Perforator Flaps for the Reconstruction of Axillary Defects: Different Designs and Applications

Ahmed Ali Ebrahiem Ali, M.Sc.
Department of Plastic Reconstructive Surgery, Faculty of Medicine; Cairo University, Cairo, Egypt

ABSTRACT

Reconstruction of soft tissue defects of the axilla represents a challenge to the reconstructive surgeon owing to the wide range of motion that should be achieved and difficulty in the maintenance of the axillary contour. Perforator flaps represent a recent advance in the reconstructive ladder with reduced donor site morbidity leading to faster recovery and decreased postoperative pain. Perforator flaps combine the reliable blood supply of parent musculocutaneous flaps with reduced donor site morbidity [(1).] Perforator flaps have the additional advantages that they can be tailored to accurately reconstruct the defect, including the flap thinning for resurfacing shallow defects, there is freedom of orientation of the pedicle, and a longer pedicle is harvested than with the parent musculocutaneous flap [(2).] Perforator flaps that can be used for the coverage of axillary defects include those based on thoracodorsal and circumflex scapular arteries. Twenty patients with soft tissue defects of the axilla were reconstructed with those perforator flaps in this study and their outcome was evaluated.

***Key words**: axilla, perforator, flap, thoracodorsal, circumflex scapular.*

INTRODUCTION

Axillary defects may result from trauma, surgery such as Excision of tumors or hidradenitis suppurativa. It may also result after release of post burn axillary contractures. Axillary post burn contracture is a challenging problem to the reconstructive surgeon due to the wide range of Abduction that should be achieved and the unavailability of local tissues to be used for Reconstruction**.** [(3)] Classifications of post burn axillary contracture were based on either the scar shape or its severity and extension.

Toet and Bosse [(4)] classified post burn axillary contractures into three types depending on the extent of scarring as follows:

- **Type I**: Both the anterior and the posterior axillary folds are involved, leaving the normal skin in the hair-bearing area. A web is formed during abduction.
- **Type II**: The inner portion of the upper arm and the adjacent trunk and one axillary fold are involved.
- **Type III:** The upper arm and the lateral aspect of the trunk are completely included in one mass of hypertrophic scar tissue.

There are several options for the coverage of axillary defects such as skin grafting, pedicled flaps e.g. latissmus dorsi, scapular and parascapular flaps and microvascular free tissue transfer. Skin grafting is the simplest reconstructive method but it has several disadvantages. Frequently there is a patchy take of skin graft due to the anatomy of the defect, and the prolonged splinting in abduction and postoperative physical therapy are always necessary to avoid additional contracture. Furthermore the cosmetic result after skin grafting is poor.

The latissimus dorsi musculocutaneous flap is the most reasonable one because of its reliable vascular supply to the muscle and skin. The overlying skin is nourished by musculocutaneous perforators which are widely distributed over its surface. The latissimus dorsi myocutaneous flap has been used for axillary contracture release by various authors [(4,5&6).]

Although these flaps are good treatment options, their bulkiness results in skin redundancy in the axillary area which is a major disadvantage in terms of cosmesis and function [(7).]

Microvascular transfer is a lengthy difficult procedure that requires special training .Perforator flaps represent the latest descendent in a line of evolution that began with the random pattern flaps[(8).]

Perforator flaps can be used for the coverage of axillary defects such as thoracodorsal artery perforator flap or those based on the perforators

of the circumflex scapular artery. Both of these vessels originate from subscapular arterial system.

The aim of this study is to evaluate both thoracodorsal artery perforator (**TDAP)** and circumflex scapular artery perforator (**CSAP)** Flaps in the reconstruction of axillary defects as regard anatomical considerations, reliability, outcome and complications.

PATIENTS & METHODS

The current study included 20 patients with axillary defects resulting from different etiologies; they were twelve males and eight female patients of various age groups from 16 to 75 years with a mean of 46 years. Patients were randomly chosen from those presenting to the plastic surgery Department of Kasr El Aini Hospitals in the period from July 2011 to September 2013.the clinical data of these patients are shown in **table (1).**

Preoperative mapping of perforators:

- Preoperative perforator mapping is performed with handheld Doppler with the patient in the lateral or prone decubitus position to simulate operative positioning.
- Based on previous anatomical studies **(9) And (10),** the perforators of the thoracodorsal artery are sought out in a region 8 cm below the axillary crease (It is an axillary wrinkle which is found at the junction of the upper arm with the shoulder/back region) and within 2 cm of the anterior border of the LD muscle. While perforators of the circumflex scapular artery are sought out in a region 2-3 cm below the triangular (omotricipital) space and 1 cm lateral to lateral border of the scapula **(15).**
- Preoperative planning of the flap is designed to include more than one perforator.
- Preoperative photographs were taken for all patients.
- Ten cases were performed as **TDAP** flap, the remaining ten cases as **CSAP** flap.

Operative details:

- General anesthesia was used in all patients.
- Proper positioning of the patient and upper extremity was done either in the lateral decubitus (in cases of TDAP or Vertically-oriented CSAP), prone decubitus (in cases of transversely-oriented CSAP) with the arm abducted 90º (so as to facilitate flap elevation and insetting).
- Dissection is performed under loupe magnification.

Table (1) The clinical characteristics of the patients.

Case No.	*Age/ sex*	*Etiology of the defect*	*Defect size/cm*	*Flap type and size/cm*	*Doppler perforator mapping*	*Donor site closure*	*complications*
1	28/M	Release of type (II) contracture	20x10 cm	Propeller TDAP flap(22x12)cm	12 and 15 cm from axillary crease, 1cm inside anterior border of latissmus dorsi.	1ry	Temporary venous congestion
2	33/F	Release of type (III) contracture	20x8 cm	Propeller transverse CSAP flap (22x8)cm	2 and 4 cm from triangular space 1 cm from lateral border of scapula	1ry closure + grafting	NO
3	30/M	Release of type (II) contracture	16x8cm	V-Y TDAP (18X9)cm	12 and 15 cm from axillary crease, 2 cm inside anterior border of latissmus dorsi.	1ry closure	NO
4	16/F	Release of type (II) contracture	16x8 cm	Propeller vertical CSAP flap (18X9)cm	2 cm from triangular space 1 cm from lateral border of scapula	1ry closure	Superficial epidermolysis of the distal tip of the flap.
5	28/M	Release of type (II) contracture	16x8 cm	Propeller TDAP (18X9)CM	12 and 14m from axillary crease, 2cm inside anterior border of latissmus dorsi.	1ry closure	Wound dehiscence (recipient)
6	25/M	Electrical burn	24x10 cm (axilla and proximal	MS-TDAP (25x10cm)	15cmfrom axillarycrease, 2cm inside anterior	1ry closure	NO

			arm)		border of latissmus dorsi.		
7	32/M	Release of type (III) contracture	18x8 cm	Propeller transverse CSAP (20x9)cm	2 cm from triangular space 1 cm from lateral border of scapula	1ry closure	Wound dehiscence (donor)
8	26/M	Release of type (II) contracture	20x10 cm	Propeller TDAP flap(21x12)cm	12 and 15 cm from axillary crease, 1cm inside anterior border of latissmus dorsi.	1ry	Temporary venous congestion
9	31/F	Release of type (III) contracture	20x8 cm	Propeller transverse CSAP flap (22x10)cm	2 and 4 cm from triangular space 1 cm from lateral border of scapula	1ry closure + grafting	NO
10	30/M	Release of type (II) contracture	16x8cm	V-Y TDAP (18X9)cm	12 and 15 cm from axillary crease, 2 cm inside anterior border of latissmus dorsi.	1ry closure	NO
11	17/F	Release of type (II) contracture	16x8 cm	Propeller vertical CSAP flap (18X9)cm	2 cm from triangular space 1 cm from lateral border of scapula	1ry closure	NO
12	28/M	Release of type (II) contracture	16x8 cm	Propeller TDAP (18X9)CM	12 and 14m from axillary crease, 2cm inside anterior border of latissmus dorsi.	1ry closure	NO
13	25/M	Electrical burn	25x10 cm (axilla and proximal arm)	MS-TDAP (25x10cm)	15cmfrom axillarycrease, 2cm inside anterior border of latissmus dorsi.	1ry closure	NO
14	34/M	Release of type (III) contracture	18x8 cm	Propeller transverse CSAP (20x9)cm	3cm from triangular space 1 cm from lateral border of scapula	1ry closure	Wound dehiscence (donor& recipient)
15	18/F	hidradenitis suppurativa excision	20x8 cm	Propeller TDAP (22x10)cm	14 cm from axillary crease 1 cm inside anterior border of latissmus dorsi	1ry closure	NO
16	25/M	Flame burn with raw area of the axilla	20x7 cm	Propeller vertical CSAP (21X8)cm	2cm from triangular space 1 cm from lateral border of scapula	grafting	Loss of distal 3 cm
17	75/F	Release of type (III) contracture with hidden marjoline ulcer inside	20x8 cm	Propeller vertical CSAP (22x10)cm	2cm from triangular space 1 cm from lateral border of scapula	1ry closure+ grafting	NO
18	26/M	Flame burn with raw area of the axilla	20x7 cm	Propeller vertical CSAP (22X8)cm	2cm from triangular space 1 cm from lateral border of scapula	1ry closure+ grafting	Loss of distal 3 cm
19	19/F	hidradenitis suppurativa excision	20x8 cm	Propeller TDAP (22x10)cm	15cm from axillary crease 1 cm inside anterior border of latissmus dorsi	1ry closure	Wound infection
20	65/F	Release of type (III) contracture	21X7 cm	Propeller vertical CSAP (22x8)cm	2cm from triangular space 1 cm from lateral border of scapula	1ry closure+ grafting	NO

Operative steps:

- **Thoracodorsal artery perforator flap** :
  - Two flaps were designed as V-Y advancement while six flaps were designed as an island propeller pattern and the remaining two flaps as muscle sparing pattern.
  - Skin incision along the anteroinferior aspect of the probable skin island or V-Y Flap coinciding with the anterior border of the latissmus dorsi muscle in order to detect the thoracodorsal artery and visible septocutaneous perforators. **Fig. (1)**.
  - Skin incision along the posterior aspect of the probable island or V-Y flap. As the dissection was found easier to search for the perforators from mediodorsal to antrolateral aspect of the patient.

The dissection proceeds in subfascial plane of the latissmus dorsi muscle using blunt ended scissors and bipolar electrocautry.

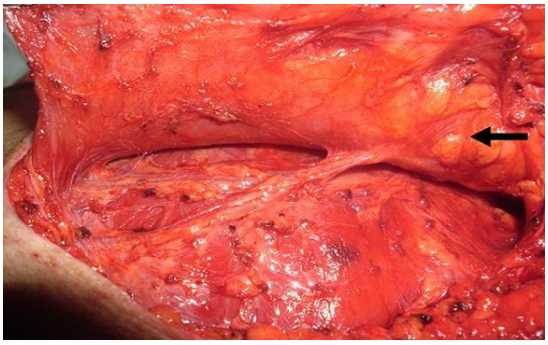

Fig. (1): Intraoperative view showing the thoracodorsal artery and serratus anterior branches& visible septocutaneous perforator (arrow pointing to it).

- Only visible pulsatile perforators are considered suitable and preserved.
- Once a suitable perforator has been identified, the cleavage plane of the latissmus dorsi (LD) muscle in which that perforator resides is developed where Muscle fibers are spread maintaining their longitudinal integrity. The perforator is dissected from the surrounding muscle fibers where they tend to lie in a fibro-fatty layer.
- The main thoracodorsal pedicle is dissected free until the required pedicle length is obtained.

Conversion to muscle-sparing designs:

- When the perforator diameter is less than 0.5mm there is a high risk for perforator avulsion. In this situation a muscle-sparing technique increases safety by preserving a 2-5 cm cuff of LD muscle around the perforators. **Fig. (2)**
- Incision of the skin between the pivot point and the recipient site to avoid subcutaneous tunneling of the flap.
- Tension-free flap inset is critical to avoid rupture of the perforator.
- Suction drains are applied both in the recipient and donor sites.
- The donor site is closed primarily.

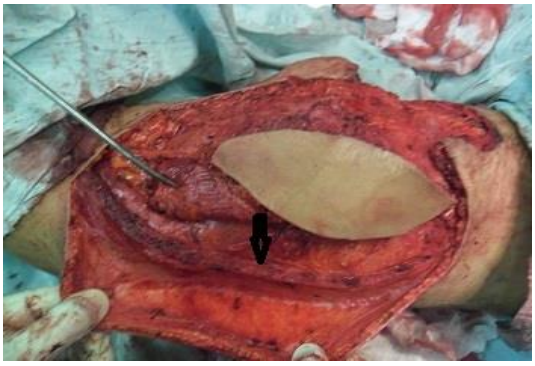

Fig. (2): Intraoperative view showing muscle sparing technique with an artery forceps pointing towards part of the latissmus harvested in the flap with a black arrow pointing towards the new anterior border of the remaining part of the latissmus dorsi muscle.

Circumflex scapular artery perforator flap :

- Design of vertical/transverse skin paddle around the CSA surface Marking and perforator Doppler signal around triangular space.
- The flap is then incised along its distal edge, deepening the incision down to the fascia of the back.
- The dissection is followed proximally to the Point of origin of the vertical and transverse branches, and The CSA itself (omotricipital space). **Fig. (3)**.
- The dissection proceeds until the cutaneous Perforator vessel can be clearly identified arising from the superficial aspect of one of these three vessels.

- The flap can then be thinned at the fascial plane separating the deep and superficial adipose layers.
- Tension-free flap inset is critical to avoid avulsion of the perforator.
- Suction drains are applied both in the recipient and donor sites.
- The donor site is closed primarily or partially by 1ry closure and grafting.

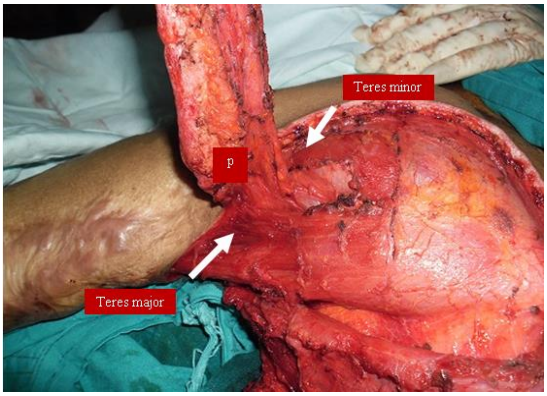

Fig. (3): Circumflex scapular artery in the omotricipital space with perforator seen (P)

Report of the clinical cases:

Case (1): (Fig.4). 28 years old male patient who sustained a flame burn to left axilla and back ١ year ago, His burns were allowed to heal spontaneously with resulting **type (II)** axillary contracture, He was admitted to plastic surgery Unit with limited shoulder abduction to only 90° **(a).** A propeller thoracodorsal perforator flap measuring 22x12 cm was designed. The flap was harvested as described previously by including the first septocutaneous perforator of the lateral branch of thoracodorsal artery **(b).**The flap then transferred to the defect and sutured in place. The donor site was closed primarily **(c).** There was temporary venous congestion which resolved spontaneously within 48 hours the patient was able to abduct his arm to 170º without any difficulty **(d).**

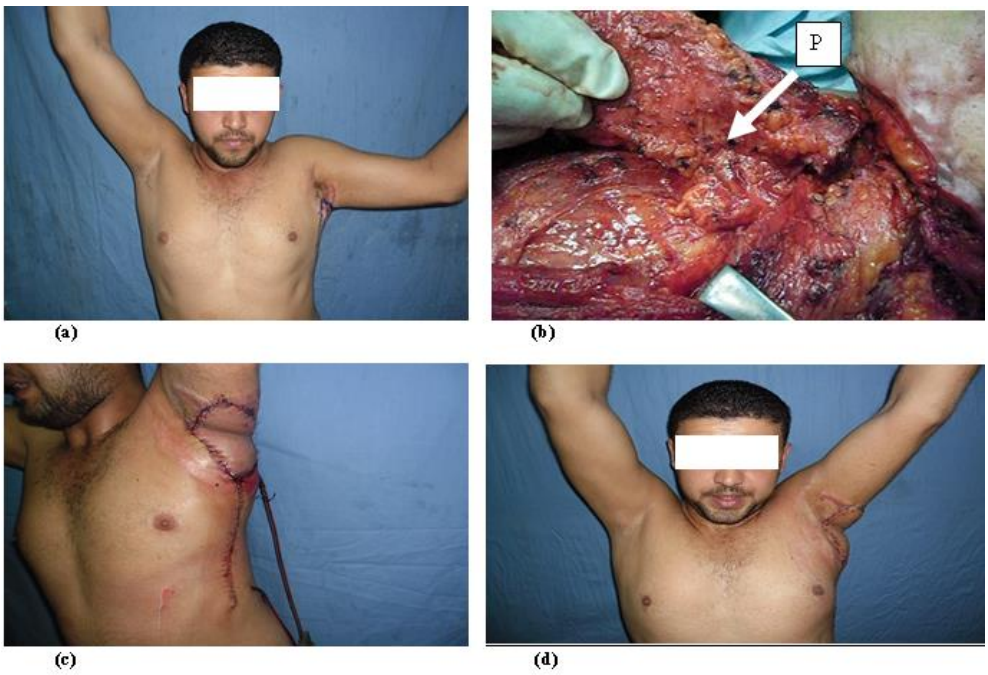

Fig. (4): (a). male patient with post. Burn type (II) lt sided axillary contracture with limitation of the shoulder abduction. (b). intraoperative view with an arrow pointing towards the septocutaneous perforator (P) vessel supplying the flap. (c). A 22x12 cm flap was transferred to the release defect and sutured. Donor site was closed primarily. (d).the same patient after removal of the stitches with completely healed recipient site with fully abducted shoulder.

Case (9): (Fig.5). 31 years old female patient who sustained a flame burn to lt axilla and back 12 year ago, her burns were allowed to heal spontaneously with resulting type (III) axillary contracture, she was admitted to plastic surgery Unit with limited shoulder abduction to only 80° **(a).** Propellar circumflex scapular artery perforator flap measuring 22x8 cm was designed **(b).**The flap was harvested as described previously by including a cutaneous perforator of the circumflex scapular artery The flap then transferred to the defect and sutured in place. The donor site was closed primarily together with grafting due to scarring of the back. The patient was able to abduct her arm to 140º without any difficulty in the post operative period **(c).**

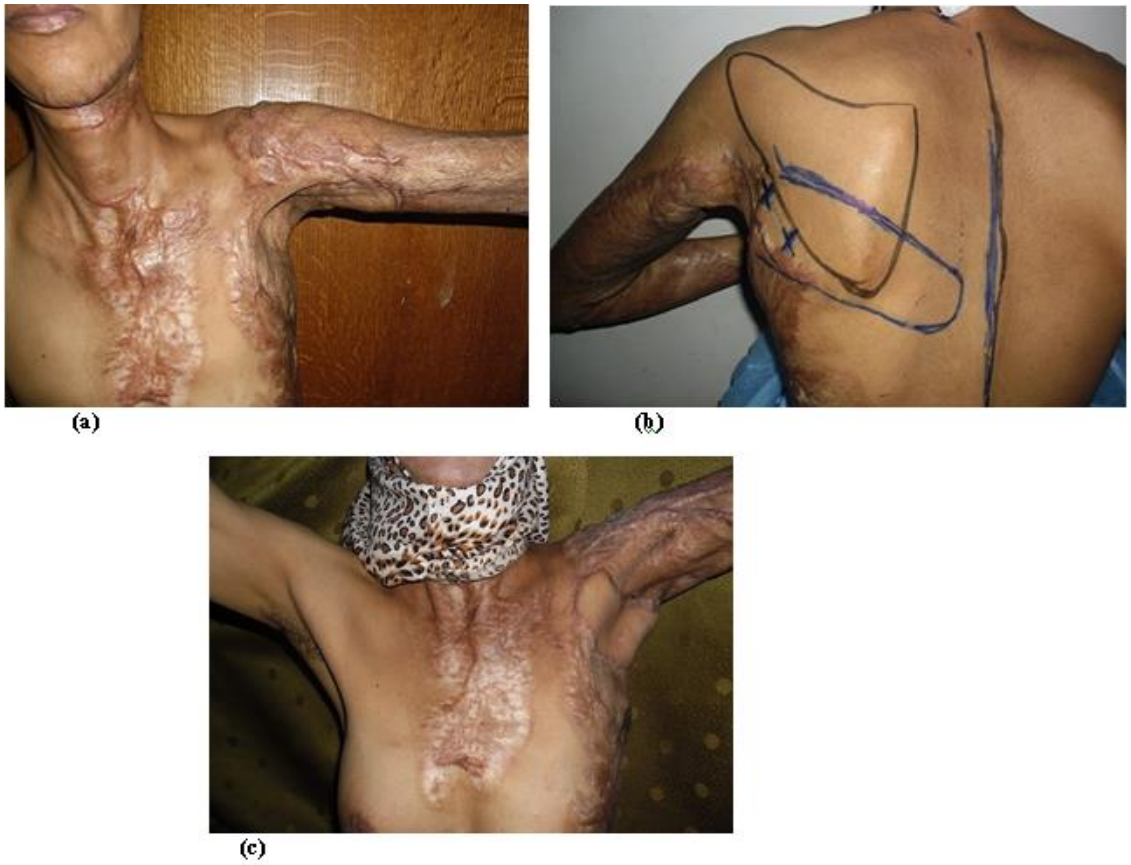

Fig. (5): (a), female patient with type (III) post. Burn lt sided axillary contracture. (b), the same patient; after preoperative marking of the propellar CSAP and the flap with a handheld Doppler. (c), the same patient four months after discharge with complete healing of the flap and improved degree of shoulder abduction.

Case (15): 18 years old female patient who presented with lt sided hidradenitis suppurativa of the axilla for 5 years resistant to medical treatment for which she was admitted to plastic surgery unit for excision of this recurrent lesion and reconstruction with propeller TDAP flap 22x10cm **(a)** and **(b).** Together with primary closure of the donor site **(c).** The patient had complete healing of the recipient site without recurrence after regular follow up.

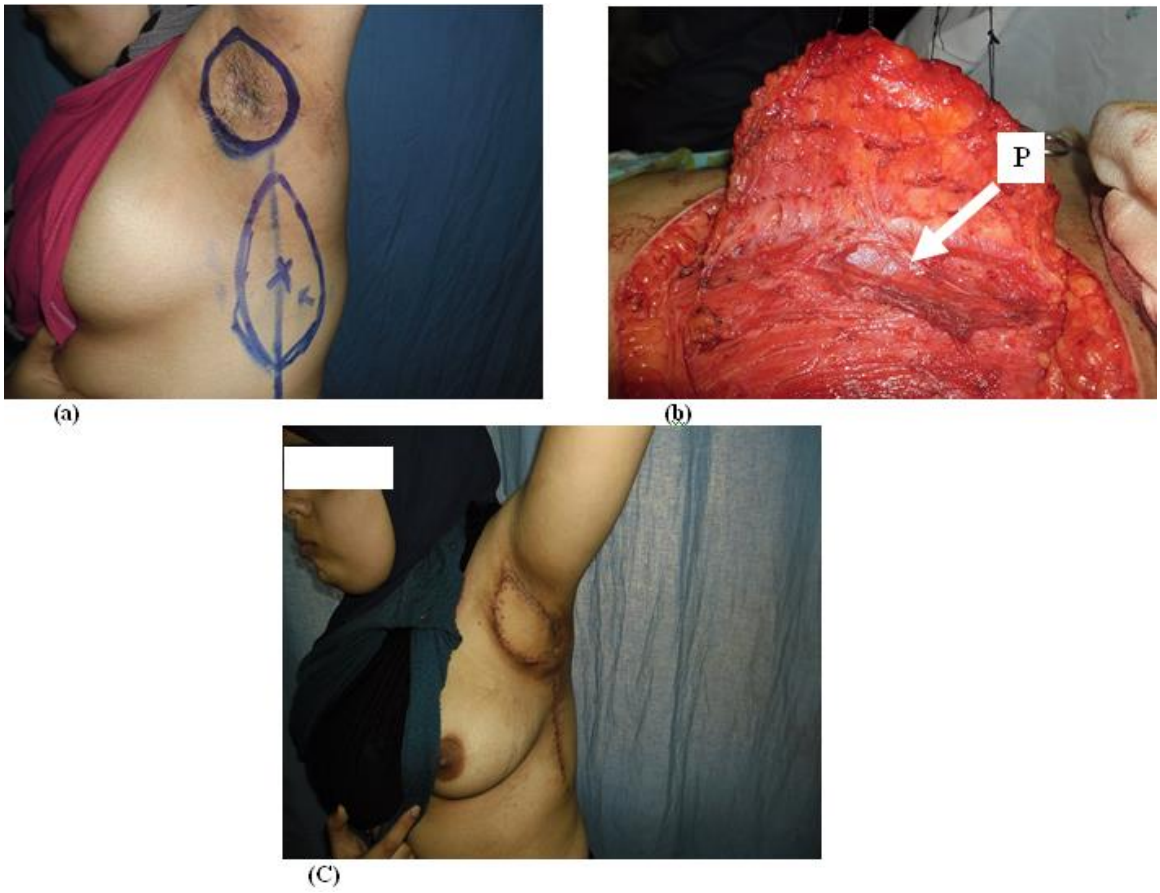

Fig. (6): (a). female patient with lt sided axillary hidradenitis suppurativa together with design of propellar TDAP flap, (b). the same patient; intraoperative view showing reliable musculocutaneous perforator (P), (c). the same patient after excision of the lesion together with reconstruction using propellar TDAP flap with 1ry closure of the donor site.

RESULTS

50% of axillary defects were reconstructed using thoracodorsal artery perforator flap; the remaining 50% of axillary defects were reconstructed using circumflex scapular artery perforator flap. A summary of the design of the flaps applied for coverage of axillary defects is shown in **(Fig.7)…**comparison between TDAP and CSAP flaps is shown in **table (2).**

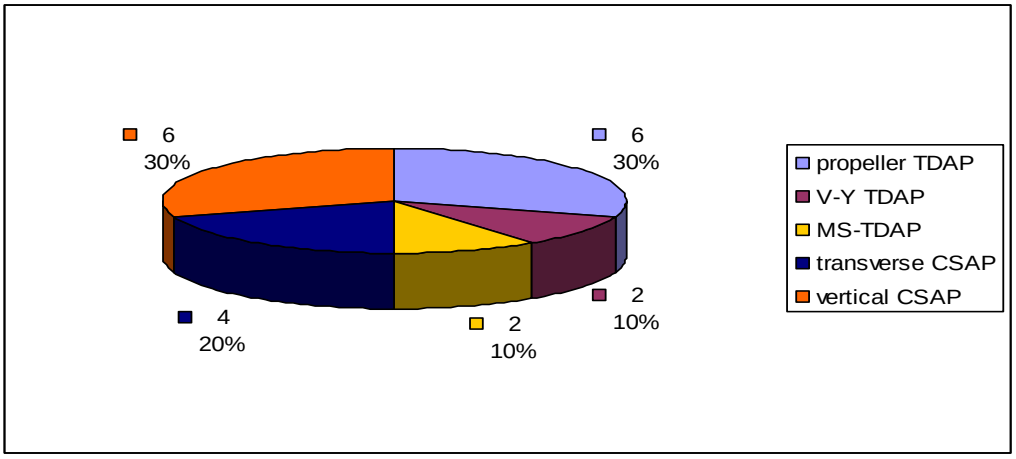

Fig. (7): Distribution of the flaps used for reconstruction of the axillary defects

Table (2): Comparison between TDAP and CSAP Flaps.

	TDAP	**CSAP**
Dominant Perforator mapping	12-14cm caudal to the posterior axillary fold,1-2cm inside anterior border of the muscle	2-3 cm caudal to triangular space, 1cm lateral to the lateral border of the scapaula
Type of the perforators	Musculocutaneous and septocutaneous.	Direct cutaneous only
versatility	Flap size up to 25x10 cm can be elevated safely.	Flap size up to 22x8 cm can be elevated safely.
designs	Multiple(Propeller ,V-Y and Muscle sparing)	Propeller (vertical or transverse).
Bulk	More bulky	Less bulky especially vertical design
Need for revisions	+++	+
Operative time	More(average 260-300min)	Less(average 180-200min)
Operative technique	More demanding(difficult)	Less demanding(easier)
Donor site morbidity	minimal	minimal
complications	less	more

DISCUSSION

The current focus of the flap surgery development is along two lines. The first is to minimize donor site morbidity, to develop thin flaps easy to mold. The second aim is to use increased anatomical knowledge to permit the design of flaps that contain only the tissues necessary for a particular reconstruction**..**

Kim et al.[11] Reported the use of thoracodorsal perforator-based cutaneous island flaps in the release of axillary contractures. The advantages of the **TDAP flap** are that it is reliable and reproducible as the scapular-thoracodorsal arterial system is robust, although the dissection is tedious. In our thesis we have performed ten TAP flaps either in the form of island, V-Y pattern and muscle sparing TAP flap.

In the previous description by **Kim et al.**[11] Harvesting TDAP flap was started with an incision at the anteroinferior aspect of the flap and then to proceed for dissection of the musculocutaneous or septocutaneous perforators after identification of the anterior border of the latissmus dorsi muscle.

In the current study the operative procedure is started by incising the anteroinferior aspect of the planned flap in order to identify the anterior border of the latissmus dorsi muscle, to expose the main thoracodorsal bundle and any visible sizable septocutaneous perforators then we incise the posteriomedial aspect of the planned flap to search for the perforators whose sites were marked preoperatively with the handheld Doppler; As the dissection was found easier to survey from mediodorsal to antrolateral aspect of the patient. The dissection proceeds in subfascial plane of the latissmus dorsi muscle using blunt-ended scissor and bipolar electrocautry till we find a reliable pulsatile perforator, once identified we continue intramuscular dissection till the main thoracodorsal pedicle. We have dissected the lateral branch of thoracodorsal artery proximally until its junction with the main trunk. Usually the horizontal branch is divided to obtain enough pedicle length. Thoracodorsal nerve wasn't divided to protect the muscle from denervation atrophy.

In several cases the dominant dissectible perforator was situated in a location more caudal to the axillary fold ***(12-14cm caudal to the posterior axillary fold),*** the perforators do not emerge in aline along the muscle fibers which means that the number of the available perforators is restricted if partial muscle destruction is to be avoided.

In the current study also ten CSAP flaps had been performed either in the form of vertical or transverse propeller island designs, it had been agreed with **Dabernig et al.** [12] In that CSAP flap involves no intramuscular dissection, has a very well localized main pedicle, and the character of skin raised can be varied by adjusting the orientation of the flap. the flap had been elevated from distal to proximal starting at the distal edge of the flap with incision deepened to the fascia then the dissection is followed proximally to the Point of origin of the vertical and transverse branches, and The CSA itself (omotricipital space), The dissection proceeds until the cutaneous Perforator vessel can be clearly identified arising from the superficial aspect of one of these three vessels. And then the flap can be thinned at the fascial plane separating the deep and superficial adipose layers .it was found a more easy and safe procedure.

CONCLUSION

When comparing thoracodorsal artery perforator (TDAP) flap to circumflex scapular artery perforator (CSAP) flap in the reconstruction of axillary defects it had been concluded that TDAP flap is more versatile, offers multiple different designs for variable reconstructive purposes however it is technically more difficult, requires longer operative time and often needs revision for debulking as requested by most of the patients in our clinical study.

REFERENCES

1. **Kroll SS, Rosenfield L. (1988):** Perforator-based flaps for low posterior midline defects. Plast Reconstr Surg. 1988; 81:561–566.
2. **Koshima I, Soeda S.(1989):** Inferior epigastric artery skin flap without rectus abdominis muscle. Br J Plast Surg. 42:645–648
3. **Higazi, M., Mandour, S., and Shalaby, H. A.(1990):** Post-burn contracture of the axilla: Evaluation of three methods of management. Ann. Mediterr. Burns Club 3: 21.
4. **Toet, L., and Bosse, J. P. (1994):** The use of scapular skin island flaps in the treatment of axillary post burn scar contractures. Br. J. Plast. Surg. 47: 108.
5. **HAMDY BASHA, MOHAMED HAMDY (1999):** Classifications of Post Burn Axillary Contracture: Reappraisal of its Rationale. Egypt. J. Plast. Reconstr. Surg., Vol. 23, No. 2: 203 – 207.
6. **Agarwal R, Chandra R. (2000):** Latissimus dorsi myocutaneous flap reconstruction of neck and axillary burn contractures. Plast Reconstr Surg; 106(5):1216.
7. **Wilson IF, Lokeh A, Schubert W, Benjamin CI.(2000):** Latissimus dorsi myocutaneous flap reconstruction of neck and axillary burn contractures. Plast Reconstr Surg; 105(1):27.

8. **Hallock GG. Direct and indirect perforator flaps (2003):** The history and the controversy. Plast Reconstr Surg. 111:855–865.
9. **Angrigiani C, Grilli D, Siebert J. (1995):** Latissimus dorsi musculocutaneous flap without muscle. Plast Reconstr Surg; 96: 1608–1614.
10. **Spinelli HM, Fink JA, Muzaffar AR. (1996):** The latissimus dorsi perforator-based fasciocutaneous flap. Ann Plast Surg;37: 500e6.
11. **Kim JT, Koo BS, Kim SK. (2001):** The thin latissimus dorsi perforator based free flap for resurfacing. Plast Reconstr Surg; 107: 374–382.
12. **Dabernig J, Sorensen K, Shawdunn J, Hart AM (2007)** the thin Circumflex scapular artery perforator flap. J Plast Reconstr Aesthet Surg 60:1082–1096.