Management of postburn axillary contractures

ABSTRACT

Many epidemiological studies have revealed the incidence of axillary contractures next only to elbow contractures as sequelae to burn injury. Even if it may be possible to prevent adduction contracture of the axilla through early splinting and range of motion exercises that counteract the position of comfort, it continues to pose a frequent problem to burn surgeons. In the increasing degree of severity, axillary contractures may involve one or both axillary folds and also involve the hair-bearing dome of the axilla. Unless severe functional disability is present, we recommend a minimum 6-month wait following wound healing to allow for scar maturation to achieve better results. In milder presentations, it may be possible to perform Z-plasties, Y–V plasties, or many other local flaps on isolated axillary bands, with the caveat that if the contractile bands are in the midst of scarring, such linear contractures may only be effectively released and resurfaced with skin grafts. While the innovative use of local skin flaps must be encouraged, we recommend a low threshold of using acceptable thickness skin grafts for coverage. Controversy exists on the best technique for axillary resurfacing in severe cases of axillary involvement. While it is relatively simple and expeditious to release the contracture and cover the extensive defect with skin grafts, it requires meticulous postoperative regimen of splinting and physiotherapy. In selected cases, uninvolved adjacent scapular and back areas allow for many fasciocutaneous and myocutaneous flaps for durable long-term results. Free flaps, traditionally less popular in this region, may be an alternative option if areas adjacent to axilla are also involved.

Keywords: Axillary contractures, fasciocutaneous flaps, local flaps, myocutaneous flaps, postburn contractures, skin grafting

INTRODUCTION

Burn survivors are often beset with crippling morbidities from contractures, persistent itch, inferior body image, and interpersonal relationships. Such morbidity from postburn sequelae magnifies the severity of burn injury and qualifies it as a significant public health issue. After surviving the devastating burn injury, the patients face tremendous social, psychological and functional hurdles while seeking employment to integrate into the society. Axillary contractures severely impede the activities of daily living of a burn survivor. It poses a considerable clinical dilemma to the physician to treat this condition with multitude of methods described in the literature. Hence, a practical review is offered with special emphasis on how the decision-making process should evolve when such a patient presents.

PREVENTION OF AXILLARY CONTRACTURES

It is widely accepted by experienced burn surgeons that adduction contracture of the axilla can be prevented through early splinting and range of motion (ROM) exercises that counteract the position of comfort, yet it poses a frequent problem. Although detailed epidemiological studies of the axillary contractures following major burns are lacking in the literature, a review of the records of 1005 patients treated at the Shriners Burns Hospital in Galveston, Texas, over the
past 25 years, indicated that the elbow was the joint most commonly affected. The occurrence of axillary deformities was also high, and there were 248 axillary deformities compared to 397 elbow deformities. Efficacy of splinting across large joint structures such as the elbow, axilla, and knee joints was studied in 1977 by reviewing the records of 625 patients. Out of involvement of 961 cases of burn injuries over the major joints in these patients, 356 cases had involved the axillae, while the elbow and the knee joint were involved 357 and 248 times, respectively. The incidence of contractures in these joints was 7.3% when the patients had worn the splints for 6 months without fail. The effectiveness of splinting was diminished to 55% if splinting was discontinued at any point within 6 months. For comparison, the incidence of contractures encountered in 219 patients who had never worn the splint was 62%. This important study was instrumental in establishing the role of splinting early on in the management of burn injuries.

Management of burn injuries around the axilla involves positioning the shoulder joint in 80°–120° of abduction and 15°–20° of flexion. This position of shoulder abduction and horizontal flexion is known clinically as scaption, and it aids in alleviating stress on the brachial plexus, and in moving edematous fluids away from the distal extremities. This is supplemented with the use of physical therapy by moving the joint actively and passively.

The intermediate period of recovery, usually considered from the 2nd month following the injury through the 4th month, is the time of remodeling/maturation of the scars marked by intense cellular activity. During this period, there is high rate of collagen turnover and gradual increase in the myofibroblast fraction of the fibroblast population in the wound. The contraction of the myofibroblasts is responsible for contraction of the scar tissues, variously described by the patients as “tightening” and “hardening” of the scars. Severe burn contracture and scarring lead to loss of function, joint deformation, and ligament shortening. During this stage, a well-designed splinting program with active and passive mobilization is essential to prevent joint contractures and deformity. An “aeroplane” splint [Figure 1] is most useful to achieve this goal. In the absence of a splint, a figure-of-eight bandage, going around both axillae may be attempted with the same aim.

**CLASSIFICATION OF AXILLARY CONTRACTURES**

Many investigators have proposed different classifications for axillary contractures. Grishkevich classified the contractures into two types: edge contractures caused by a tight web and strip contractures caused by a wide scar. Hallock classified axillary contractures into four types: solitary anterior or posterior web, scar bands adjacent to axilla, and anterior and posterior webs with the cupola spared and total axillary obliteration. Huang et al., using the ROM, classified axillary contracture as mild with <25% loss of ROM, moderate with 25%-50% loss, and severe with >50% loss.

To simplify surgical decisions in managing axillary contractures, Kurtzman and Stern classified them into three types.

- **Type 1**: Contracture involves either the anterior (1A) or posterior (1B) axillary fold
- **Type 2**: Contractures involves both the anterior and posterior axillary folds
- **Type 3**: Contractures involve both axillary folds and the axillary dome.

**GUIDELINES FOR BURN RECONSTRUCTION**

There is a paucity of recent studies or case series in the literature that address the treatment of axillary contractures. The ensuing discussion provides authors’ expert opinion, tempered with the available literature, in a practical review to enable readers to choose appropriately among the multiple options that are available (Level of Evidence – V).

It is pertinent to review the basic tenets of burn reconstruction proposed by Feldman. These guidelines hold true for any part of the body getting treated.

- Analyze the deformity and note distorted and absent tissue
- Generate a long-range plan for reconstruction that establishes priorities and addresses both functional and aesthetic concerns
• Delay reconstruction until the scars and grafts have matured. Use splints and elastic garments to minimize scar hypertrophy
• Release extrinsic contracture before intrinsic contracture
• Orient scars parallel to relaxed skin tension lines
• Identify and ration potential donor site skin
  • Resurface according to regional esthetic units. If possible, adjacent units should be covered with a single large graft to avoid seams between territories
  • Match donor skin according to thickness, color, and texture. Thicker skin grafts produce less postoperative contracture
• Protect new scars and grafts from ultraviolet radiation to decrease the chance of hyperpigmentation.

**Timing of reconstruction**

In burn reconstruction, the deformities that impose functional impairment are tackled before directing the efforts to improve the appearance. Therefore, the limitation of shoulder function receives higher priority than improvement of scarring on the trunk.

Even if there is no exact scientific basis, it has been recommended a “moratorium” of 2 years be exercised for burn reconstruction. It is believed that operating on an “immature” scar characterized by redness, induration, inelasticity, and lack of tensile strength is technically cumbersome with difficult hemostatic control of the wound. A high rate of recontracture noted in instances where partial-thickness skin graft is used for releasing a wound showing active inflammatory processes may support a delay in initiating burn reconstruction till scar maturation. However, if severe functional disability is present, the authors would advocate the early release of contracture, but for other instances, a minimum 6-month wait following healing would produce better results.

**Sequence of contracture release**

The sequence of release in case of extensive body contractures is always from proximal-to-distal. The proximal joint contracture is released separately and completely before going on to the more distal joints. Thus, release of axillary contracture is the starting step before the treatment of concomitant elbow and hand contractures. Similarly, if neck and axillary contractures coexist, the neck contracture should be released and resurfaced in the first stage. It is not advisable to release both the neck and axilla at the same stage because the postoperative splinting after release of axilla compromises the postoperative neck position following release.

**Surgical approach to the release of axillary contractures**

**Type 1 and 2 contractures**

A plethora of local tissue rearrangements have been tried for mild contractures. It is appealing to use local flaps from surrounding skin, as it will not contract with passage of time and it obviates prolonged postoperative splinting. While it may be attractive to perform Z-plasties or Y-V plasties on axillary bands, often the contractile bands are in the midst of scarring and such linear contractures may only be effectively released and resurfaced with skin grafts. Still, occasionally, it may be possible to safely raise thick flaps of mildly scarred tissues for interposition. While the innovative use of local skin flaps must be encouraged, a low threshold of using acceptable thickness skin grafts is advisable.

**Type 3 contractures**

Such severe contractures require copious amounts of skin for resurfacing, whether furnished in form of skin grafts or flaps. Controversy exists on the best technique for axillary resurfacing. Both methods have their relative advantages and disadvantages, but in severe contractures, it may only be possible to use a skin flap in the region of axillary dome with skin grafts to the remaining raw areas. Availability

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**Figure 2:** Photo courtesy Dr. Arun Goel. Lok Nayak Hospital, Delhi. (a and b) A 30-year female with neck, bilateral axillary, and bilateral breast contractures with extensive scarring of the upper trunk. (c) Two-year postoperative results following release of all contractures and upper trunk scarring. The staged contracture release sequence was neck, bilateral axilla followed by bilateral breast, and the entire resurfacing has been achieved by split skin grafts. The released regions were maintained with splintage, pressure garments, and silicone sheets.
of dermal regeneration template reignites the debate on optimal method of burn reconstruction.

Common to all approaches of resurfacing is achieving adequate release by incising the scar at its point of maximal tension. Release of severe axillary contracture also requires releasing the pectoralis or latissimus fascia. Gentle mobilization of the shoulder joint is done to stretch the neurovascular bundle. In long-standing severe contractures, the vessels might go into spasm if the vigorous stretch is attempted. In such cases, a less than optimal release is accepted on the table and postoperative serial, incremental splinting is employed to attain full release of axilla by gentle stretch of the neurovascular structures. Resurfacing such severe cases has to be with split skin grafts to the partially released axilla and the release angle is maintained by a splint. Serial incremental splinting is initiated 2 weeks following surgery to allow skin grafts to stabilize.

**RECONSTRUCTIVE OPTIONS FOR AXILLARY CONTRACTURES**

**Split skin grafts**
All grafting techniques rely on revascularization from the wound bed and require avoidance of shearing forces,
infection, seromas/hematomas, or poor contact. To secure a good contact, a tie-over bolster dressing with cotton or foam/sponge is advisable. Alternatively, a vacuum-assisted closure (VAC) dressing over the skin graft may be employed.

Split-thickness skin graft (STSG) continues to be widely used for axillary contractures [Figure 2] as full-thickness skin grafts (FTSG) of sufficient sizes are often not available.[18] Donor sites are chosen based on availability, size requirements, and color match to the recipient defect. It may be sometimes necessary to reharvest from previous skin graft donor sites. Meshing or pie crusting of the skin graft may be necessary to achieve either graft expansion or to drain seroma/hematoma. As STSGs are prone to graft contraction, poor color match and also lack durability for areas of increased friction like axilla,[19] it has been recommended that a thicker STSG (0.012–0.020 inch) may be used in resurfacing these defects.[4] Postoperative scar modulation techniques, such as pressure therapy and silicone gel/sheeting along with splinting, must be instituted once the graft is securely adherent.[20] The use of FTSG is limited as sufficient donor skin may not be available. Many investigators have used staged tissue expansion of FTSG donor sites when there is a need for a large FTSG.[21] The lower abdomen and inguinal regions are possible harvest sites for FTSG.

Dermal replacements

By providing a thick layer of regenerated dermis, dermal replacements, have the potential to provide all of the advantages of FTSGs without the donor morbidity. Although several options are available, Integra seems to be the one with consistent clinical use.[22-24] Products that consist of processed human dermis (e.g., Alloderm) or a collagen matrix alone (e.g., Matriderm) require take of a simultaneously applied, thin STSG, which can often be problematic, precluding its popular use.[25]

After complete release and creation of resultant defect, the wound edge is overlapped by 2–3 mm of the skin substitute and secured using staples. A VAC device is used to secure it to the recipient bed. The VAC dressing is changed every week till full vascularization is achieved, usually by 4 weeks. The silicone layer is then replaced by a thin (0.005–0.008 inch) STSG. Many authors have reported encouraging results with this technique for contracture release and scar resurfacing.[23,24] The benefits reported include a thicker dermis, improved surface, more pliability, greater durability, less recurrence, and reduced donor-site morbidity. However, apart from a prohibitive cost, the disadvantages include somewhat unpredictable “takes,” the need for a two-stage procedure and a surface without adequate pigmentation, which might make it less acceptable in non-Caucasian races.[23,24]

Skin flaps

Advantages of using flaps in burn reconstruction include restoration of skin characteristics with minimal wound contraction. Absolute indications include poorly vascularized wound bed, exposed vital structures or a site with an unstable scar, or a chronic open wound.[26] Skin and fasciocutaneous flaps are the best choice because they provide thin and pliable replacement in axillary scarring.

Most local flaps of geometric designs incorporate some form of transposition (Z-plasty)[27] or advancement (Y–V) technique[28] or a combination of the two movements (e.g., VM plasty,[29] five-and seven-flap Z-plasty,[30,31] and trapeze flap-plasty[32]). Flaps based on a subcutaneous pedicle (e.g., central axis and its variants like rhomboid, propeller, etc.[33-35]) can also be useful for less extensive joint contractures.

For limited requirements, local skin flaps may even be developed from surrounding areas which may be mildly scarred or skin grafted. It is necessary to raise these flaps thick while maintaining a reasonable length-to-width ratio and limited mobilization.[24]

Z-plasty remains the most popular technique to release linear contracting bands [Figure 3]. Z-plasty lengthens the scar in the direction of the common limb and relocates the scars into a new, less conspicuous (e.g., relaxed skin tension line) position. Serial/multiple Z-plasties are successive small Z-plasties, oriented in the same direction along the line of contracture. This technique uses multiple, smaller flaps, which have a more favorable blood supply than a single large flap. This technique is more desirable if the surrounding skin is scarred or skin grafted. It also distributes the release more evenly along the line of contracture and requires less recruitment from the side.[31,38]

If normal tissue is present around the linear scar band, as in milder contractures, it may be more advantageous to use a four-flap Z-plasty[26] or a three-quarter Z-plasty.[4,5] The advantage of these techniques is that it inserts normal tissue, with normal pliability and elasticity, into the line of scar contracture.

Advancement flaps require significant advancement of tissue resulting in substantial tension.[26] Y–V advancement flaps have been used when sufficient laxity is present perpendicular to the scar contracture axis.[28] It is generally used as a
series of Y–V flaps (running Y–V advancement flaps) and can theoretically result in a length gain of 100%.[36,37]

Five-flap and seven-flap Z plasties have also been described,[30,31] but they have not become popular because of relatively complicated flap design. Recently, Grishkevich has described an ingenious “trapezeplasty” for axillary contractures in a series of 346 axillary contractures in 277 patients with esthetic and durable outcomes.[32]

Ertas et al. described an elegant technique of using subcutaneously based rhomboid flaps, used alone or in series, for the treatment of axillary contractures. They report good reliability of these flaps in preventing recontracture in less severe forms.[33] Hyakusoku et al. summarized their experience, over 15 years, of using subcutaneous based flaps in “propeller fashion” for axillary and cubital contractures.[34] They term the evolution of variations of the technique (propeller flap, multilobed propeller flap, scar-band rotation flap, and pinwheel flap) over time as “central axis flap methods” [Figure 4]. These methods have been recently reviewed, and good long-term outcomes have been reported.[35]

With more severe involvement of axilla, that obliterates the dome, larger local pedicled flaps are indicated. Fasciocutaneous flaps are very useful as they provide tissue of ideal thickness for the reconstructive needs. These flaps can be dependably elevated even on burn-injured skin owing to preserved blood supply in the deep fascia.[36] These flaps may be elevated from the lateral chest, the lateral back, parascapular, cervicohumeral, or thoracoacromial regions. In addition, the posterior upper arm and inner arm can be used depending on the relationships between the scar tissue and the available donor site.[37-44] Parascapular region is especially valuable. Depending on the three cutaneous branches of the circumflex scapular artery, the scapular flap is designed horizontally in the middle scapular region, the parascapular flap obliquely in the lower scapular region, and the ascending scapular flap vertically in the upper scapular region. All can be used for axillary reconstruction.[45,46] The next level of sophistication is provided by islanding these flaps. It increases the reach and avoids the dog-ear at the base of the flap. For example, the scapular island flap utilizing the circumflex scapular artery, a branch of the subscapular artery, as its vascular pedicle can be rotated 180° on this pedicle to inset into the axillary defect after contracture release.[45,46] Similarly, perforator flaps, most commonly based on perforators from the thoracodorsal artery, provide a skin flap from the same region, with greater pedicle length and easier donor site closure.[47] Most of the “central axis flaps” mentioned above, are in fact propeller-perforator flaps[48] in which dissection of perforators is not done, but they still easily permit a 90° flap rotation.

Muscle-based flaps have been described but are not popular because of their bulk and associated morbidity. Historically, the latissimus dorsi (LD) myocutaneous flap was used to cover large defects.[50,51] Free flaps are very rarely employed for axillary contractures. Platt and associates report that of 604 patients who required surgical intervention for burns from 1989 to 1993, only 1.5% needed free tissue transfer.[52] Thin, free-flap options from the anterolateral thigh, scapular/parascapular areas, and radial forearm are most useful in burn reconstruction and may also be used in axilla.[53,54]

SPLINTING FOR AXILLARY CONTRACTURES

Aeroplane splint

The splint can be made of thermoplastic material or aluminum. The spreading angle of the splint is adjusted to achieve maximum shoulder abduction. It is desirable to attain the ideal of 80°–120° abduction after release of the axillary contracture. In a developing contracture, the abduction angle may be less to begin with but the splint angle is increased by serial splinting as the joint abduction increases, to achieve a “nonsurgical release.” Splinting should be maintained for a minimum period of 6 months after maximal abduction is attained. This arbitrary time limit is set to coincide with the time taken for scar remodeling and biomechanical maturation.

In resource-limited settings, an indigenously fabricated aluminum splint using metallic braces and joints can be crafted [Figure 1]. Although heavy and somewhat cumbersome to use, it has the advantage of allowing adjustment of the angle as the scar gets “released” with time. Even a Plaster of Paris aeroplane splint can be used effectively in a severely resource-constrained setup.[55]

A “figure-of-eight” compression dressing

In the past, occupational therapists in resource-limited settings have used an elasticized bandage to wrap around the shoulder joint in a “figure-of-eight” fashion to extend and abduct the shoulder. The dressing was worn continuously and removed only for cleansing.[9] The mobility of the joint increased as the scar tissues across the axilla softened.[4] It often caused skin breakdown and was difficult to apply without expert help.

Limitations of the review

In the absence of recent studies in literature evaluating the treatment modalities of axillary contractures, a systematic
review or meta-analysis was not possible. It is acknowledged that this is a limitation of this review that only provides authors’ expert opinion along with a collation of different publications on the topic.

CONCLUSIONS

Axillary contractures may affect anterior, posterior, or both the folds in the increasing order of severity after survival from major burns involving proximal upper limbs. There is significant restriction of movements with such contractures that affect the activities of daily living. Surgical treatment is aimed at providing lasting and durable release and restoration of range of movements of the shoulder joint. We offer the following recommendations:

- **Type 1 contractures:** Local tissue arrangements based on random pattern flaps such as Z plasty and Y–V plasty
- **Type 2 contractures:** Central axis flaps
- **Type 3 contractures:** Regional flaps such as parascapular flap, LD flap, thoracodorsal artery perforator flap, and split skin grafting in appropriate cases.

Consent for publication

Both the authors provide their consent for publication. Written informed consent of publication of the photos of the patients was obtained from the patient or the guardian.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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