Prevention and Surgical Management of Postburn Contractures of the Hand

Duretti T. Fufa · Shiow-Shuh Chuang · Jui-Yung Yang

Published online: 28 November 2013
© Springer Science+Business Media New York 2013

Abstract In addition to burn surgeons, skilled nurses, and therapists, hand surgeons are a key part of the multidisciplinary team caring for patients following thermal injury to the hand. Despite appropriate initial treatment and compressive therapy, contractures are common after deep burn. The most common and functionally limiting are web space and hand contractures. Web space contractures can be managed with excision followed by local soft tissue rearrangement or skin grafting. The classic burn claw hand deformity includes extension contracture of the metacarpophalangeal joints and flexion contractures of the proximal interphalangeal joints. The mainstay of management of these postburn contractures includes complete surgical release of scar tissue and replacement by full-thickness skin graft. In cases in which scar contracture release results in major exposure of the tendons or joints, distant tissue transfer is required. This review focuses on prevention and management of late sequelae of thermal injury to the hand focusing on contractures of the webspaces and hand.

Keywords Burn · Hand · Contractures · Reconstruction

Introduction

The hands account for less than 5 % of total body surface area. Despite this small percentage, many burns requiring hospitalization involve the upper extremity [1, 2•]. Hand burns are

considered severe injuries by the American Burn Association and should be referred to specialized care centers to minimize sequella of thermal injury including nail deformities, hypertrophic scars, boutonniere deformity, digit loss, and contractures [2•]. The Chang Gung Memorial Hospital Burn Unit in Taiwan treated 4129 burn admissions from 2003–2012. Of these, 31 % (1271) involved burns to the hand. The most common burn mechanism was scald burn, followed by flame, chemical, and electric. Children less than age 10 accounted for 68 % of the hand burn admissions. Of 1271 hand burn admissions, 53 % (675) required surgical treatment for debridement or skin coverage procedures.

Serial clinical evaluation by an experienced burn or hand surgeon remains the gold standard for determination of depth of hand burn injury. First-degree and superficial second-degree burns heal satisfactorily within about 2 weeks with good functional and aesthetic results. Deep second-degree (partial-thickness), third-degree (full-thickness), and fourth-degree (tendon, bone, nerve, or joint involvement) burns take longer than 2 weeks to heal, predictably produce scar and contractures, and may require operative debridements and wound coverage procedures [3].

Following documentation of hand burn depth and adequate fluid resuscitation, principles of acute hand burn management include escharotomy and/or fasciotomy (in cases of circumferential full-thickness burn), early wound coverage, positioning, functional splinting, and early supervised motion [1, 3–5]. The burned upper extremity should be maintained in an elevated position and splinted with the metacarpophalangeal joints in flexion and interphalangeal joints in extension. A multidisciplinary approach including burn and hand surgeons with occupational and physical therapists is ideal. In the subacute phase, maintenance of motion, compressive dressings, and scar management (massage, silicone sheet compression) are the mainstays of treatment. Despite appropriate early management and scar therapy, thermal injury to the hand can

D. T. Fufa (✉)
Hospital for Special Surgery, 535 E 70th Street, New York,
NY 10021, USA
e-mail: fufad@hss.edu

S.-S. Chuang · J.-Y. Yang
Chang Gung Memorial Hospital, 5, Fu-Hsing Street, Kweishan,
Taoyuan 333, Taiwan

Fig. 1 Clinical photograph and radiograph of a severely contracted hand in a pediatric patient demonstrating malalignment of the thumb ray secondary to contracture

result in several sequelae. The most common sequelae include nail deformities, digit loss, hypertrophic scars, boutonniere deformity, and contractures [6]. The most complex and functionally limiting of these sequelae include web space, flexion, and extension contractures and are the focus of this review.

Clinical Presentation

The majority of deep dermal and full thickness burns involve the dorsum of the hand. This is due both to the natural response to use the hands to shield the face and body and distinct properties of the palmar vs dorsal skin. Dorsal skin is more thin and pliable and the extensor mechanism lies just deep to a thin layer of subcutaneous tissue. The glabrous skin of the palmar surface, on the other hand, contains thicker skin and subcutaneous tissues. Additional fibrous septae, as well as the palmar fascia, protect the flexor tendons. For these reasons, the dorsal skin and extensor mechanism are more susceptible to contractures than the palmar skin. Hand burns in children may follow different patterns. The mechanism of injury in children more commonly

involves the child touching a hot object or submerging the hand in a hot substance. Therefore, postburn flexion contractures are generally seen in the young population.

Extension contractures of the metacarpophalangeal (MP) joint have been classified by Graham [7•]. Type I contractures demonstrate more than 30° of passive flexion with the wrist in maximum extension, but are limited to less than 30° with the wrist in maximal flexion. This degree of contracture is anatomically limited to the skin. Type II contractures fail to reach 30° of passive flexion even with the wrist in maximal extension. These contractures involve scarring of both the skin and MP joint capsule. Type III contractures are the most severe and the MP joint position is fixed regardless of wrist position. Contractures of this degree also include bony or articular abnormalities (Fig. 1). Use of these physical examination findings can aid in surgical planning to inform the surgeon if superficial soft tissue procedures will suffice or if capsular procedures will also need to be used. The most severe dorsal hand burns result in a claw hand deformity with the MP joints in rigid extension and proximal interphalangeal (PIP) joint flexion contracture (Fig. 2). Severe contractures may also extend to the wrist. Wrist contractures usually only involve the skin without deeper capsular or bony structures, except in chronic or severe cases.

Postburn contractures also involve the webspaces and can lead to substantial functional and aesthetic deformity. Web contractures may involve the dorsal web, palmar web, or interdigital space (so-called burn syndactyly) [8] (Fig. 3). These contractures affect the normal 45° dorsal slope and palm-to-finger ratio in predictable ways. Web contractures of the thumb may involve only skin, or in more chronic settings, also include fibrosis and shortening of the adductor pollicis [9]. Severe and chronic cases soft tissue contractures may have underlying bony abnormalities, so we routinely recommend radiographic evaluation prior to determination of a treatment plan.

Fig. 2 Burn claw hand deformity demonstrating MCP joint hyperextension and PIP joint flexion

Fig. 3 Webspace contractures: **A**, Thumb web contracture; **B**, Syndactyly-type digit contractures

Treatment

Prevention of Hand Burn Contracture

At the time of initial treatment, the hand should be splinted in an “anti-deformity” position with the wrist extended 20°–30°, MP joints flexed 70°–90°, interphalangeal (IP) joints fully extended and thumb maximally abducted. Hand elevation with the shoulder abducted decreases edema and can further prevent contractures of the shoulder web in cases of more extensive burn (Fig. 4). We initiate an early supervised passive motion protocol within the first 2 weeks following acute surgical management. At this early sub-acute time period, patients are fit for pressure garments. Silicone sheets are particularly useful to apply pressure to the dorsum of the digits and webspaces (Fig. 5). These therapies decrease scar formation through an effect of pressure as well as creating a state of relative hypoxia [2•]. Compressive garments should be worn a minimum of 23 hours daily for at least the first 6 months to 1 year following severe hand burn. Despite adequate early rehabilitation and scar management, debilitating deformity still develops in severe burns.

Fig. 4 Axillary splint

Indications for Surgical Release

Allowing for full scar maturation, the aforementioned rehabilitative strategies are generally carried out under close supervision of physical and occupational therapists for one year prior to considering reconstructive surgery [10]. Persistent functional limitation despite therapy is the indication for surgical treatment of postburn contractures. The definition of functional limitation may be distinct for each patient based on his or her personal and professional requirements and may even include aesthetic considerations. Early surgical

Fig. 5 Wrist and finger splints and web compression splints

Fig. 6 Before and after-z-plasty for release of interdigital webspace contracture

intervention (prior to 1 year following burn injury) is undertaken in the presence of a substantial contracture and functional deficit combined with a 2-month plateau in progress with therapy. In the majority of cases, we avoid performing reconstructive surgery on a scar that has not fully matured.

Surgical Management Web Space Contracture

Postburn webspace contractures thumb and digits are common after conservative management of hand burns [11••]. Contractures of the first webspace are of particular functional importance because of their impact on thumb abduction and circumduction. In addition to skin contractures for which a host of standard z-plasties and web deepening procedures can be used (Fig. 6), further consideration should be given to the possibility of muscle contracture or fibrosis requiring releases

in chronic cases. In such cases, local soft tissue may not be sufficient, and require the addition of soft tissue in the form of skin grafts, local or distant tissue transfer.

Our typical surgical management of first web contracture begins with selection of a local tissue rearrangement based upon the specific case. If this fails to provide adequate span of the first webspace, we perform additional release of the first dorsal interosseous muscle. Small resultant defects may be treated with full-thickness skin grafting (FTSG) from the groin or in cases in which the surrounding soft tissues are healthy, a first dorsal metacarpal artery flap from the dorsum of the index finger [12]. However, given the importance of the thumb web, in cases of severe contracture in which local soft tissue is obviously insufficient or if there is joint exposure after release, we choose to augment the local environment with free tissue transfer to minimize the chance of subsequent recurrence (Fig. 7) [13–15].

Fig. 7 Electric burn to the first webspace treated with free lateral arm flap

Fig. 8 Severe burn syndactyly

Contractures of the second-fourth web can be categorized as primarily affecting the dorsal web, palmar web, or interdigital space, leading to syndactyly [8] (Fig. 8). These deformities are of both functional and cosmetic consequence. Our surgical approach to interdigital web space contractures differs based on the degree of involvement. The palmar margin of the web space normally extends to the middle of the proximal phalanx. For contractures in which the distal margin of the web lies between this normal position and 75 % of the length of the proximal phalanx, we can typically reconstruct the web using local tissue rearrangement. If the interdigital contracture extends beyond 75 % of the length of the proximal phalanx, we use a dorsally based hourglass flap for web space reconstruction [16]. Following web reconstruction, particularly when skin grafts have been used, postoperative compression is essential to prevent recurrence.

Fig. 9 Z-plasty for release of wrist scar contracture

Surgical Management of Burn Claw Hand

Surgical management of classic burn claw hand deformity involves wide surgical excision followed by soft tissue coverage for the resultant defect. The pathology involves the metacarpophalangeal, proximal interphalangeal and distal phalangeal joints. As a result, surgical release must address each of these levels, accurately identify the depth of involvement (skin, joint capsule, and/or bone), and use appropriate techniques to insure complete release. We prefer to use soft tissue releases to capsulectomy of the MCP joint where possible. Tendon lengthening of the extensor pollicis longis, brevis, and extensor digitorum are rarely used.

Once adequate release has been achieved, the resultant soft tissue defect can most often be resurfaced using full thickness skin graft. The groin provides both a large area for donor tissue with a discrete surgical scar. We prefer full thickness skin grafting to split thickness grafting due to less secondary contracture postoperatively [17, 18]. Free tissue transfer is rarely utilized, except in cases in which there is severe tendon or bone exposure or in cases in which the remaining soft tissue bed is unlikely to provide adequate blood supply for graft take.

We avoid wire fixation of the joints in the positions of maximal MCP joint flexion and IP joint extension if possible due to the desire to initiate early range of motion. However, in cases of very severe or recurrent contracture or of incomplete surgical release, may be employed to help maintain correction. On deflating the tourniquet prior to FTSG, we ensure

meticulous hemostasis to allow for graft take and to minimize postoperative swelling that may limit motion and promote scar contracture recurrence. In addition, it is important to check circulation of the all digits. Full-thickness skin grafts are covered with bolster dressings.

Wrist contractures may occur over any surface resulting in either extension, or more commonly flexion contractures. They are typically limited in depth to the soft tissues making standard scar management possible. This includes scar excision and z-plasty (Fig. 9). More severe cases may require tenotomy of the flexor carpi radialis, flexor carpi ulnaris and, or palmaris longus [18].

Postoperative Rehabilitation Following Hand Burn Reconstruction

Rehabilitation following delayed hand burn reconstruction is essential and mimics the principles of rehabilitation used following acute injury: splinting and positioning, supervised motion, and use of pressure dressings and garments. All of these methods are initiated by 2–3 weeks regardless of the reconstructive procedure performed. Following FTSG, as soon as the graft shows good take, we initiate full active motion with therapy.

Conclusions

Deep burns to the hand are severe injuries with high potential for scarring and contracture. They should be managed acutely by a team experienced in the principles of determination of burn depth, need for debridement, and knowledgeable about splitting, early motion, and compressive therapy. Despite adequate acute management, functionally limiting contractures may occur. If possible, we delay surgical management of contractures until 1 year after burn to allow for scar maturation. Surgical management of hand and web space contractures is based on aggressive scar excision and replacement with supple tissues (most commonly full-thickness skin grafts). Following surgical management of postburn contractures, rehabilitation for splinting, compressive therapy and motion is essential. In our experience, surgical correction of webspace and hand contractures results in meaningful functional enhancement. The outcomes depend primarily on the severity of contracture. Functionally limiting recontracture is rare in our experience and its best prevented by appropriate therapy.

Compliance with Ethics Guidelines

Conflict of Interest Duretti Fufa declares that he has no conflict of interest. Shiow-Shuh Chuang declares that he has no conflict of interest. Jui-Yung Yang declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by the authors.

Reference

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Tredget EE. Management of the acutely burned upper extremity. *Hand Clinics*. 2000;16:187–203.
2. • Kreymerman PA, Andres LA, Lucas HD, Silverman AL, Smith AA. Reconstruction of the burned hand. *Plast and Reconstr Surg*. 2011;127:752–2011. *An up to date review of acute and subacute management of hand burns with focus on therapy. Also mentions late sequelae with a discussion of reconstructive options.*
3. Stern PJ, Yakuboff KP. Burn contractures. In: Chapman MW, editor. *Chapman's Orthopaedic Surgery* 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2001. p. 1763–80
4. Luce EA. The acute and subacute management of the burned hand. *Clin Plast Surg*. 2000;27:49–63.
5. Cartotto R. The burned hand: optimizing long-term outcomes with a standardized approach to acute and subacute care. *Clin Plast Surg*. 2005;32:515–27.
6. Yang JY, Yang SY, Chen WF. “Onion” flap: a novel technique for reconstruction of burn nail deformities. *J Trauma*. 2012;72: 1424–8.
7. • Graham TJ, Stern PJ, True MS. Classification and treatment of postburn metacarpophalangeal joint extension contractures in children. *J Hand Surg Am*. 1990;15:450–6. *The classic reference describing and classifying contractures of the metacarpophalangeal joint following severe hand burn. Discusses the clinical and treatment implications of the degrees of contracture to guide surgical management.*
8. Gulgonen A, Ozer K. Correction of postburn contractures of the second through 4th web spaces. *J Hand Surg*. 2007;32:536–64.
9. Smith MA, Munster AM, Spence RJ. Burns of the hand and upper limb—a review. *Burns*. 1998;24:493–505.
10. Kurtzman LC, Stern PJ. Upper extremity burn contractures. *Clin Plast Surg*. 1990;6:261–79.
11. •• Kamolz LP, Kitzinger HB, Karle B, Frey M. The treatment of hand burns. *Burns*. 2009;35:327–37. *A detailed review of epidemiology, acute, subacute, and late care of the burned hand. While the focus is on early management, it includes a good discussion of reconstruction of claw deformity and palmar contractures.*
12. Yang JY. The first dorsal metacarpal flap in first webspace and thumb reconstruction. *Ann Plast Surg*. 1991;27:258–64.
13. Tsai FC, Yang JY, Mardini S, Chuang SS, Wei FC. Free split-cutaneous perforator flaps procured using a three-dimensional harvest technique for the reconstruction of postburn contracture defects. *Plast Reconstr Surg*. 2004;113:185–93.
14. Ulkur E, Uygur F, Karagoz H, Celikoz B. Flap choices to treat complex severe postburn hand contracture. *Ann Plast Surg*. 2007;58:479–83.
15. Woo SH, Seul JH. Optimizing the correction of severe postburn hand deformities by using aggressive contracture release and

- fasciocutaneous free-tissue transfers. *Plast Reconst Surg*. 2001;107: 1–8.
16. Salisbury RE, Bevin AG. Burn syndactyly the “hourglass” procedure. In: Salisbury RE, Bevin AG, editors. *Atlas of reconstructive burn surgery*. Philadelphia, USA: W.B. Saunders; 1981. 38: p.180–5.
 17. Mann R, Gibran NS, Engrav LH, Foster KN, Meyer NA, Honari S, et al. Prospective trial of thick vs standard split-thickness skin grafts in burns of the hand. *J Burn Care Rehabil*. 2001;22:390–2.
 18. Beasley RW. Secondary repair of burned hands. *Clin Plast Surg*. 1990;6:319–41.