role of burn rehabilitation therapy in the management of the burned hand.

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