# Management of Postburn Contractures of the Upper Extremity

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**Postburn contractures of the upper extremity are better prevented than treated, but many patients still suffer from this disability, especially after suboptimal primary care or major burns. Principles applicable to release of postburn contractures of the upper extremity are discussed, with a joint-specific review of relevant techniques to accomplish the release of the contracture. Pre- and postoperative care is discussed. (J Burn Care Res 2007;28:212–219)**

Postburn contractures are distressingly common and severe in developing nations and are a significant problem in developed countries as well. Infants rolling into unprotected fires or explosions of poorly made stoves are the most common causes of these burns in developing countries. Failure to seek medical help, inadequate medical care, and inadequate posthealing care are common causes of burn contractures. Using PubMed, a review of articles published in English-language journals between January 1990 and May 2005 was conducted on all articles related to burn contractures of the upper extremity.

## PRINCIPLES OF MANAGEMENT

### Prevention

Clearly, the best treatment is prevention. Potokar[1] notes that preventive strategies can be primary, secondary, and tertiary. Primary prevention aims at reducing burn incidence through safer cooking methods, fireguards, and education of fire hazards in schools and community settings. Secondary prevention is aimed at reducing the severity of the burn through promoting good first aid practices. Tertiary prevention is aimed at reducing the mortality and morbidity of burns. The mainstay in tertiary prevention is allowing uncomplicated healing of burns whenever possible and using early primary excision and grafting to achieve stable skin cover when not possible.[2] There are two key elements in burn contracture prevention, namely splinting of the burned area in its anatomic position and regular exercises through each joint's full range of motion.[2,3] Kwan and Ha provide an excellent description of the clinical rationale and considerations involved in choosing different splints to apply in upper-limb burns.[4,5] Developments in splints during the past 15 years have certainly contributed greatly in reducing burn contractures, and new advances continue to be described. Schwanholt et al[6] describe a wrist extension/metacarpaophalangeal joint hyperextension splint to prevent contractures in deep palmar burns. Yotsuyangi et al[7] describe a compressive splint that is simple and easy to apply for use following skin grafting of the palm in children. A new type of splint has been described that provides active-resistive movements of the hand while reducing both production time and patient- therapist session requirements.[8] Although no randomized studies on preventive splinting techniques could be found, the anecdotal evidence appears convincing. Government intervention in the form of public education and manufacturing guidelines for stoves, as well as improved primary burn care, are necessary to decrease the frequency of burns and subsequent burn contractures. Mani and Chhatre[3] note that the incidence of burn contractures have decreased dramatically in the West as the result of improvements in the aforementioned factors.

### Preoperative Considerations

Burn contractures, especially severe ones, have a tendency to recur without adequate intra- and postoperative care.[9] The management strategy must be directed at reducing this tendency. Some authors recommend waiting 6 to 12 months before release, but do not support this recommendation with evi-

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dence, whereas others operate earlier.[9–12] Greenhalgh et al[13] have shown that early release is not associated with a worse outcome and argues that waiting for maturation of the scar is not necessary. Early release should especially be performed if secondary deformity is occurring. Waiting at least until the acute burn is healed will presumably decrease the risk of postoperative infection. Some burn contractures can be sufficiently treated by stretching/exercise or serial casting, although there is little literature to support this. Bennett et al[14] describe their serial casting technique with a mean increase of range of motion of 54%. There were minimal complications, it was well accepted by patients and eliminated the need for surgery in 8 of 15 patients. While patients are awaiting surgery, the partaking of stretching exercises and splinting will improve their joint and mobility can allow surgery to be safely delayed until the scar is mature.[14] The amount of release that can be obtained at one time is often limited by associated contractures of joints, tendons, and ligaments. Schwarz and Joshi as well as Stern et al note that the completeness of release that can be expected from a procedure depends on the age of the patient, the age of the burn injury, and the severity of the deformity.[10,15] They also note that the length of time of splinting required and the amount of therapy required after release is dependent on these same factors.

Watson[16] emphasizes that it is important to focus the reconstructive efforts on what the patient desires and requires and not to attempt an over-optimistic goal of normal form and function. Obtaining a more physiologic position with minimal range of motion is not a good functional result in the upper extremity. Long-term hand therapy and follow-up often are not possible in developing countries and emphasis must be given to training the patient and caregiver in the importance and performance of therapy in the home setting.[10] Without this focus, impressive pre- and postoperative photos may not translate into equally impressive functional gains.

## Operative Strategy

Often multiple limbs are involved. Salisbury[17] stresses that it is important for the surgeon to make an overall plan and to perform as many procedures at each operative session as is reasonable to minimize the number of aneasthetics. The recent emphasis on cost reduction has led to the realization that a well-planned surgical program will give cost-savings to the patient and as well will shorten the rehabilitation phase. Several authors have demonstrated that the use of flaps over joints will definitely decrease the recurrence rate because of inclusion of normal skin and subcutaneous tissue, and splinting need not be done more than about two weeks.[18–20] After a graft, the patient's compliance is needed to maintain night splinting and stretching exercises from 6 months to 1 year. Distant flaps in the hand are bulky and give a less than optimal functional and cosmetic result.[21] If the scar tissue is of very poor quality, or the scar is unstable, then excision of this part of the scar is advisable.[2,3]

Specific techniques used are as follows. Many of the recent developments in this field in the last 10 years have come from the Indian subcontinent. Kucan and Bash[9] stress that the well-described reconstructive ladder should be followed, choosing the most simple method that will achieve the reconstructive goals. In order of increasing complexity, the relevant reconstructive methods are Z-plasty, skin grafts, local skin flaps, local muscle flaps, fasciocutaneous flaps, free flaps, and cross-limb flaps.[9] There is considerable evidence that where possible a flap is the best option over the flexor aspect of joints. This concept must be balanced by noting that much of this evidence is recent, and it is unclear how much of the improvement in results is due to the surgical procedure and how much could be the result of improved splinting techniques. No randomized studies have been done in this field.

**Release and Skin Grafting.** The release is usually a fishmouth type of incision.[2] The literature would suggest that the remaining defect is surfaced with full-thickness skin graft if at all possible. Several authors have shown that split-thickness plantar skin grafts will give similarly excellent color matching with minimal contraction.[22,23] Both will give a more durable and cosmetically pleasing result than a split-thickness graft and will be much less likely to contract.[24–26] Large full-thickness grafts can be obtained from the groin or suprapubic areas with minimal donor defect. If the defect is too large, then split thickness skin can be used, but this is definitely second choice.[24–26] One can combine both techniques, using full-thickness graft at the joint line and split-thickness graft adjacent to this.[9]

**Local Flaps.** Perhaps the commonest is the Z-plasty, although the Z-plasty in burns does have a high risk of tip necrosis. This can be avoided by the use of a partial Z-plasty with 90 degree angles (Figure 1). Both Ebbehoj and Goodacre recommend the Y-V or V-Y plasties as safer.[27,28] Other flaps that have been used are transposition or advancement flaps, the trapezoid plasty, the digital island flap, fillet flap, lateral or dorsolateral flap, dorsometacarpal flap, cross finger flap, flag flap, and the adipofascial turnover flap.[2,29–33]

**Regional Flaps.** Flaps such as the radial forearm fasciocutaneous flap, posterior interosseous artery

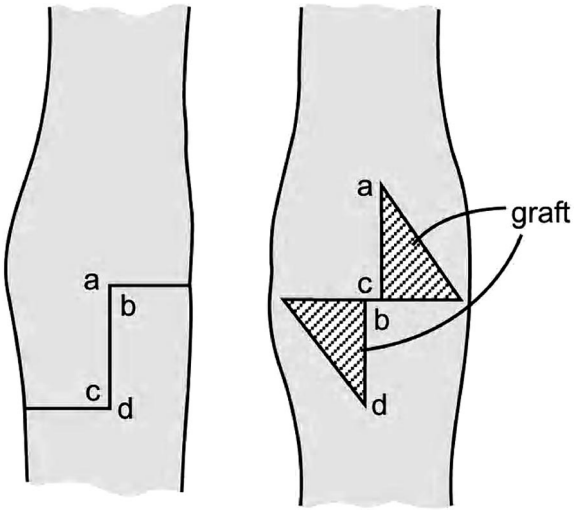


**Figure 1.** Partial Z-plasty with 90° angles.

flap, or latisimus dorsi flap are reliable with minimal donor morbidity.[34–36]

**Distant Flaps.** These flaps are rarely required, and the tissue bulk and the time spent operatively or awaiting vascularization of the flap before division makes these flaps a method of last choice in most instances.[10] These older techniques are being replaced with newer local or regional flaps, or with skin grafts with aggressive therapy. Useful examples would be a groin flap, Louvre flap, abdominal flap, or cross arm flap for hand defects.[30] Free flaps have the advantage of being able to be harvested from a completely unscarred region and have good results reported.[37,38] However, in most cases, simpler alternative techniques can be used.

**Ilizarov Technique.** Gradual distraction of a contracted joint also can be used to restore a joint to its normal position.[39,40] Calhoun et al and Ullman reported the use of the Ilizarov in the burned lower extremity with impressive results.[39,41] However, in a later report, Carmichael et al[42] reported that 69% of contractures recurred at an average of 17 months post treatment. The Ilizarov technique has the advantage of stretching the underlying soft tissues and joint capsule at the same time. Gulati et al[43] report on a 20-year experience on 218 cases with good results. They used external stabilizers for approximately 6 weeks after contracture release to obtain further range of motion of the involved joint. They used it in pediatric patients as well with success. Ilhami et al[44] report the use of this technique on six hands of five patients with severe late burn contractures of the hand who had had an average of five previous unsuccessful prior procedures. Only one hand had a clear functional benefit. Salafia and Chauhan[40] note that disadvantages include the prolonged time required in the devise, the risk of pin-tract infections, and increased expense. Particularly in the hand the prolonged treatment required may lead to stiff joints. Overall, the evidence is equivocal, but this modality of treatment needs further investigation.

## SPECIFIC POINTS BY ANATOMIC LOCATION

### Axilla

Contractures in this area are difficult to manage because of joint stiffness, difficulty in splinting, and the high recurrence rate with inadequate care. They are classified as type 1, which are those limited to the anterior or posterior axillary web, type 2, those involving both webs but sparing the cupola, and type 3, those with obliteration of the axilla.[10,45] The use of a flap is recommended by most surgeons, although Abaidullah and Aslam[46] report excellent results with simple skin grafting and postoperative figure of eight bandaging. Greenhalgh et al[13] also report good results with skin grafting only in 52 procedures, using only night splinting in most cases.

For type 1 or 2 contractures, local flaps will usually suffice.[10] For tight bands with unburned surrounding skin, Hirshowitz and Karey recommend a five-flap release (Figure 2),[47] or a transposition flap can be used as reported by Armstrong.[33] Karacaoglan and Uysal report good results with a seven-flap plasty.[48] For minimal contractures, Goodacre[27] recommends Y-V plasties. When using local flaps in type 2 contractures, the surgeon must be aware that the vascularity of the flaps can be compromised by performing the anterior and posterior fold flaps simultaneously. If in doubt, the flaps should be staged.

For broader contractures or type 3 contractures, fasciocutaneous flaps should have viability equal to muscle flaps with better cosmesis and should be considered the first choice. Medial arm or parascapular flaps are relatively simple with a high survival rate, and also have good functional results reported.[19,33,49]

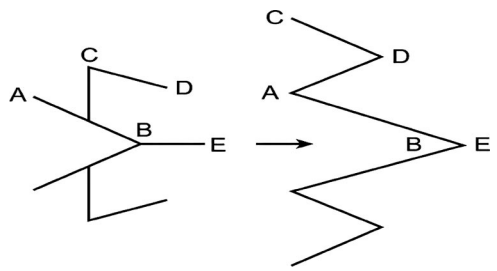


**Figure 2.** Five-flap release.

More recently, the axial bilobed, ascending scapular, and thoracodorsal perforator-based flaps have been described with good functional and cosmetic results reported.[19,50–52] These flaps should be considered if scarring prevents the use of the simpler medial arm and parascapular flaps. Fasciocutaneous flaps with scarred overlying skin can be used, but achieving primary closure of the donor site may not be possible.[46] Hyakusoku et al[53] describe a "propeller flap" with satisfactory results. Tiwari et al[20] note that in the axilla, fasciocutaneous flaps, as opposed to musculocutaneous, do not compromise function, are less bulky and are easier to dissect. They report no recurrences in 30 procedures, although follow-up was short (range, 3–18 months). There is no evidence that muscle flaps produce better functional results than fasciocutaneous flaps. However, in rare situations of severe adduction with the arm attached to the chest wall the latissimus dorsi or pectoralis muscle flaps can be used.[54,46]

Whichever flap is used, the flap must cover the joint line after which remaining defects on the chest and arm can be skin-grafted. Postoperative splinting is uncomfortable and must be maintained for months afterskin grafting, but necessary for 10 days to 3 weeks only when flaps are used.[20,49] These patients will need prolonged physiotherapy to overcome the shoulder stiffness that is often associated with these contractures, and to prevent recurrence of the contracture. In adults one can expect continuous improvement in range of motion for several months afterrelease.[10,23,27]

## Elbow

These have been classified as negligible, those with less than 10° of extension loss; mild, those with greater than 11–49° extension loss; moderate, those with 50–89° of loss; and severe, those with greater than 90° extension loss.[14] In adults, this joint becomes very stiff and not infrequently two procedures are needed.[10,14] The joint area is best covered with a flap. A thin band can be managed with a five-flap release (Figure 2 and 3) V-Y or Z-plasties.[14] With moderate contractures, a single or multiple bipedicle flap can be used as described by Prakash, where one of the flaps lies over the joint.[55,56] Skin grafting is used to cover the defects above and below the joint. This technique is simple, requires only 6 to 8 weeks of postoperative night splinting, and has a very low morbidity rate because the flap is essentially fully vascularized. This flap has significantly simplified the care of elbow burn contractures and should be considered as the procedure of choice in moderate burn contractures of the elbow. The propeller flap has also been used in the elbow with success.[53]

Stern et al[15] suggest that larger contractures can be managed by a forearm transposition fasciocutaneous flap to cover the joint, and remaining defects above or below the flap can be grafted. Turegan et al[57] also report good results using a reverse lateral arm flap. Yang[58] reports satisfactory results in 11 of 12 patients using a reverse medial arm flap, although all but one of these contractures were less than 50°. Overall, results with elbow releases have a lower success rate than other joints. Stern et al[15] using a variety of techniques, report full extension restoration in 82% in contractures less than 50° and in only 50% in contractures greater than 50°.

Elbow burn contractures are more likely to be complicated by heterotopic bone formation.[15,58–60] The surgeon must be aware of this possibility, diagnose this before any skin contracture release, and plan operative strategy accordingly. Some surgeons perform both the skin release and heterotopic bone release in one sitting, although Ring reports the need for reoperation in 30% of patients.[60] Baux et al recommend two staged procedures.[59]

## Wrist

This joint usually can be released and grafted without exposure of tendons or ligaments, even with contrac-

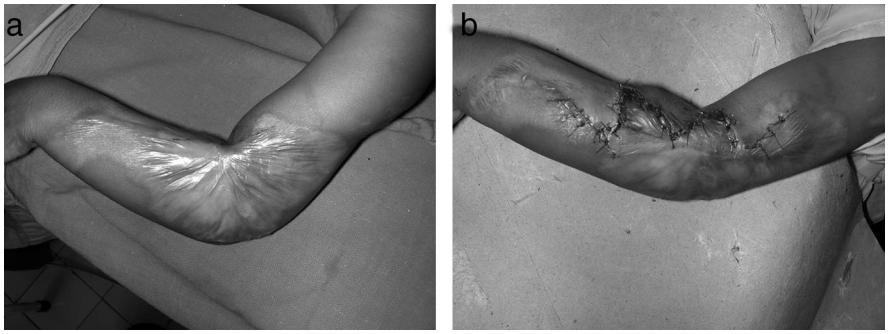


**Figure 3.** (a) Burn contracture of elbow; (b) elbow after five-flap release.

tures of up to 160°.[10] The strong carpal ligament prevents significant bowstringing of deep structures. Tendons are more likely to become exposed with severe dorsal contractures and, if needed, a groin flap will provide good coverage. There is a low risk of recurrence if appropriate splinting is used. Madhuri and Dhanraj[61] report the successful use the Ilizarov technique to correct a severe long-standing wrist contracture.

## Metacarpal Phalangeal Joints

Release of flexion contractures generally will have a high success rate as flexion is the position of safety for this joint and, again, full-thickness or super-full thickness skin grafts will create good results.[10,13]

It is much more difficult to obtain full release from extension contractures. The contracture may be in the dorsal skin, the extensor mechanism, or the joint capsule/collateral ligaments. The collateral ligaments become tight when left for a prolonged period in the extended position, preventing full flexion of the joint even when the skin is fully released. Graham et al have classified metacarpophalangeal (MCP) joint extension contractures as type I (>30° MCP flexion with wrist in maximal flexion), type II (<30°), and type III (>30° of hyperextension).[62] This classification has prognostic utililty, as improvement was seen in 95% of type I contractures, 73% of type II contractures, and 47% only of type III contractures. Surgical options in this situation are as follows:

1. Obtain maximal release of the contracture and then use postoperative physiotherapy/serial splinting to gain further range of motion in flexion. This is generally quite successful, although a second release may be needed.
2. Release of the joint capsule and collateral ligaments at the first procedure. Salisbury recommends capsulectomies of both metacarpal phalangeal and proximal interphalageal (PIP) joints, if necessary, to improve the range of motion, power and dexterity.[17] This may require flap coverage that would require either a groin or radial forearm flap, or raising a flap from the proximal dorsum of the hand which would then cover the MCP joints.[63] The viability of this last flap could be in question due to the poor skin quality. Woo and Seul[64] reports 11 cases of severe postburn dorsal contractures that were corrected with extensor tenotomy, joint capsulotomy, and release of volar plate and collateral ligaments. The soft-tissue defects were reconstructed with various fasciocutaneous free flaps with flap survival in all cases and good functional gains in all but one hand.
3. The Ilizarov system can be used. Gulati et al[43] report the use of the JESS to correct metacarpophalangeal contractures with good results.

Whether dealing with flexion or extension release, the use of K-wires is recommended for 2 to 4 weeks postoperatively, as plaster alone is usually unable to maintain an adequate position.[16,31,62] After this period, aggressive therapy is started with splinting between therapy sessions. By 6 weeks postoperatively, night splinting alone should suffice. In severe contractures in single digits, especially when associated with PIP flexion contractures, amputation may be the best option.[62]

## Interphalangeal Joints

Good results are reported with full thickness skin grafts or split-thickness plantar grafts.[6–13] Small grafts can be obtained from the ulnar aspect of the wrist crease.[65] The digital nerves and vessels are significantly at risk during release and must be carefully preserved.[28] They often tent up somewhat after release, but the graft will easily take over top of them if tie-over dressings are used. A separate release incision for each joint is required. K-wire fixation usually is recommended for 2 to 4 weeks postoperatively,[16,31] although Alexander et al[26] report no improvement in skin graft take and worse functional results with the use of K-wires.

This common practice requires further research. With lesser degrees of contractures, Y-V plasties or Z-plasties can be used with or without skin grafting.[10] Peker and Celebiler[32] reports combining these two techniques with good results in 37 patients.

Occasionally, when tendons are exposed during release, cross finger or side finger transposition flaps may be used with success.[31] A reverse dorsal metacarpal flap has also been reported for cases where cross-finger flaps are not available.[66] With severe contractures, at times a PIP arthrodesis will improve function and decrease pain.[28] Salisbury warns against joint replacement in this situation as they are fraught with hazard due to the poor quality of overlying skin.[17]

## Thumb

Salisbury notes that "the thumb is 50% of the hand."[17] Considerable efforts must be made to fully release the thumb, which in severe adduction contractures may involve carpometacarpal joint release and adductor release. Dmitriyev and Petrov[67] found significant improvement of overall hand function with release of severe thumb adduction contractures.

On the basis of the position of the thumb metacarpal, Stern et al[68] classified thumb contractures in children into four categories: adduction, opposition, extension and flexion. The contractures were further classified as mild, moderate or severe, based on the amount of motion lost. Surgical release was carried out in 108 hands and coverage obtained with local flaps or Z-plasties, skin grafts or a combination of local flaps and skin grafts. They found that extension contractures generally did poorly in comparison with flexion contractures. Severe contractures and those with a subluxated or dislocated joint were associated with worse results. There was a trend towards better results when skin grafts (as opposed to local flaps) were used, especially in the treatment of moderate and severe contractures.

A five-flap release may be used to open the thumb webspace, or simply release the webspace and use a full-thickness skin graft to cover the defect. Other successful local flaps that can be used are the simple Z-plasty, four-flap Z-plasty, modified double-opposing Z-plasty, or rotational flaps from the dorsum of the thumb, index finger, or hand.[67,69] For more severe contractures in which a local flap would be insufficient or unavailable, a forearm flap may be used to give good skin coverage, which can be a reverse flap or a free flap.[29,38,70,71] This can be especially effective for severe webspace contractures.

## POSTOPERATIVE CARE

### Wound Care

After skin grafting, many surgeons will open the dressings at 1 week postoperatively. Schwarz and Joshi[10] report doing the first dressing at 2 to 3 weeks, with near 100% take in more than 90% of grafts in clean cases. This method reduces the postoperative pain associated with dressing changes, and simplifies care and cost significantly requiring less in- and outpatient care.

### Postoperative Therapy

The importance of postoperative therapy in the burned hand cannot be overemphasized. Regular therapy sessions by a cooperative patient are essential to obtain a maximal range of functional motion. During the last 15 years, a much greater awareness has arisen of the negative influence of joint stiffness and pain on final outcome of the hand. Pandya[2] emphasizes the importance of coordinating proposed operations with the involved hand therapist. Adequate pain control is necessary during these sessions. Chronic pain is a common problem and interferes with successful therapy.[17] Acute pain after the release of a burn contracture is universal and likewise slows the return of mobility of the hand. Both acute and chronic pain must be adequately controlled with analgesics to obtain compliance with therapy.[17]

Prolonged static splinting is required after skin-grafting procedures, but therapy sessions should be started within 2 to 3 weeks after surgery, removing the splint for each session. An excellent description of splinting of the postoperative burned hand is given by Jordan.[5] By 6 weeks after the surgery, night splinting alone should be sufficient and may need to be continued for up to a year,[10,68] and even up to 2 years.[72]

Colditz has reported excellent results with the use of serial splinting in the stiff hand from a variety of causes.[72,73] This therapy technique is time intensive for both patient and therapist, ranging from 4 to 8 or more weeks if the stiffness is longstanding. In the postburn hand this technique would be of most value after skin release to regain range of motion from stiff joints. In the hand, an outrigger device allowing active flexion with passive extension is valuable but difficult to provide in the developing country situation.[72] If a second procedure is required one should wait at least six to 12 months between procedures to allow therapy time to gain maximal improvement of joint range of motion. The increased emphasis on functional outcome in addition to outcomes such as graft take and flap survival is a welcome development. However, few authors have reported on functional measures beyond the range of motion achieved.[74] Tanaka and Harco[75] report on the functional impact of surgical interventions in contractures of the axilla. Gulati et al[43] evaluated the impact of interventions in hand burn contractures using a simple five-point activity of daily living independence scale. Palmieri et al[76] report on the use of three dimensional motion analysis to assess the impact of surgical release on joint movement during activities of daily living. Use of standardized functional outcome measures such as the DASH[77] and the Upper Extremity Function Scale[78] is still lacking and should be used in future studies. Both need to be validated in patients with burn contractures of the hand.

## CONCLUSION

Burn contractures of the hand can produce a significant impact on quality of life by reducing a patient's ability to perform activities of daily living. Appropriate hand therapy combined with timely surgical release will give a much more functional hand. The range of possible procedures available for the reconstruction of the burned hand is considerable and has

increased greatly in the past 15 years. The choice of the correct procedure suitable to the contracture, the patient, and the surgical team must be well considered with all those involved to achieve optimal results. Appropriately timed and selected operations with early postoperative mobilization will achieve optimal functional benefits while keeping morbidity to a minimum. Level 1 and 2 evidence (randomized studies) is essentially lacking in the field of the treatment of burn contractures, and solid research of this level would be a welcome contribution.

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