A CLINICAL STUDY
OF AXILLARY
POST BURN SCAR CONTRACTURE

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A dissertation submitted to the Tamil Nadu Dr.M.G.R. Medical University in the partial fulfillment of the requirement for the award of M.Ch. Branch III (Plastic Surgery) degree August 2005-2008

CERTIFICATE

This is to certify that this dissertation titled **"A CLINICAL STUDY OF AXILLARY POST BURN SCAR CONTRACTURE**" is a bonafide work done by **Dr. S. KUMARAN**, in the Department of Plastic and Reconstructive Surgery, Christian Medical College and Hospital, Vellore in partial fulfillment of the rules and regulations of the Tamil Nadu Dr. M.G.R medical University for the award of M.Ch degree (Branch III) Plastic Surgery under the supervision and guidance of **PROF. ASHISH KUMAR GUPTA** during the period of his post-graduate study from August 2005 to Dec 2007

This consolidated report presented herein is based on bonafide cases, studied by the candidate himself

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AIMS AND OBJECTIVES

The aims and objectives of the study are

- To analyze all cases of axillary post burn scar contracture in our Department from August 2005 to Dec 2007

- To analyze the age, sex, side distribution of axillary contracture

- To classify axillary contracture based on type and severity

- To study the various surgical options used for axillary contracture by

    - ❖ Duration of hospital stay
    - ❖ Complication rate
    - ❖ Re contracture
    - ❖ Patient compliance

INTRODUCTION

Post burn axillary scar contracture are common after deep thermal burns to the upper extremities. Because of poor positioning of the axilla during the acute burns period or improper rehabilitation post burn axilla contracture produces both functional and anatomic deformities. Surgical intervention is still a challenge, because the axilla is a unique three dimensional pyramid. It is often seen in our environment following poorly treated burn injuries especially when the conservative approach is the method of achieving cover for a burn wound around the shoulder joint. Post burn axillary contracture almost always interferes with and limits abduction of the shoulder joint. This interferes with the ability to feed and to perform other important upper extremity function. A variety of therapeutic options such as skin grafting, multiple Z plasties, and local flaps are reported in literature for the treatment of axillary contracture. There are also many methods described for post operative splinting of the axilla. A study of post burn axilla contracture was done and analysis of axillary contracture was done based on age, sex, years of post burn, classification of the axilla contracture based on anatomy distortion and on severity of functional limitation, surgical option used and its complications with follow up of patient and patient compliance.

REVIEW OF LITRATURE

Classification of axilla contracture

There are many classifications for axilla contracture. Each classification has its own advantage and disadvantage.

Axilla contractures are broadly classified into two groups:

1. Those involving the hairy dome.

2. Those that do not involve the hairy dome.

Grishkevich classified the contracture into two types[1]:

1. Edge contracture caused by a tight web

2. Strip contracture caused by a wide scar

Achauer classified axillary contracture into four types[2].

1. Anterior or posterior axillary fold only

2. Both anterior and posterior axillary fold with apex spared

3. Involves entire axilla

4. Scars of the axilla and the adjacent areas

Kurtzman and Stern classification[3]

1. Type I A – Anterior axillary fold involved
2. Type I B – Posterior axillary fold involved
3. Type II – Both anterior and posterior axillary fold involved
4. Type III – Type 2 with axillary dome involvement

Hallock's classification[4] –Modified from Salisbury and Berlin[5] into four types

1. Solitary anterior and posterior web
2. Scar bands adjacent to axilla
3. Anterior and posterior webs with the cupola spared
4. Total axillary obliteration

Based on the functional limitation of the upper limb function Huang et al[6] classified the axilla contracture into three types

1. mild less than 25%
2. moderate in between 25% to 50%
3. severe more than 50%

Another functional classification by Hamdy Basha[7]

1. Mild type – limitation of abduction above 150 degree with a linear traction band
2. Moderate type – limitation of abduction was from 120 to 150 degree
3. Severe type – limitation of abduction was below 120 degree

The functional classification has following advantages:

- It prevents the overlap between different degrees of post burn axillary contracture
- Provides idea about the amount of soft tissue loss
- Has prognostic value for follow up

Surgical techniques

5 flap plasty:

This was first described by Hirshowitz[3,9]. Bridle scars of the axilla can usually be corrected by Z- plasties either single or multiple. A four flap Z plasty or a six flap both based on the split Z- plasty of Limberg have also been described. The disadvantage of these techniques is that the incisions encroach on the area of hair- bearing skin at the apex of the axilla which often escapes burning. As a result unattractive tufts of hair grow on unusual sites. The ideal axillary web correction should leave the apex of the axilla intact and in situ and the 5 flap provides this advantage.

Flap design:

The triangular flaps of two Z – plasties and Y-V advancement flap constitute the five flaps and their design is shown in the figure-1(a), 1(b) and 1(c). The flap CDE encloses the apex of the axilla and its tip D lies at the midpoint of the line AB which runs along the ridge of the web. GA and HB complete the outline of the two Z- plasties; the angles 1 and 2 are about 80 degree. The incision DF opens into a triangular defect into which CDE is advanced. The part which is advanced and the only part undermined lies on the under surface

of the web, and thus no change in position of the axillary apex occurs. The length DF is adjusted for the best fit. Because the ridge of the web is curved the angles ADF and BDF are slightly larger than 90 degree and some trimming may be necessary. Most operations for axillary webbing are carried out in children and the problem of displaced axillary hair does not appear until puberty when it can be distressing.

7 flap plasty:

This flap was described for axilla and groin contractures by N.Karacaoglan [9] and A.Uysal.

Technique:

The geometry of the seven flap palsty (Fig 2(a) and 2(b)) consists of two half Z plasties and one W-M plasty. After the release of the contracture the 3, 4, 5 flaps were interdigitated as in W-M plasty and flaps 1,2,6,7 were transposed as in half Z plasty. All of the flaps must be raised with underlying fascia[10] in order to enhance viability.

Seven flap has seven local flaps [11].But the flaps has to designed properly so that the hair bearing skin does not get disturbed. It is ideal for single band contracture because the gain in length achieved is more than 180 degree.

There is more chance of flap tip necrosis since the flaps are small and the fascia has to be included while raising the flaps but it may not be possible in deeply burnt axilla where fascia is also burnt.

Running Y-V plasty:

This flap was first described by Rolf R. Olbrisch[12] in 1991.To lengthen the scar cord , tissue is introduced from the side transverse to the course of the scar in the form of many consecutive push- forward flaps running in opposite directions. These are cut as juxtaposed Y-V flaps. The smaller triangular flap is pushed into the stem of the Y, so that a V is formed. Depending on the length of the Y stem, the lengthening of the scar is modified. The deeper the push- forward flaps can penetrate into the Y stem, the wider its arms are pushed apart to lengthen the scar. The sum of the lengths of the divergent arms obtained in each individual Y-V push-forward flap equals the gain in length of the scar to be corrected.

Flap design: Fig 3(a), 3(b) and 3(c)

A running zigzag line is drawn over the entire extent of the scar cord. Its arm length may be longer than the entire scar. At the tip of the running V-V, the Y stem is now attached with a length that should be at least one – half of

that of the V arms. The incision of the skin passes directly into a transection of the scar tissue, then beneath it into soft fat tissue with normal blood flow or muscle fascia. Any mobilization of the wound margins would be wrong. The wound margins of the scar spontaneously slide apart in a W form on the normal subcutaneous fat tissue, so that the scar appears lengthened with direct slackening in a wound that gapes open over its entire length. Without further reduction in the length of the scar, the lateral tips of the flap are inserted as a push forward flap into the corresponding defect. They slide easily over the entire deep base of the wound. The flap tips with their endangered blood flow do not have to be detached from their substratum or from the attached subcutaneous tissue.

Running Y-V plasty offers several advantages[13,14].

- The scar tissue is completely severed several times and staggered.
- The scarred skin is not rotated as a rotation flap freed of its substratum as in the Z plasty, but slides on healthy subcutaneous tissue as a push-forward flap. In this way, disorders of blood flow in the flap tips are avoided, as have repeatedly been observed in Z plasties in extensive burns. Y-V plasties can be cut without this danger, even in the center of large scar sections and connected scar cords, and can be used to lengthen the scars.

Disadvantage:

The disadvantage of Y-V plasty compared with Z plasty is that the Y-V plasty must be sketched correctly from the beginning and must be definitively cut. In Z plasty, the scar cord can be initially incised over its course, and the arms of the Z are cut only as required afterward. Nonetheless, this flexibility is attained at the risk of blood flow disorders.

VM plasty:

The VM – plasty was first described for post burn syndactyly release[15]. Then it was applied to contracted scars, epicanthal fold correction and web space reconstruction[16,17,18]. This method is a combination of YV- plasty and multiple Z – plasty techniques (Fig 4(a) and 4(b). It gives very limited contracture release and can be used for single band contractures of the axilla.However it can be used as a combined flap with other flap techniques. The only noted disadvantage of the VM plasty is the “dog ear” form that remains at both ends.

Propellar flap method:

Multilobed propeller flap method was described in 1991 by Murakami et al[19]. This method can be used in cases where normal skin is still present on the flexor side of the joints. In most axillary burns the center of the axilla survives as does some normal skin. This is a very good method for the release of axillary contracture but only one disadvantage is that sometimes requiring skin grafting at the flap donor site after transposition of the flap.

The flap is designed (Fig 5(a) and 5(b)) as an ellipse centered with the long axis along the normal skin and once transposed at 180 degrees it covers the defect created by the release of axilla band contracture. The flap is vascularised from the subcutaneous pedicle in the central portion. The pedicle is made as thick as possible to maintain the rotation angle without high tension. Either clockwise or counterclockwise direction is used for flap rotation. The donor site is usually covered with skin graft as described before if it cannot be closed primarily. To overcome the difficulty modification of propeller flap[20] was designed by the same authors. In this the flap is designed in the form of trilobes or quadrilobes. Likewise it can be rotated clockwise or anti clockwise if the flap is symmetrical. If it is asymmetrical, the bigger lobe should be used to divide the contracture.

The rationales for flap design are:

1) Scarred lobes attached to the original propeller skin flap can obtain sufficient blood supply from the subcutaneous pedicle of the normal tissue which reduces the probability of scarred flap necrosis

2) These scarred lobes are available for closure of the donor sites adjacent to them which obviates the need for skin grafting. When band contractures are present with normal skin in between the band, a tri lobed flap or a quadrilobed flap should be used to release both contractures at the same time.If the skin adjacent to the contractures is soft and extensible a trilobed or quadrilobed flap according to the shape of the scar or hair bearing skin is designed. If adequate normal skin is available to design a large quadrilobed flap it is easier to release contractures and close the donor skin than it is with trilobed flap. If the normal skin available is small than a trilobed flap is designed because a small quadrilobed flap does not release the contracture band adequately.

3.) This flap has the advantage of expansion in the long term follow up even if adequate release was not possible because of smaller flap.

Para scapular Flap:

The parascapular flap[21,22] provides a fasciocutaneous flap[23] with similar characteristics to those of the scapular flap. The flap can be larger in width than the scapular flap, approaching 15 cm and has been harvested as long as 25 cm (Fig 6(a)).

Anatomy:

Back muscles:

The posterior view in the fig 6(b) reveals the muscles of the back. The deltoid muscle has been removed for clarity. The parascapular flap is outlined with the dashed line. The superior aspect of the flap is centered over the triangular space, where the circumflex scapular artery nourishes the parascapular flap after it travels through the triangular space. The borders of the triangular space are made up of the

- Teres minor
- Teres major
- Long head of triceps

The latissimus and teres major muscles are important landmarks since flap dissection proceeds from inferior to superior and these are identified early in the dissection. The elevation of the flap (Fig 6 (c) is performed in the areolar fascial layer just above the thick muscular fascia of the back. The infraspinous fascia overlying the infraspinatous muscle and the teres minor fascia overlying the teres minor are particulary thick. If the flap is elevated deep to the this muscular fascia, the dissection can become confusing and especially difficult around the pedicle where the fascia surrounds the triangular space.

Vascular Anatomy:

The circumflex scapular artery is a branch of the subscapular artery which takes origin off the axillary artery. The circumflex scapular artery arises about 1 to 4 centimeters from the origin of the subscapular artery, but can on occasion arise directly from the axillary artery. After the circumflex scapular artery pierces the triangular space it sprouts a transverse cutaneous scapular branch and a vertical parascapular branch. The parascapular branch forms the basis of the parascapular flap.

The subscapular artery pedicle can be from 3 to 6 cm in length with vessel circumference at this level up to 4 millimeters in size. Although the circumflex scapular artery is usually accompanied by two venae comitans, the

subscapular artery is typically accompanied by one vein. The pedicle is marked out with an equilateral “scapular triangle” using the most prominent part of the scapular spine laterally, the root of the scapular spine, and a corresponding point on the lateral border of the scapula respectively latter represents the point of emergence of the circumflex scapular artery and its branches from the muscular omotricipital triangle and into the fascial layer. It has been found that these three points maintain an equilateral triangle on the scapula in both full adduction and abduction. Although the point of emergence of the vascular pedicle varies with movement of the scapula, this geometric relationship is maintained. It is important to ensure that the root of the scapular spine is not mistaken for the superior angle of the scapula. This can be avoided by marking the patient in his or her operating position either in full adduction or in full abduction, when the bony landmarks are most prominent.

Flap Dissection:

The patient is placed in the lateral decubitus position on a beanbag. Optionally, the prone position can be used if a posterior wound must be resurfaced. The prone position can be technically more difficult since arm positioning can not be adjusted as easily as in the lateral decubitus position.

The ipsilateral arm is left free and included in the operative scrub. A stockinet around the arm and Mayo stand with a well-padded pillow helps to rest the arm during surgery.

The incision is marked using the scapula as a guide. The scapula is outlined and an elliptical incision is used to mark the flap. It must include the triangular space within its border so the pedicle vessel is captured in the flap. A point roughly one fingerbreadth below the mid point of the scapula on its lateral aspect marks the triangular space. A pencil Doppler probe can help confirm the pedicle location. The width of the flap can reach 15 centimeters with primary closure and has been reported to be as long as 25 centimeters.

The flap is elevated from inferior to superior. The elevation of the flap is performed in the areolar fascial layer just above the thick muscular fascia of the back. The infraspinatus fascia overlying the infraspinatous muscle and the teres major fascia overlying the teres major are particularly thick. If the flap is elevated deep to this muscular fascia, the dissection can become confusing and especially difficult around the pedicle where the fascia surrounds the triangular space. In the medial incision the transverse arterial branch can be visualized and is ligated to continue flap isolation to the pedicle. As the triangular space is identified and the pedicle traced into the triangular space,

self retaining retractors and adjusting the right arm position to maximize exposure are helpful. Numerous branches must be isolated and ligated at this level before the flap is traced to the circumflex scapular artery and if needed the subscapular artery. A counter incision in the axilla can be helpful to expose and dissect the subscapular system.

Trapezius island flap:

The lower trapezius island flap has been used commonly in head and neck reconstruction.

Technique:

The technique of trapezius island flap was fully described by Tan and Tan[24] in their study. It can be used for contracted posterior axillary fold with peri axillary scarring either alone or associated with contracted arm pit and anterior axillary fold[25]. The flap is designed while the patient is standing up or sitting by marking the trapezius muscle, scapula, and T10 dorsal process. The skin paddle is designed at a right angle or obliquely downward to the lateral border of the trapezius muscle, just below the tip of the scapula and extending above the lower part of the trapezius up to the T10 vertebra .However, a skin paddle with a long fasciocutaneous extension should have sufficient proximal overlap with the muscle to capture perforators supplying the flap. The axis of

the extension should follow the direction of the ribs, as terminal branches of the dorsal scapular artery form a network of choke vessels with the intercostal perforating vessels. This design enables the flap to have a wider arc of rotation and better inset into the axilla, and enhances the reach of the flap, which is pivoted at the level of the base of the spine of the scapula. The skin paddle size ranges from 7 to 9 cm wide and from 14 to 17 cm long without prior surgical delay. The patient is placed in the prone position if only the posterior axillary fold is to be reconstructed, or in the lateral decubitus position if the whole axilla needs to be released and reconstructed. After proper release of the axilla to attain the maximum abduction and extension, the raw area is measured and, accordingly, the skin paddle size and direction can be modified. Elevation of the flap begins with an incision along the lateral border of the skin island down to the latissimus dorsi muscle. It is important to include the fascia overlying the muscle and then to dissect from lateral to medial under this fascia. This method automatically leads the surgeon under the lateral border of the trapezius and preserves the latissimus dorsi muscle. Elevation of the flap then proceeds upward with division of the muscle fibers of origin from the spinous process of the thoracic vertebrae and fibers of insertion in the spine of the scapula. Dissection proceeds upward without the need for a vertical skin incision until the upper border of the rhomboid major

muscle, which can be divided if needed to free the dorsal scapular artery pedicle. The dorsal scapular artery can be seen, where it merges from between rhomboid muscles, and the descending branch of the transverse cervical artery can be seen as it appears medial and superior to the dorsal scapular artery. The fasciomyocutaneous flap is then passed through a subcutaneous tunnel superficial to the latissimus dorsi muscle and scapula to reach its destination in the axillary region, where the skin island is inset to cover the axilla, while the raw area in the upper arm may be covered by split-thickness skin graft if needed. One should be careful not to stretch the pedicle excessively, and if the long skin paddle cannot be completely delivered from its tunnel, the buried portion could be deepithelialized. The donor site is closed primarily, and usually undermining is needed to close the defect. A suction drain is left in the axilla under the flap and in the back for 5 days, and prophylactic antibiotics may be given. The arm is kept abducted for 1 week; with the patient lying in bed either prone or in the lateral decubitus position. Physiotherapy for the shoulder joint starts after the third week.

On the basis of the anatomical studies and the description of Mathes and Nahai [26], the lower trapezius muscle flap receives its dominant blood supply from the descending branch of the transverse cervical artery, which enters the muscle at the base of the neck and then descends vertically along the deep

surface of the muscle midway between the vertebral column and the medial border of the scapula. This description makes it mandatory that the cephalic end of the flap be at least 7 to 8 cm proximal to the tip of the scapula so that the musculocutaneous perforating vessels in this area will be raised with the skin island. Proper design of the flap is critical to its extended arc of rotation and survival, and makes the distolateral half of the flap beyond the tip of the scapula a random pattern flap[27].Tan described a technique based on the dorsal scapular artery that incorporates an extension of the flap that runs obliquely from the tip of the scapula toward the midaxillary line. He named this flap the extended lower trapezius island myocutaneous flap. On the basis of his anatomical study, he found that the dorsal scapular artery is the dominant blood supply of the lower trapezius muscle and extends beyond the lateral edge of the muscle to a distance in excess of 13 cm [24].This fasciocutaneous extension of the vertical trapezius island myocutaneous flap based on the dorsal scapular artery makes the axillary region easily and reliably reached with non scarred pliable skin. This flap fulfills many of the requirements for axilla reconstruction. In moderate to severe post burn contractures of the axilla, this flap offers some advantages, including the following:

(1) The pedicle of this flap is away from the region of the scarred and distorted axilla with constant anatomical landmarks;

(2) The skin island is usually spared in burns around the axilla;

(3) The resulting donor site is well hidden, is easily closed with safe undermining on non burned skin, and is not continuous with the axillary release incision;

(4) It allows various orientations of the island skin to fit into the axilla without pedicle kinking;

(5) It does not cause distortion of the adjacent skin;

(6) Mobility of the flap is sufficient to cover the whole axilla;

(7) No contour or functional defects are created by flap elevation and rotation;

(8) In the axilla, it provides durable coverage, with minimal immobilization of the shoulder; and

(9) It is a very useful technique for recurrent cases, as the pedicle site is not disturbed by other techniques.

Subcutaneous Pedicle Rhomboid Flap:

Linear post burn scar contractures are usually released by using a Z-plasty or V-Y-plasty. Z-plasty and V-Y-plasty, however, are not effective for wide contractures or quadratic contracture with 2 or more contracture lines. In the treatment of such cases, the use of subcutaneous pedicle flaps is advantageous. The concept of subcutaneous pedicle flaps in the treatment of

wide post burn scar contractures was first mentioned by Suzuki et al.[28] In 1994, Uzunismail et al[29] described the subcutaneous pedicle rhomboid flap, and the technique was successfully used in the treatment of digital and first web space contractures in the burned hand.

Surgical Technique:

Subcutaneous pedicle rhomboid flaps (Fig 7) are designed along the long axis of the contracture line with 120- and 60-degree angles. The length of the flaps is as long as the contracture length. For long contractures, the length of the flap is not shorter than half of the contracture length. In cases of 2 or 3 contracture lines located closely to each other, single rhomboid flap may be used to release 2 different contracture lines. Flaps are incised down to the healthy subcutaneous tissue or muscle fascia so that they are freed from the surrounding tense skin. The tension over the contracture line is relieved by the relaxation incisions that are made in "cut as you go" manner. The emerged defects are then closed by suturing rhomboid flaps in V-Y advancement along the long axis and in Y-V advancement along the relaxation. The finesse of rhomboid flap depends on lengthening the contracture band by relaxation incisions and closing the emerged defect by suturing the rhomboid flap in V-Y and Y-V advancement.[30]

Advantages:

1.) Planning the rhomboid flap is simple and flexible as one has the freedom to adjust the amount of skin elongation by relaxation incisions.

2.) The gain in length is not dependent on the angle of its constituent flaps, their numbers, or flap thickness, as is the case with Z-plasty. In rhomboid flap technique, the relaxation incisions release the scar and the flap resurfaces the emerged defect.

3.) Studies indicate that the rhomboid flap can easily close a defect generated by the relaxation incisions, which produce a 75% to 90% gain in length, without need of skin grafting. [30]

4.) As no undermining is carried out, the risk of flap necrosis is always less in rhomboid flap when compared with triangular flaps in Z-plasty. The broad subcutaneous pedicle of the rhomboid flap is very reliable, and this gives the opportunity to apply the technique in wide burn sear areas.

5.) Distortion of the surrounding skin or displacement of anatomic landmarks is rare with this technique.

6.) Another advantage of rhomboid flap technique is the capability of releasing 2 contracture lines with a single flap. When the contracture lines are too close to each other, using Z-plasty for the release is nearly impossible because the bases of triangular flaps face to each other in all circumstances. In

such cases, a single rhomboid flap may be designed between the 2 bands and the relaxation incisions may release both contractures.

7.) The broad subcutaneous pedicle of the rhomboid flap is very reliable. Even in the event of contracture recurrence, it is safe to design a new rhomboid flap over the old scars or adjacent to them as other non undermined flaps.[31, 32, 33]

Latissimus dorsi flap:

Vascular anatomy:

Dominant Pedicle: Thoracodorsal artery and venae comitantes

Regional source: Subscapular artery and vein

Length: 8 cm

Location: Enters the deep surface of the muscle in the posterior axilla 10 cms inferior to the muscle insertion into the humerus.

Secondary Segmental Pedicles: Lateral row- four to six perforating arterial branches and venae comitantes.

Medial row- four to six perforating vessels and venae comitantes.

Function: The latissimus dorsi muscle adducts, extends, and rotates the humerus medially. It is an expendable muscle since function is preserved by the remaining synergistic shoulder gridle muscles.

Procedure:

The latissimus dorsi fasciocutaneous flap, described by Tolhurst and Haeseker in 1982, has been advocated as reliable for reconstruction of axillary burn contractures.[34]

The reconstructive procedure is performed in a standard fashion.[35]

The patient was placed in the mid lateral position, while the latissimus dorsi myocutaneous flap was elevated (Fig 8(a) and 8(b) . Orientation of the skin paddle was either vertical or horizontal, depending on the donor area suitability and the shape and position of the recipient site. The skin was sutured temporally to the muscle fascia early in the procedure to avoid shearing any musculocutaneous perforators. The thoracodorsal pedicle was dissected as high as necessary to allow the flap to reach the far aspect of the recipient site. The latissimus dorsi myocutaneous flap was passed in the subcutaneous plane, under the axillary skin superficial to the pectoralis major muscle and clavicle. To provide a tunnel without any compromise to the vascular pedicle, any overlying scar tissue, as well as part of the pectoralis

major muscle, was divided as needed. The donor site was closed primarily. For insetting the flap into the axillary defect, the patient was repositioned in the supine position. Because it is doubtful that a latissimus dorsi fasciocutaneous flap could provide sufficient, reliable skin coverage for these severe axillary burn contractures, skin grafting would probably be required to close the donor sites. This robust flap is a dependable reconstructive option because of the reliable vascular supply to the muscle and skin. Both the long vascular pedicle of the latissimus dorsi muscle and a pivot point in the axilla allow this flap to easily reach the axilla.

Thoracodorsal Perforator based Cutaneous flap:

Using the cutaneous flaps from the back result in an aesthetically undesirable appearance and limitation of arm adduction at the reconstructed axilla, to overcome this disadvantage, the thoracodorsal perforator– based cutaneous flaps thin to preserve the subdermal vascular network, as with the other thinned musculocutaneous perforator–based flaps, and these thinned flaps were used to correct the severe axillary burn scar contractures.

Flap Design and Elevation:

First, the cutaneous perforators of the thoracodorsal artery on the back using a Doppler flow meter before the operation was marked. The first

musculocutaneous perforator usually emerges from the point 8 to 10 cm inferior to the axillary fold and 1 to 2 cm posterior to the lateral border of the latissimus dorsi muscle. The cutaneous flap was designed preoperatively, including the point where the cutaneous perforator was detected, as its long axis was perpendicular to the running of the latissimus dorsi muscle. The patient was placed in lateral decubitus position under general anesthesia. By a transverse incision, the axillary contracture was released until the shoulder joint was abducted as fully as possible. The preoperatively designed thoracodorsal perforator–based cutaneous flap was modified to fit the subsequent axillary skin defect. After incising the superomedial portion of the designed flap, it was raised to the level of the subcutaneous tissue above the dorsal thoracic fascia from the medial to the lateral side, and the cutaneous perforators were identified near the lateral border of the latissimus dorsi muscle. After incising the superolateral portion of the flap, the main trunk of the vascular pedicle (the thoracodorsal vessel) was identified under the latissimus dorsi muscle and was deeply dissected beyond the branch to the serratus anterior muscle. The largest perforator was traced to it through the muscle with ligation of the other intramuscular vessel branches. During this dissection, the thoracodorsal nerve and its branches were preserved. After the

vascular pedicle was completely isolated, the cutaneous flap was totally elevated.

Flap Thinning:

After elevation of the flap, thinning was performed. The superficial fascia in the elevated flap divides the adipose tissue into two types; relatively large fat lobules lie deeply, and the small fat lobules lie superficially, to this fascia. The adipose tissues lying deeply to the superficial fascia were removed using scissors. If needed, the superficial adipose tissue also could be removed. In the area around the cutaneous perforator, about 1 cm of adipose tissue was preserved to avoid vascular pedicle injury. Finally, the flap thickness was reduced to about 8 to 10 mm almost uniformly after thinning. This thinned cutaneous island flap was transposed into the axillary defect, and the donor site was closed directly or with a split thickness skin graft.

Skin Grafts:

Free skin grafts dates back as far as 2000 BC. The first sufficient description of the use of a full thickness skin graft was by John Reisberg Wolfe (1823 – 1904), a Hungarian ophthalmic surgeon. He used a full thickness skin graft from the forearm to release a post burn contracture (lower eyelid ectropion). Since then many surgeons have used skin grafts to release post burn contractures at various other sites.

Full thickness skin graft – consists of epidermis and full thickness of dermis. Splint thickness skin graft – consists of epidermis and a variable proportion of dermis. Split thickness skin grafts are described as thin, intermediate or thick according to the thickness of dermis included.

Method of harvesting:

The full thickness skin graft is cut with a scalpel while split thickness graft is usually cut with a special instrument. The full thickness skin graft once cut leaves behind no epidermal elements in the donor area from which resurfacing can take place. The split thickness skin graft leaves adnexal remnants, pilosebaceous follicles and sweat gland apparatus, as foci from which the donor site can resurface. As a result the donor area of a split skin graft heals spontaneously, and requires no care other than that usually

accorded any raw surface. The donor area of a full thickness skin graft has to be closed by direct suture or if it is too large for this, covered with a split skin graft.

The properties of the full thickness skin graft are relatively constant; those of the split skin graft depend in some degree on the thickness of its dermal component. The full thickness skin graft takes less readily than the split skin graft, and before it can be used successfully conditions have to be optimal. The full thickness skin graft remains virtually at its original size. The split thickness graft tends to contract subsequently if circumstances permit, e.g. across a flexure. The stability of a graft depends on dermis, and the thicker graft stands late trauma better than the thin graft. During its transfer from donor to recipient site a free graft is completely, even if only temporarily, detached from the body. While so detached such a graft remains viable for a limited period whose precise limit depends on the ambient temperature at which the graft is maintained. In order to survive permanently it has to become reattached, and obtain a fresh blood supply from its new habitat. The process which results in its reattachment and revascularization are collectively referred to as take. The process of take consists of fibrin adhesion, revascularization and maturation.

Donor sites:

Split thickness graft:

1.) Thighs

2.) Arms

3.) Buttocks

4.) Abdomen

Full thickness graft

1.) Post auricular skin

2.) Upper eyelid skin

3.) Supraclavicular skin

4.) Flexural skin

5.) Thighs and abdominal skin.

Assessment of graft thickness is mainly by noting the translucency of the graft, the pattern of bleeding of the donor site that is a high density of thin bleeding points means thin graft. Thicker graft gives a lower density of larger bleeding points.

In studies it has been found that for the same site, release with split – thickness grafts was associated with more releases of the contractures than with full thickness skin grafts. Also, the interval between the initial release and first release was shorter than with full thickness skin grafts.[36]It was also noted that children required more procedures during growth spurts, reflecting the differential effect of the growth of the normal skin and contracture tissue. Patients reported more satisfaction with texture and color match with the full – thickness skin grafts. There was comparable donor-site and graft morbidity with both graft types.

Donor site morbidity:

1. Infection- usually with staphylococcus aureus
2. Hypertropic scars

Graft site morbidity:

1. Lumpiness and hypertrophy
2. Excessive hair growth
3. Graft discolouration/ pigmentary changes
4. Sensory disorders – pain, paraesthesia, numbness

5. Infection

6. Partial loss

7. Poor wound healing / unstable scar after trauma.

Full thickness skin grafts approximate more closely to normal skin in texture, color, and resilience than split – thickness grafts. However full thickness skin grafts take less readily than split thickness grafts and suffer the setback of limited availability.[37,38] The latter problem, in some situations , may be offset by pre-expansion of the donor sites.[39] Full thickness grafts also contract much less, as in an inverse relationship between thickness of the dermis and graft contraction[40, 41, 42] The use of skin grafts for post burn contracture release is simple, reliable, and safe. They are particularly useful for an extensive area of release. Their main disadvantage is the tendency to recontracture, necessitating further release, which is less of a problem when using full thickness grafts. Whenever possible, use of full-thickness skin grafts in preference to split thickness grafts in post burn contracture release.

Post Operative splinting:

Post operative splinting after post burn axilla contracture is very important to prevent re contracture mainly after contracture release and split thickness skin grafting. Many methods are available as follows. The axilla concavity and abducted positioning does not allow for easy splint fabrication and donning.[43]

Aeroplane splint:

This splint can be made from thermoplastic materials[44] to high- density foam.[45]

High density foam splint:

It requires the following materials:

1.)High density foam

2.) Cloth material for straps

3.) Velcro

4.) Measuring tape

5.) Small saw

6.) Heat gun

Fabrication of high density foam splint involves the following steps:

Measurement of length from patient's axilla to hips and to finger tips. Then with the help of these measurements a triangular pattern is cut with the help of saw. Two triangular openings are cut into the pattern for Velcro straps. Then heat the outer edges of the splint with the heat gun in order to make smooth surfaces. Now it is placed on the patient and the cloth is cut with Velcro attached so that it can be fastened to the axilla.

This foam is designed for patients who spend majority of their time in supine position. It is ideal for children and infants since the child does not need to be abducted or remain stationary for prolonged periods of time. It also has the advantage that it cannot be easily removed by children. It does not need additional padding.

Figure of 8 sling:

This has better patient compliance than other methods of splinting[46]. It consists of a collar-n-cuff sling of soft sponge in an elastic tubular sling for the purpose. It must be tied under tension in a cross shape on the back with two loops in the axillae.

MATERIALS AND METHODS

This study is a prospective analysis of all post burn axillary contractures which were treated with contracture release with split thickness skin grafts and by flaps in the Department of Plastic and Reconstructive Surgery, Christian Medical College, Vellore from October 2005 to December 2007.

All patients who had axillary post burn scar contracture and who underwent surgical management were included in the study.

Exclusion criteria:

1.) Patients who had previous operative procedure for axillary contracture
2.) Patients who had burns of the elbow and hands
3.) Patients who had post burn axillary contracture less than 3 months.

Patient demographics:

The total number of post burn axillary contracture was 31. Out of this 21 had right side axilla involved and 10 had left side involvement (Fig 9). The mean age of the patient with axilla contracture was 26.2.years (range 3 to 62 years) and there were 7 men (22.6 %) and 24 women (77.4 %). The patient demographics of both groups are shown in table (Fig 10).

The severity of axillary contracture (Fig 11) was classified into 3 types based on functional restriction as

1.) Mild – able to abduct the upper limb above 90 degree

2.) Moderate – able to abduct the upper limb from 30 to 90 degree

3.) Severe – able to abduct the upper limb less than 30 degree

There were 8 cases of mild contracture (25.8 %), 18 cases of moderate contracture (58 %) and 5 cases of severe contracture (1.6 %).

The duration of post burn scar contracture of axilla that is the time from the time of acute burns to the time when the patient under went surgical procedure has a mean years of 3.7 (range from 1 to 30 year).

All patient were classified into 4 types based on Achauer classification (Fig 12)

Type 1: Anterior or posterior axillary fold only

Type 2: Both anterior and posterior axillary fold with the apex of axilla spared

Type 3: The entire axilla involved

Type 4: Scars of the axilla and the adjacent areas

Out of the 31 cases there were 10 cases of Type 1 (32.3 %) , Type 2 there were 10 cases (32.3 %) , Type 3 there were 7 cases (22.6 %) and 4 cases of type 4 (13.0 %) .

Operative procedure:

All patients had been admitted pre operatively and evaluated with proper documentation of the history and clinical findings including the range of motion of the shoulder joint mainly abduction. All the cases were done by single surgeon except 4 cases done by other surgeons. They were all done in supine position with an arm board extension for patients who under went incision release of scar contracture with split skin grafting. For patients who under went parascapular flap for contracture release patient were initially put in supine and after contracture release the patient was turned in lateral position for flap elevation and insetting.

The types of surgical procedure which the patients underwent were:

1.) Incision release and skin grafting

2.) 5 Flap plasty

3.) Running Y – V plasty

4.) Para scapular flap

All patients were administered one dose intravenous antibiotic at the time of induction.

In patients who under went incision release and skin grafting tie over dressing followed by an aero plane splint was applied before the patient recovered from anesthesia. The donor site was closed with paraffin dressing over the raw area. For patients who underwent 5 flap plasty and running Y-V plasty light wet dressing were applied without any splints. For patients who under went parascapular flap corrugated drains were placed below the flap after inset and one drain in the flap donor site. The flap donor site was closed primarily if possible without tension along the suture line otherwise the donor site was covered with split thickness skin graft. No dressing was applied over the flap except a light dressing over the drain site. In the post operative period skin grafts were inspected on the 9^{th} post operative day and the suture line care was given daily for the flap cases. Drains were removed on the second post operative day. For patients who under went contracture release with flaps patients were started on passive shoulder abduction exercises on the 2^{nd} day.

For patients who under went incision release and skin grafting passive physiotherapy was started once skin graft has taken well mostly after 2 weeks. Active exercises were started after one month and the aero plane splint was

advised for the patient at least 6 months. For 2 months splint has to be worn for 24 hours a day except during taking bath. Then for 4 months splint has to be worn during the night time. Scar massage and skin graft massage with oil based cream was advised to all the patients.

Immediate complications of the surgery like graft loss; wound infection and flap tip necrosis were recorded.

Assessment of functional outcome:

Functional outcome was measured by noting the degree of shoulder joint abduction achieved. Patient results were classified into good, moderate and poor. All patients were assessed for a period of 1&1/2 years with regular interval at 3, 6, 9, 12, 15 and 18 months. The compliance of the patient was also classified as poor, moderate and good. Patient who came for 6 follow ups and using splint and doing physiotherapy as per advice were considered good. If the patient comes only 3 visits but continuing physiotherapy without using splints was considered moderate. Poor if patient comes less than 2 visits and not doing any physiotherapy and splints.

The re contracture rate was also noted down for both skin graft and flap cases.

Analysis was done about the complication rate, duration of hospital stay, re contracture rate and patient compliance between graft and flap cases. The clinical photographs of the patients are shown in the figure.

Statistical analysis of all data was done using the SPSS 11.0 for windows software.

RESULTS

COMPLIANCE**:**

The compliance of the patients in our study was poor in 10 patients that is patient who came for less than 2 visits and who did not do any physiotherapy and did not use splint (32.6 %), moderate in 9 patients that is patient who came for at least 3 visits and were using splint at least 12 hours per day and doing some physiotherapy(29.0 %) and good in 12 patients that is patient who came for 6 follow up visits and were regularly using splint and doing physiotherapy (38.7 %) – Fig 13.

Compared between patients who underwent flap for contracture release and patients who under went incision release and skin grafting there was no statistical significance as shown in the table 1.

COMPLICATIONS:

There were no major complications in the post operative period. In 5 patients who underwent incision release and split thickness skin grafting had graft loss ranging from 2 % to 10% (Fig 14). For 3 patients who had between 5 to 10 % graft loss re grafting was carried out. Re grafting was done to prevent healing by wound contracture and thus producing re contracture of

the axilla. For 2 patients who had 1 to 2 % graft loss graft loss conservative management of regular dressings with hydrocoll moist dressings was carried out and the wound healed in1 week. For these patients who had graft loss active physiotherapy was delayed till the wound has completely epithelialised or graft has taken well. Usually it took on the average 2 weeks before the active physiotherapy was started. There were no complications in the remaining 26 patients.

On comparison between patients who had incision release and split thickness skin grafting and patient who underwent flap for contracture release for complications there was a statistical significance of .042 as shown in table 2.

RECONTRACTURE:

The re contracture patients were put into the following groups

1.) No re contracture

2.) Mild re contracture (less than 30 degree loss of release achieved)

3.) Moderate re contracture (in between 30 to 90 degree loss of release achieved)

4.) Severe re contracture (more than 90 degree loss of release achieved)

On comparing patients who had incision release and skin grafting and patients who underwent flap for contracture release on the rate of re

contracture there was statistical significance of .003 as shown in the table 3. It is found that patient who had flap for contracture release had no re contracture but patient who had skin graft had some re contracture.

DISCUSSION:

In this study of post burn scar contracture of the axilla, on analysis of sex distribution the number of females was higher than males. Compared with other studies the sex ratio is higher in females[47]. It may be because in Indian population still the commonest mode of suicide is by self implicated thermal burns pertaining to dowry related causes.

In our study the age distribution was more clustered between 20 and 40 (almost 50%) and the mean age was 26.2 years. In western population studies have shown bimodal distribution that is, it is more common in the extremes of age. In Indian and in under developed countries like Nigeria the age group is more common in the middle age. This variation may be because accidental burns are more common in extremes of ages and suicidal burns are common in middle age group. In western population the cause of burns is accidental when compared to under developed countries where the cause is suicidal in nature.

In our analysis of the side involvement right side axilla was more commonly involved than the left side and the reason maybe that dominant hand involvement is always more common since as a reflex it is used to protect for burns.

It has been found that when we compared the side of axilla contracture with the duration that the patient takes to come for treatment , whatever the severity or functional restriction of the shoulder joint patients who had right side axilla scar contracture came early (mean of 2.03 years) for treatment than the left side (mean of 5.07 years). This may be again because of the same reason those patients who are right dominant tend to face more difficulty to carry out their routine daily activities than the patient who have left side involvement (non dominant).

In our study the commonest grade of functional limitation is the moderate grade where they can abduct the shoulder joint between 30 to 90 degrees. When we compared the time interval between the burns and the time when the patient came for treatment, patients who had mild grade came late for treatment (mean 5.63 years) as these patients were able to do all their daily routines without any functional limitation. But patients who had moderate (mean 3.38 years) and severe (1.8 years) grades came for early treatment because of their functional limitation of their daily routines.

When we analyzed the type of axilla contracture Type 1 and 2 are more common than type 3 and 4. It is also found that patients with type 3 and 4

were associated more commonly with involvement of the scar contracture of elbow, hand and chest wall.

The average difference in hospital stay after flaps and skin grafts was found to be statistically significant in our analysis. The mean hospital stay for skin grafted cases was 13.8 days and that of flap cases was 5.4 days in our study (Table 4). This shows that flaps are cost effective in terms of hospitalization cost. In poor developing countries where health care setup is not good, flaps are better for contracture release as patients are hospitalized for shorter time and also they can return to their work early when compared to patients who underwent skin grafting after contracture release.

Skin grafting when used for contracture release brings new, non bulky skin from a previous uninjured area of the body instead of traumatizing the scarred skin or compromised adjacent skin. Their disadvantage is that they have a tendency to re contracture necessitating further releases[48]. Prolonged periods of post operative splinting are required to maximize aesthetic and functional results. They also have more complication rate like graft loss, donor site morbidity of lumpiness, hypertrophy, excessive hair growth, graft discoloration, sensory disorders, parasthesia , numbness, infection and partial loss. Another important issue is that contractures are produced not only by

skin loss but also by the differential growth rate between the burn scar and the rest of the adjacent normal skin and tissues[49,50]. Growth occurs in three phases. There is a rapid growth in infancy and in some premature babies extending to the second year. This is followed by a marked deceleration of growth. Then there is a steady but slower rate of growth between 2 to 10 years of age, with a gradual further decline in rate in the pre pubertal years. Finally in the third (or pubertal) phase, growth is rapid. Late maturers will continue physical growth into the range of 19 to 21 years of age[51]. A possible reason for contractures developing in later life could be an increase in general body fat associated with an increase in age.

In cases where flaps were used for contracture release 5 flap plasty is the commonest method used followed by running Y-V plasty and parascapular flap. The flap type should be selected according to the location and shape of the scar[51]. For single band contractures on the anterior or posterior axillary line, a skin elongation procedure such as Z plasty or running Y-V plasty is selected. The main advantages of these flaps are that they give good lengthening of the scar resulting in good contracture release. These flaps are easy to design, cosmetically has less chance of distortion of axillary hair if properly designed. It has another added advantage that these flaps grow along with the growth of the patient if release is done in the growth spurt age. In our

study 15 patients underwent 5 flap plasty and 2 under went running Y-V plasty. There were no post operative complications and the results achieved were good contracture release with no re contracture for one and half year follow up. In other studies flap tip necrosis was reported in 1 to 2 % of cases in patients undergoing 5 flap plasty[51].

The parascapular flap is a good choice for reconstruction of all types of axillary contracture releasing defects with satisfactory results in terms of function and cosmesis. In our study we used para scapular flap for 3 of our patients. We did not use the island para scapular flap as the skin over the para scapular flap was also scarred. We used split thickness skin graft to close the donor defect. We achieved good contracture release and the patient compliance was good. Re contracture was also not seen in the follow up period. We feel parascapular flaps are good choice in cases of severe axilla contracture. In female patients who have more fat in the parascapular area the flap after elevation becomes more bulky. Thinning of the flap is possible and described but we feel that flap becomes thin over time because of fat re distribution and better to leave the flap as such. It is always ideal to mark the perforator and the pedicle with a hand held Doppler before raising the flap as most often that area is also scarred and there maybe distortion of the vascular architecture because of contracture.

The limitations of the study were:

1.) The functional outcome assessment in our study is done only for one and half years. Long term follow up is needed.
2.) For severe contracture only parascapular flap was used for contracture release although free flaps, propeller flaps, Latissmus dorsi flaps are described in literature.

CONCLUSION

Post burn axillary contracture release with flaps gives very good result in terms of less hospitalization days, low re contracture rate and good patient compliance although it requires skill and knowledge to choose the right flap for each contracture type .Contracture release with split skin grafting although easy to execute and can be done for any type of axillary contracture has more re contracture rate and poor compliance because of long term splinting. In our study the results of contracture release with flaps were good with no major complications and it also does not require long term splinting when compared to split skin grafts. In developing countries where patient has to go for work early it is always better to do a contracture release with flap.

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PROFORMA FOR AXILLARY CONTRACTURE

NAME:

ADDRESS:

HOSPITAL No:

AGE:

SEX:

DURATION OF HOSPITAL STAY:

ETIOLOGY OF BURNS:

NUMBER OF YEARS SINCE BURNS:

TYPE OF AXILLARY CONTRACTURE:

MORPHOLOGICAL CLASIFICATION*:*

Type 1

Type 2

Type 3

Type 4

FUNCTIONAL CLASSIFICATION:

Mild

Moderate

Severe

SURGICAL PROCEDURE DONE:

Split Skin Grafting

5 Flap Plasty

Running Y-V Plasty

Parascapular Flap

POST OPERATIVE COMPLICATIONS:

FOLLOW UP:

AT 3 MONTHS, 6 MONTHS, 9 MONTHS, 12 MONTHS AND 15 MONTHS AND 18 MONTHS

Compliance of patient

Recontracture rate