MANAGEMENT OF THE BURNED HAND

Carol Carmudie
Prince of Wales Hospital, Sydney

The hand appears to be the most common part of the body involved in burns as it is either used to shield the body from the burning agent or to extinguish the effects elsewhere on the body. The saying that “next to life there are hands” demonstrates the importance that is placed upon the use and need of one’s hands in order to carry out everyday tasks of normal living. In order to manage burns to the hands, the effects of the injury and the aftermath must be understood and one must not only consider the hands, but the patient as a whole. The regime of treatment used at the Prince of Wales Burns Unit involving nursing care and physiotherapeutic techniques, is outlined, and the need for understanding of the pathophysiology of burns in order to correctly manage the burned hand is emphasised.

ASSESSMENT OF THE BURNED PATIENT

When the person is admitted to hospital suffering from burns to the hand, priorities must be established to effectively treat and save as much viable tissue as possible. Of course, precedence is given to life salvage if burns have occurred over vast areas of the body, but with regard to the hand, treatment will be concerned with healing of the burns, and the resumption of maximum mobility — an area that concerns the physiotherapist.

Initial assessment has importance for immediate management and prognostic implications. Parks et al. (1977) recommends that burns are assessed as partial thickness, deep dermal or full thickness, and define these as follows:

Partial thickness — the epithelium is involved and the injury appears as erythema. The burn always heals, does not scar but is very painful e.g. sunburn.

Deep dermal — the epithelium and part of the dermis are destroyed, but dermal aspects such as sweat glands and hair follicles are present to permit re-epithelialisation. Deep dermal burns may grossly appear to be full thickness, are not painful, will heal after several weeks and may result in severe hypertrophic scarring. Moderate dermal burns are painful and will heal after several weeks without scarring.

Full thickness — the entire thickness of the skin and lower levels are destroyed. The burns are usually not painful (due to the destruction of nerve endings), and will not epitheliate spontaneously but will heal by granulation. This will result in severe hypertrophic scarring.

To assess the extent of the burn, Wallace’s Rules of Nine are used. (Settle 1977). Table 1 outlines the relationship between the area burned and its percentage of the total body area and figure 1 shows this relationship visually.

Carol Carmudie graduated from the Cumberland College of Health Sciences, 1975, with a Diploma in physiotherapy and is currently physiotherapist, Burns Unit, Prince of Wales Hospital, Sydney.

### Table 1

<table>
<thead>
<tr>
<th>Area</th>
<th>% Total Body Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm</td>
<td>9 each</td>
</tr>
<tr>
<td>Head</td>
<td>9</td>
</tr>
<tr>
<td>Trunk—front</td>
<td>18</td>
</tr>
<tr>
<td>—back</td>
<td>18</td>
</tr>
<tr>
<td>Leg</td>
<td>18 each</td>
</tr>
<tr>
<td>Perineum</td>
<td>1</td>
</tr>
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</table>

FIGURE 1
Wallace’s Rules of Nine (Settle, 1977)

Small or scattered burns can be estimated by imagining how many times the palm of the hand will fit into the area, remembering that the palm comprises about 1 per cent of the total body area. There is a similar set of rules for children to accommodate the differences in body area compared with adults. Thus, the hand represents only 2-3 per cent of the body area, but what an important 2-3 per cent it is!
THE PATHOPHYSIOLOGY OF BURNS

The hand becomes oedematous shortly after thermal injury. This is due to changes in capillary permeability in tissues affected but not totally destroyed by heat. “Protein-rich fluid escapes from the vascular compartment and penetrates all structures of the hand”, (Whitson, 1971). Oedema is followed by excessive protein synthesis, producing fibrous tissue that envelopes tendon sheaths, capsules, fascia and elastic tissues. Thus, post-burn oedema may cause severe functional and rehabilitation problems.

The structures most affected by burns of the hand are on the dorsum due to the soft and thin covering there, as compared to the thick and tough skin on the palmar surface.

“At the level of the Metacarpo-phalangeal (MCP) joints, the extensor tendons and intrinsic muscles join to form a common extensor mechanism. The extensor is referred to as the central extensor and that of the intrinsics is called the lateral bands. The lateral bands lie volar to the axis of flexion of the MCP joints and dorsal to the axis of the inter-phalangeal (IP) joints which explains their action of MCP flexion and IP extension. This is called the “intrinsic positive position” or “safe” position (Newmeyer and Kilgore, 1977). (See Figure 2a.) The incorrect position is the claw hand deformity or the intrinsic negative position. This consists of MCP hyperextension and IP flexion. Thus by placing the MCP joints in flexion the collateral ligaments will be maintained in a lengthened position, and with the IP joints in extension, tension and trauma to the central slip of the extensor mechanism over the proximal inter-phalangeal (PIP) joint will be avoided. Hence the need for proper splinting to ensure the “safe” position of the MCP and IP joints.

Fibrous tissue formation occurring after oedema affects certain structures in the following way:

The collateral ligaments are composed primarily of collagen and are lengthened when the MCP joint is flexed, and shortened when the joint is extended. When the joint is constantly maintained in hyperextension, this ligament remodels in a shortened position. This then prevents MCP joint flexion.

The volar surfaces of the heads of the second, third, fourth and fifth metacarpal bones are connected by the deep transverse metacarpal ligament, which also preserves the metacarpal arch. With fibrous tissue formation the transverse metacarpal ligament becomes abnormal and thickened. Mobility of the fourth and fifth metacarpal heads is lost. Effective flexion of the MCP joints is prevented.

The spaces between the gliding tendons and surrounding spaces are obliterated by fibrous tissue. The adhesions can become firm and limit active flexion, and if going so far as to interfere with the interossei and lumbrical actions, will result in an immobile MCP joint.

Injury to the extensor mechanism can also cause the boutonniere deformity to occur (Newmeyer, 1977). This is caused by the destruction of the extensor mechanism over the PIP joint, allowing the lateral bands to slip down and become flexors instead of extensors of the joint, pulling the distal inter-phalangeal (DIP) joint into hyperextension (Figure 2b). The deformity can be corrected with splinting where the PIP joint is maintained in extension but the splint will allow free movement of the MCP joint.

The chronic boutonniere deformity however, will require surgery. Here tendon grafts are done where the graft is woven through the lateral bands of the extensor hood near the PIP joint and sutured securely. The intrinsic musculature upon contraction will extend the PIP joint through the action of the tendon graft (Larson, 1970).

In the opposite deformity, the swan neck, there is either loss of volar support for the PIP joint or loss of extension at the DIP joint. As a result, the DIP joint droops and the PIP joint goes into hyperextension. Correction entails splinting or surgery but may not be as troublesome as the boutonniere deformity. If, however, in both conditions there is great tissue loss at the tip of the finger, and there is non-viable tissue over the PIP and DIP joints, then amputation may be necessary.

Hypertrophic scarring represents an overactive healing process (Parks et al. 1977). Abnormal metabolic processes occur in the cells, and the rate of collagen and enzyme activity is increased. It may not occur for three to four months after the burn, and maturation is indicated by softening, flatten-
ing, and loss of redness of the scar — a process that may not occur for many months. Also, it must be remembered that not only a full thickness burn results in hypertrophic scarring, but a deep dermal burn may have the same result.

MANAGEMENT OF BURNS

Nursing care involves the application of topical agents to prevent infection. At the Prince of Wales Unit the agent used is silver sulphurdiazine (SSD). The ideal agent should be cheap, easy to use, acceptable to both patient and staff, have no allergic properties, effective, not produce resistant stains and be non-toxic (Baldwin, 1974). SSD cream fulfills all these ideals. It appears to act by the slow release of silver ions which act in the cells to prevent uncoiling and reduplication of bacteria, and therefore, infection.

A plastic disposable glove is filled with SSD and the glove is fitted over the hand. This method is more satisfactory than the use of a plastic bag as the glove helps to maintain the shape of the hand; the cream is able to remain in place all over the hand and there are no bulky dressings present to restrict active movement.

Debridement of the burn can take place in lux baths. Adherent dressings are floated off in the bath (which is at body temperature) and the physiotherapist uses the bath as a medium for exercise. Bathing is suspended for at least five days after grafting to allow the grafts to "take". No movement is allowed until initial dressings are removed. This prevents the shearing effect of tight dressings on the vessels running from the graft to the receiving site. Some surgeons advocate grafting quite soon after the injury, (especially if the dorsum is affected), with a method called "tangential excision". This consists of removing the burned tissue, layer by layer, down to the level where "pin-point" bleeding occurs, then autografting the excised surface with sheets of skin instead of small, postage stamp grafts — avoiding scar formation at graft junctions. This method is often advocated in deep dermal burns, where it is believed that removal of necrotic tissues quite soon after the burn will protect potentially necrotic deep layers. This prevents superficial burns from becoming deep ones, thus allowing early mobilization and preserving function (Janzekovic, 1970).

![Figure 3](image)

The use of K wires to prevent deformity. Also used to internally fix fractures.

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Postage stamp and mesh grafts may be chosen when the burn is extensive (as a greater area can be covered), and where the areas available for donor sites are limited. Skin is cut from selected donor sites and spread onto tulle. The area to be grafted is debrided and the grafts are then applied. Donor sites and grafted areas are then dressed and graft sites left immobile for five days. The hand is usually positioned in the "safe" position with splints and after the grafts "take" during the five day resting period, physiotherapy is resumed.

If metacarpal flexion is difficult to maintain, Kirschner wires may be used, passing through the metacarpal heads and into the proximal phalanges. Also, the wires can be used to internally fix fractures and maintain a correct position while the fracture ends unite, (Figure 3). Non-viable tissue around the tips of the fingers may lead to amputation.

Further surgery may be indicated later where deformities have occurred, secondary to pathological processes that develop deep below the cutaneous level and do not respond to preventative measures. For example, Z-plasty may be performed to release tight skin that has bridged across a joint or a tight tendon that holds a finger in an abnormal position.

FIGURE 4
Sling and Spring system.

PHYSIOTHERAPY FOR THE BURNED PATIENT

The role of the physiotherapist is governed by the aims of restoring function, preventing deformity through the use of splints and passive and/or active exercises, and, due to the end result of severe burns, the measuring and ordering of pressure garments to prevent deformities occurring from hypertrophic scarring.

Many ideas have been put forward as to the most effective method of controlling and eventually eliminating oedema. Methods advocated include the elevation and immobilization of the arm with a compression bandage applied; mobilization of the arm and the use of night splints; and the use of an intermittent pressure device.

Studies by the United States Army Institute of Surgical Research (Salisbury et al. 1973) show that in the first seventy two hours post-burn, the intermittent pressure device proves the most effective. This did not, however, correlate with improved function. Post-burn three to seven days showed that elevation and active exercises proved the most effective. After three weeks none of the tested patients had oedematous hands, regardless of initial treatment. However, one must realize that it is imperative to reduce oedema as soon as possible to prevent complications. The method advocated by the Prince of Wales Unit is elevation of the hand with the elbow at 90°, and active exercises are enforced. Stringent elbow exercises are also done to prevent elbow contractures. This method appears to be the easiest for nursing care.

Methods of elevation include the use of rolled-up towels or pillows, or the spring and sling system used at the Prince of Wales Unit, (Figure 4). The forearm is supported in the sling, which is in turn supported by clamps attached to a spring. This method is used in conjunction with splinting to hold the hand in a correct position.

One important aspect in the salvage of hands and fingers is the reduction of oedema. Deep dermal or full thickness circumferential burns may produce a tourniquet effect on the hand and cause vascular impairment. At the Prince of Wales Unit, escharotomy is used which involves incisions over the limb to the fingertips, hence releasing pressure of the oedema on the circulation, (Figure 5).

The method of reducing oedema is accompanied by the use of splints to maintain a "safe" position, i.e. not straining ligaments and tendons, especially on the dorsum of the hand, and also to prevent deformity. The "safe" position, as shown later, is quite different from the usual "functional" position.

For partial thickness burns, the splint is worn until oedema decreases and the patient is able to
perform active exercises, under the supervision of the physiotherapist. For deep dermal and full thickness burns the splint is worn at all times except for periods of supervised exercise. Continuous splinting is maintained until there is good, visible, dry skin coverage and stable, maturing grafts over the MCP and IP joints. The patient must be able to maintain full PIP joint extension actively, and when the development of deformity no longer threatens, night splinting may be appropriate or the splint discarded altogether.

The splints used at the Prince of Wales Unit are of orthoplast. This is easily malleable in hot water and is applied to the hand, which may be wrapped in velband or gauze prior to moulding the splint to protect the hand from the heat. The splint is moulded and kept in shape and position with crepe bandages. When cool, it is removed and the splint may be then spot-heated to make further adjustments. The splint can be quickly solidified when held under cold water. When re-applied, the bandages securing the splint should be wrapped firmly around the hand, especially across the PIP joints to maintain their extension.

The desired splinting position is:

0 — 30° wrist extension
45 — 70° MCP joint flexion
PIP and DIP joint extension

The thumb is abducted and extended to maintain the web space. (Figure 6a).

Figure 6b illustrates incorrect positioning of the splint, resulting in a “claw hand” deformity.

The splint can be reinforced to maintain the correct shape by placing a strip of orthoplast onto the underside of the splint up to the DIP joint. Also the thumb can be reinforced to ensure proper web spacing.

Measurements required to make the splint (as recommended by Tanigawa et al. 1974) are:
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FIGURE 6
(a) The hand in the intrinsic positive position.

(b) Incorrect positioning: The splint has slipped forward. The MCP joints are in extension and the PIP joints are in flexion — the making of a "claw" hand or the "intrinsic negative" position. (Malick 1974).

The width of the hand at the metacarpal heads
the length of the fingers from the transverse palmar arch to 1.3 cms beyond the tip of the middle finger
the length of the thumb from the web space to 0.6 cms beyond the tip.

The first two measurements form a right angle. The finger measurement line is continued for the length of the thumb measurement. The pattern is then drawn with an inverted thumb piece, leaving room for the thenar eminence. (Figure 7). The splint, when in the intrinsic positive position will prevent strain on the extensor mechanism. Where possible measurements can be taken from the patient's non-burned hand, and these can be slightly enlarged to accommodate changes in the burned hand caused by oedema.

When a patient has sustained burns to both hands a pattern may be made from one's own hand, allowing for differences in size when comparing one's hand to that of the patient's. The splint can be applied quickly, and be adjusted to fit the patient's hand by spot-heating. The procedure for making the pattern is as follows: (Figure 8).

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With the hand placed palm down, trace an outline of the hand, (ensuring that the radius is in line with the index finger). Mark in the level of the wrist, the elbow, two thirds the distance between these two points, and the metacarpophalangeal crease.

Mark in a line perpendicular from the wrist line to the metacarpophalangeal crease line. One centimetre from the junction of these two lines mark in a dot.

Starting from this dot, draw a curved line to the point where the wrist line intercepts the hand outline. Proceed one centimetre from the outline to the two third line. With rounded edges, continue one centimetre from the medial edge across the top of the hand, level with the tip of the middle finger. Drop the line to the wrist level. All edges of the splint are rounded to prevent pressure areas.

The pattern is then traced onto the orthoplast, and the splint made.

Most patients with deep dermal or full thickness burns do not realise that after the burns have healed, the development of hypertrophic scarring occurs.

Hypertrophic scarring can be controlled with the use of pressure gradient garments. These are gloves, made of lycra, that fit firmly on the hand, in order to provide pressure to flatten the scars, and allow the skin to become soft and pliable (Malick, 1975). Figure 9 shows deformity of the hand caused by hypertrophic scarring.
FIGURE 9
Hypertrophic scarring causing a claw hand deformity.

FIGURE 10
The use of velfoam as a webspacer to provide extra pressure in the finger web spaces.

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FIGURE 11
Hypertrophic scarring controlled by the use of a JOBST pressure gradient glove.

The physiotherapist measures the patient's hand(s) prior to discharge from the unit. In the course of follow-up treatment the gloves will be fitted by the physiotherapist to ensure their correct fit, and the patient instructed on the use and care of the gloves. As the scars flatten, the gloves become loose and will not provide adequate pressure, thus, the hand needs to be re-measured. Extra pressure in the webspaces can be made by the use of a piece of velfoam that has slits to accommodate the fingers, (Figure 10). The glove is then worn over the foam.

Figure 11 shows hypertrophic scarring being controlled through the constant wear of JOBST pressure gradient gloves.

SUMMARY
The severity and extent of the burn will determine how the burned hand will be managed. Initially, oedema in deep dermal and full thickness burns must be controlled to minimize functional problems. In conjunction with this, splinting is used to prevent deformity and preserve the extensor mechanism. As soon as possible, debridement of non-viable tissue will take place and the excised area is grafted. Topical agents are used to prevent bacteria formation and further tissue loss. Hydrotherapy, in the form of lux baths is used to loosen adherent dressings, and allow further debridement to take place, and is also a medium for exercise.

The role of the physiotherapist should not be underestimated. Splint making, and the use of exercise in conjunction with surgical correction are most important in preserving function and preventing deformity, keeping in mind the patient's hand dominance and occupation. The extent of damage to the hand will be accentuated if the injury has occurred to the patient's dominant hand. Here in retraining for function, the physiotherapist liaises closely with the occupational therapist to fully rehabilitate the patient in all activities of daily living.

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H. Wadsworth — Lecturer in Physiotherapy, Cumberland College of Health Sciences, Lidcombe.
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