International Handbook of Occupational Therapy Interventions

Chapter 11
Splinting: Positioning, Edema, and Scar Management Due to Burn Injury

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After burn injury, the ultimate goal is to assist an individual to achieve optimal function and independence.

Abstract To achieve optimal function and independence, an individual relies on the combined use of a number of treatment modalities available to therapists (Simons et al., 2003). This chapter provides an overview of (1) classification and epidemiology of burn injury; and (2) intervention modalities that aim to minimize impairment to body structures and body functions after burn injury, by using positioning and splinting, and edema and scar management.

Keywords Burns, Contracture • Cicatrix hypertrophic • Edema • Rehabilitation

Purposes

Health professionals have been treating clients with burns for two millennia. Medical advances over the past three decades have resulted in declining mortality and shorter periods of hospitalization when burns are treated in a specialist burn unit. From this time, it was also realized that morbidity was reduced if occupational therapists, physical therapists, dieticians, psychologists, and social workers became an integral part of burns care (Herndon and Blakeney, 2007; Janzekovic, 1970).

Method

Candidates for the Intervention

People with wounds caused by burn injury should be referred for occupational therapy. The severity of a burn injury is determined according to the surface area affected and depth of the burn. The total body surface area (TBSA) affected is

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reported as a percentage (%TBSA), which ranges from <1% to 100%. The depth of the burn wound relates to the layers of skin that have been affected. Skin is considered to have two layers: the epidermis and dermis (Sheridan and Thompkins, 2007). The dermal layer is further classified as papillary dermis (upper layer) and reticular dermis (lower layer). Traditionally burns were classified as first, second, or third degree, depending on whether the burn was superficial, partial thickness, or full thickness. Fourth-degree burns involve underlying tissues such as muscle and fascia. However, since 2001, the main classification system used throughout the world is superficial, superficial partial, deep partial, or full thickness (Shakespeare, 2001).

Superficial burns involve only the epidermis. Although painful, healing usually occurs within 1 week without any residual scarring (Bessey, 2007).

Superficial partial-thickness burns involve only papillary dermis and epidermis. Burns of this depth are expected to heal in 1 to 2 weeks and should not result in visible changes to the skin beyond 6 months (Bessey, 2007).

Deep dermal partial-thickness burns involve epidermis and dermis to reticular dermis. It is usually expected that burns of this depth would take longer than 3 weeks to heal, and skin grafting is recommended to promote early wound closure and to reduce the degree of residual scarring (Bessey, 2007).

Full-thickness burns entail involvement of the whole thickness of the skin and possibly subcutaneous tissue. Skin grafting is essential since there is little potential for spontaneous healing (Greenhalgh, 2007).

To obtain the objective of optimal function and independence, treatment modalities to minimize the risk of impairment to body structures and body functions must be commenced upon admission after the burn injury. If wounds are considered partial or full thickness in depth on a flexor surface of the body (e.g., cubital fossa, popliteal fossa), the client is at significant risk of long-term functional impairment. If a burn heals spontaneously (i.e., without the need for skin grafting) with complete skin coverage of the affected area within 2 weeks, it will do so without a hypertrophic (red, raised, rigid) scar or functional impairment, but can result in long-term pigment changes. If healing takes more than 3 weeks, hypertrophic scarring inevitably results and can lead to functional impairment (Greenhalgh, 2007). As a general rule, the depth of the burn is usually underestimated at initial presentation (Sheridan, 2002), and the burn is rarely of uniform thickness (Johnson, 1994).

Epidemiology of Patients with Burns

The majority of burns are caused by scalding, fire, or hot surfaces (Forjuoh, 2006). Worldwide, burns in the under-5 age group account for a quarter to a half of all burn injuries treated in burn centers (Ansari-Lari and Askarian, 2003; Komolafe et al., 2003; Laloe, 2002). The majority of burns to young children occur as accidents in the home environment (Ansari-Lari and Askarian, 2003; Hemeda et al., 2003;

Laloe, 2002; Van Niekerk et al., 2004), while adult burns occur in the home, workplace, and outdoors in approximately equal proportions (Forjuoh, 2006). Most regions report scalds as causing the majority of burns to young children and the elderly (Al-Shehri, 2004; Ansari-Lari and Askarian, 2003; Belba and Belba, 2004; Dewar et al., 2004; Forjuoh, 2006; Tarim et al., 2005; Van Niekerk et al., 2004). Flammable liquid burns are common from cooking accidents in developing countries and in adolescent and young adult boys experimenting with petrol and other accelerants (Henderson et al., 2003). Burns from house fires or clothing ignition generally produce the most severe and lethal injuries (Forjuoh, 2006). Low socioeconomic status of the family and low educational level of the mother are the main demographic factors associated with a high risk of childhood burn injury (Ahuja and Bhattacharya, 2004; Van Niekerk et al., 2004). Nonaccidental burn injury (i.e., abuse) is present in a higher proportion of families with a single parent, a younger mother, a low income, or an unemployed parent (Brown et al., 1997).

Settings

The overall care of clients with burns depends on the depth and extent of the injury, their age, the degree of wound healing, the presence of infection, and the psychosocial status of the client and family. Therefore, a multidisciplinary team is required to ensure that every aspect of the client's physical, psychological, and social needs is met during hospitalization and following discharge. Complex social issues often affect the delivery of a client's care, and therefore require skilled personnel to manage adjustment to hospitalization (Phillips and Rumsey, 2008). Often, for reasons of managed care or distance, clients with burns are referred to their local service providers for regular follow-up upon discharge, with less frequent reviews by the specialist burns unit. Therapists working outside a specialist burns center are encouraged to consult closely with their colleagues within the specialist units for advice and support in burn client therapy management (Simons et al., 2003).

The Role of the Occupational Therapist in Applying the Intervention

The occupational therapist (OT) is an integral part of a multidisciplinary burn team. The OT will be involved from the time of admission to the hospital to assess and treat impairment to body structures and function (e.g., contractures and scarring), as well as facilitating clients' ability to participate in meaningful occupation throughout their recovery to scar maturation and beyond.

Results

Clinical Application

This section describes three interventions provided by occupational therapists in burn care: splinting and positioning, edema management, and scar management.

Splinting and Positioning

Appropriate splinting and positioning, whereby tissues are maintained in an elongated state, are fundamental to the prevention of contractures, compression neuropathies, and decubitus ulcers following burn injury (Spires et al., 2007). Skin requires sustained mechanical stretch to facilitate alignment and lengthening of collagen and other fibers (Richard and Ward, 2005). The splinting protocols commenced by Willis (1969) continue as the basis for therapeutic intervention today.

Contractures, that is, the inability to perform full range of motion (ROM), result from factors such as limb positioning, duration of immobilization, and muscle, soft tissue, and bone pathology, placing the person with a burn injury at risk of secondary medical and functional deficits (Fig. 11.1) (Schneider et al., 2006). Joints overlaid by deep partial-thickness or full-thickness burns are at high risk for developing contracture. Contractures are a common problem following burn injury, and have been reported in up to 42% of patients receiving burn care (Esselman et al., 2006). The shoulder, elbow, and hand are most commonly affected (Schneider et al., 2006).

Minimizing contractures generally involves positioning of the actual joint. Positioning promotes extension and abduction (Fig. 11.2). Specific injuries require an individualized approach (Richard and Staley, 1994). A splinting or positioning device may be required for the prevention of ankle contractures during prolonged bed rest and also when exposed tendons require protection (Spires et al., 2007).

Splinting of the burned area may be undertaken using a range of media (foam, thermoplastics, neoprene) (Richard and Staley, 1994). The time needed for use of both pre- and postsurgical splinting depends on factors such as the client's age, the length of time since burn injury, and the severity of the deformity (Esselman et al., 2006). Prolonged *static splinting* is required following skin grafting procedures, but therapy should be started within 2 to 3 weeks with the splint removed for each session. Six weeks after the surgery, night splinting alone should be sufficient and may need to be continued for 1 or 2 years (Schwarz, 2007). If full ROM is not maintained, a program of stretching is recommended. A *positioning and splinting schedule* is developed for each client by the OT in collaboration with the burn team. Once the acute phase is over, occupational and physical therapists monitor and modify exercises and splints to maintain functionality until the reconstructive phase begins. At that time, prosthetic and orthotic devices and splints focus on rehabilitating the patient, with an emphasis on activities of daily living (Latenser and Kowal-Vern, 2002; Richard and Staley, 1994).

Fig. 11.1 Contractures to wrist and fingers because of hypertrophic scarring.

Fig. 11.2 Antideformity positioning from the onset of burn care.

Considerations for Treatment

The centripetal movement of skin peripheral to the wound is thought to increase tension in surrounding tissue, which decreases tissue reserves and makes the tissue that remains less responsive to elongation. The deleterious effects of these natural biologic occurrences are further compounded when extremities are not positioned appropriately (Richard et al., 1996). When contracture is present, a sustained force to tissue will produce tissue elongation and a subsequent plastic change in length, resulting in improved range of movement. Treatment intensity is determined by scar blanching (the clinical sign that the tissue's yield point is approaching) and tolerable pain (Spires et al., 2007). Gentle, prolonged stretch to healing tissue at its longest tolerable length for at least 6 to 8 hours per day is most effective (Chapman, 2007). The joint needs to be moved slowly and repeatedly to its end range several times before applying a prolonged stretch, which is maintained until the tissue blanches (Spires et al., 2007).

Splints must be "user-friendly," as poorly applied splints can cause nerve injury, loss of skin grafts, and worsening of a burn wound. An effective splint avoids pressure over bony prominences and is compatible with wound dressings and topical medications. Splints fabricated of re-mouldable materials can be modified, as the client's needs change. Factors to consider when prescribing a splint include the area of the body injured, extent and type of injury, the functional goal being addressed, and patient cooperation (Spires et al., 2007).

Evidence-Based Practice

There is much evidence, predominantly level IV studies (Edlund et al., 2004), which demonstrates that splinting is common practice, frequently used at the time of admission to the burn unit, for full-thickness burns and after grafting (Esselman et al., 2006). When compared with a multimodal approach (massage, exercises, pressure), those treated with progressive treatment, including static or dynamic splints and serial casting, required significantly fewer days to correct the contractures (Richard et al., 2000).

Edema Management

Edema is an interstitial protein-rich substance that forms a gel-like consistency and impedes vascular clearance. The superficial lymphatic plexus resides within the dermal–epidermal junction; therefore, deep partial-thickness and full-thickness burns can cause impairment to the superficial or deep lymphatic system. Edema arises from the lymph vascular safety system being exceeded, or lymph transport capacity being compromised (Hettrick et al., 2004).

On admission to the hospital, the severely burned client requires fluid resuscitation, which increases edema in the extravascular space that can limit joint motion (Latenser and Kowal-Vern, 2002; Spires et al., 2007). Edema develops within 8 to 12 hours after burn injury and peaks at approximately 36 hours. Failure to reduce edema in the first 48 to 72 hours can result in a fixed deformity (Richard and Staley, 1994).

Edema management is especially important with hand burns due to the dependent position of the hand (Esselman et al., 2006). Lymphedema, that is, chronic edema that is sustained for more than 3 months, is a rarely reported complication associated with burn injuries. Risk factors for lymphedema development include circumferential extremity involvement and fascial excision (Hettrick et al., 2004).

Considerations for Treatment

In the acute phase, *edema reduction* is pursued by elevation of the extremities above heart level. Elevating the hand and arm is accomplished using splints, bedside troughs, or similar devices (Richard and Staley, 1994). Web spacers (i.e., strips of foam/dressing product/molds) can be placed between digits to prevent fluid collection and edema formation (Latenser and Kowal-Vern, 2002) and elasticized bandages are used to decrease edema (Esselman et al., 2006). Exercise of the burned body parts helps to maintain joint mobility and muscle function (Latenser and Kowal-Vern, 2002). If the patient is alert and able to participate, a program of active and active-assisted exercise is appropriate. In obtunded or critically ill patients, passive range-of-motion exercises that emphasis the outermost wrinkle of the joints are prescribed to reduce contractures and functional loss.

Immediately following autografting, active and passive exercises are not performed on the limb. Depending on the type of graft, the condition of the graft wound, and the judgment of the surgeon, no exercise is performed for approximately 3 days on mesh grafts and 5 days for sheet grafts. Heterografts, synthetic dressings, escharotomies, and surgical debridements are not contraindications to exercise (Spires et al., 2007).

Wrapping burned extremities with elastic bandages when the patient is sitting or ambulating contributes to a decrease in edema and is used to avoid venous pooling, which can lead to graft sloughing (Spires et al., 2007). Should lymphedema be present, it can be managed with specific manual techniques, special bandaging and compression wraps, and remedial exercise (Hettrick et al., 2004).

The OT, in conjunction with the physiotherapist, is generally responsible for providing a positioning program, as well as either a passive or active exercise program from the day of admission until patients are fully mobilized and exercising (Latenser and Kowal-Vern, 2002). The OT enables clients to complete their daily functional tasks independently. Using assessment tools with demonstrated reliability the OT looks for (1) the presence of edema or lymphedema, such as the “figure of 8 method” (Maihafer et al., 2003; Pellecchia, 2003); (2) deepening of skin folds; and (3) absence of visible venous alterations and Stemmer’s sign (Hettrick et al., 2004).

Education and communication among all burn team members, clients, and caregivers are necessary if an effective positioning and exercise program is to be successful (Richard and Staley, 1994).

Evidence-Based Practice

To date, evaluations of edema management techniques are predominantly based on case reports (Esselman et al., 2006). Further research would benefit from a scrutiny of the methods in both adult and pediatric populations, as well as focusing on the relationship between impairments to body structures and functions, and participation in a broad range of activities post-burn injury.

Scar Management

Hypertrophic scarring is caused by proliferation of dermal tissue following skin injury (Aarabi et al., 2007). Scar is considered immature if it is red, raised or rigid, and mature when it is nonvascular, flat, pliable, and soft. Approximately 1 to 3 months after healing of deep partial-thickness or full-thickness burns, hypertrophic scarring typically appears and may create a wide range of cosmetic and functional problems. The inflexibility of the scar may limit motion of the joint or soft tissue (Spires et al., 2007).

Scar management interventions include compression and the use of silicone. The use of pressure as a major treatment modality for scar suppression commenced in the early 1970s, following observed improvements of scarring with the use of a pressure garment (Macintyre and Baird, 2006). The use of silicone gel sheeting started in 1981, with treatment of burn scars (Perkins et al., 1983). The first silicone applications (elastomers) were individually made as a pressure device or pad to solve concavity problems under pressure garments (Malick and Carr, 1980).

The purpose of scar management is to prevent the development of impairments of body structures and functions from scarring, edema, or musculoskeletal changes, and to remediate or compensate for musculoskeletal or neurologic deficits. The estimated prevalence of hypertrophic scarring varies due to many factors but is reported as high, ranging from 32% to 67% in individuals with severe burn injury (Bombaro et al., 2003; Esselman et al., 2006). Wounds that need more than 10 to 14 days to heal are at risk of developing hypertrophic scarring and are therefore treated prophylactically (Chapman, 2007).

Considerations for Treatment

Pressure garments are typically introduced as soon as the patient is able to tolerate pressure (Fig. 11.3). The use of pressure in the pregrafting or healing stages has been advocated by some authors to prepare the wound bed and assist graft retention. Compression to healed wounds can prevent raised scarring if applied early and can accelerate scar maturation (Chapman, 2007; Van den Kerckhove et al., 2005). Garments are to be worn continuously for at least 23 hours, removed only for hygiene purposes and laundering. Pressure is continued until scar maturation has occurred, which generally takes up to 6 to 18 months, and in exceptional cases up to 5 years (Chapman, 2007; Macintyre and Baird, 2006). Commonly a silicone Silastic sheet, gel sheet, or pad is used in combination with a pressure garment. Inflatable silicone inserts are available in which the pressure on the scar can be adjusted using a pump (Van den Kerckhove et al., 2001).

Fig. 11.3 Custom-made pressure garments are measured and fitted when the child's skin is able to withstand pressure and edema has resolved.

Garments should extend at least 5 cm (2 inches) beyond the margins of the scar(s) in order to apply an even pressure. Where it is difficult to provide pressure, such as at the web spaces between fingers, additional inserts of silicone or moldable materials are required to ensure an intimate fit (Spires et al., 2007). Silicone gel sheeting is ideally applied up to 24 hours per day from when epithelialization (i.e., healing) has occurred until the scar matures. The recommended initial duration of the treatment is 12 hours/day, particularly when it is used in combination with pressure, on children or in warm weather or climates. Strict guidelines are necessary for cleaning and disinfecting both the product and the skin. Gel sheeting may be stabilized at the edges with tape to prevent slippage and displacement during body movement (Van den Kerckhove et al., 2001).

The OT prescribes a pre-fabricated pressure garment. The fit of the garment is assessed regularly, and adjustments are made or new garments are supplied to ensure that adequate pressure is maintained (Macintyre and Baird, 2006). A reduction in the pressure of the garment is more significant over the first month of wear for garments that provide pressure >20 mm Hg (Van den Kerckhove et al., 2005). It is generally recommended that the garment be replaced every 2 to 3 months (Esselman et al., 2006).

Complications from compressive garments have been reported as wound breakdown, skeletal deformation, growth retardation, and obstructive sleep apnea

(Bourget et al., 2007; Rappoport et al., 2008). Complications from silicone gel sheeting (rash, ulcer, erythema, and pruritus) have been reported by some authors in over 50% of cases (Rayatt et al., 2006). While these complications are more common in children and when the gel is kept in place with pressure garments or adhesive tape, they usually resolve when the therapy is stopped temporarily or with hygiene measures (Van den Kerckhove et al., 2001).

Evidence-Based Practice

Hypertrophic scarring is collagen arranged in random orientation with whorls and nodules. Mechanical pressure facilitates the alignment of collagen fibers in a more parallel, normal orientation (Spires et al., 2007). Additionally, it is widely believed that pressure controls collagen synthesis by limiting the supply of blood, oxygen, and nutrients to the scar tissue, and reduces collagen production to the levels found in normal scar tissue more rapidly than the natural maturation process by replacing the pressure exerted by the destroyed skin on underlying tissues. A common belief is that the application of pressure alleviates the itchiness and pain associated with active hypertrophic scarring (Macintyre and Baird, 2006). Silicones are entirely synthetic polymers generally based on a dimethyl siloxane monomer and contain a repeating unit of structure. They have a silica-derived backbone and organic groups such as SiOC chains attach directly to a silicon atom via silicon carbon bonds (Van den Kerckhove et al., 2001). The working mechanism of silicone is unclear but the effects may be mediated through the pressure therapy principle (optimizing pressure) and hydration of the scar, due to a diminished water vapor loss through the silicone pad. It is thought that hydration should also benefit joint motion when used over a burn wound contracture due to diminished mechanical stress on the tissue (i.e., less tension or traction in the wound) (Van den Kerckhove et al., 2001). Little scientific evidence regarding the clinical effectiveness of pressure therapy has been reported, but a large body of dermatologic/histologic, clinical, and anecdotal or case-study evidence supports its use (Macintyre and Baird, 2006). When objective measures of scar thickness and erythema were considered with patients randomized to high-pressure/low-pressure groups, it was reported that garments must deliver a pressure of at least 15 mm Hg to accelerate scar maturation (Van den Kerckhove et al., 2005). Studies that randomized patients to pressure/no pressure or to high-pressure/low-pressure treatment and used a subjective measure (number of days pressure therapy required) reported no difference between the two groups (Chang et al., 1995).

Trials evaluating silicone gel sheeting as treatment for scarring are of poor quality and highly susceptible to bias. Weak evidence exists of a benefit of silicone gel sheeting as a prevention of abnormal scarring in high-risk individuals. When compared to no treatment, silicone gel sheeting reduced the incidence of hypertrophic scarring in people prone to scarring (relative risk [RR] 0.46, 95% confidence interval [CI] 0.21–0.98) and improved scar elasticity (RR 8.60, 95% CI 2.55–29.02)

(O'Brien and Pandit, 2006). Silicone gel sheeting has also been reported to effectively reduce thickness, pain, itchiness, and pliability of severe hypertrophic scarring in a Chinese population ($n = 45$). Objective measures of pigmentation and scar thickness and subjective measures of scar appearance, pain and itchiness, were used (Li-Tsang et al., 2006).

Additional studies to understand the prevalence and risk factors for the development of hypertrophic scarring are required. It is currently not known how pressures exerted on the surface of the body are diffused into the underlying tissue (Macintyre and Baird, 2006), nor is there clear scientific evidence that pressure therapy is effective for the treatment of hypertrophic scarring or what the optimal pressure to be applied is (Esselman et al., 2006). Further randomized trials are needed in this area.

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