Abstract:
Thoracodorsal artery perforator flap is a relatively new flap in the armamentarium of the plastic surgeon. It has been used in the reconstruction of axilla, breast and back. The aim of this study was to study the feasibility of utilising thoracodorsal artery cutaneous, musculocutaneous and septocutaneous perforators as a basis for propeller flaps for covering various defects in the trunk.

Keyword: thoracodorsal artery, perforator flap, propeller flap, axilla, back

A CLINICAL STUDY OF THORACODORSAL ARTERY PERFORATOR BASED PROPELLER FLAPS IN RECONSTRUCTION OF TRUNK DEFECTS

INTRODUCTION:
The thoracodorsal artery perforator flap is a relatively new flap available for reconstructive surgery. Over the past few years, free style free flap or pedicled transfers of this flap have been used for various reasons. This flap has been used as a pedicled flap for reconstruction of regional defects on areas such as the trunk, axilla, and breast, or as a free flap in the reconstruction of various defects in areas such as the skull base, face, elbow, forearm, breast and lower extremity. The thoracodorsal artery perforator flap has decreased the morbidity of the donor area with added advantages that include a good prospect of raising a long vascular pedicle if needed, easy thinning of the flap and the conservation of the functions of the lattisimus dorsi muscle.

The purpose of this article was to study the feasibility of utilising thoracodorsal artery cutaneous, musculocutaneous and septocutaneous perforators as a basis for propeller flaps for reconstructing various defects in the trunk.
PATIENTS AND METHODS
In the time period from August 2010 to January 2013, 8 patients underwent thoracodorsal artery perforator based propeller flap reconstruction. In 4 of these cases, the flap was used for reconstruction of axillary defects. In 4 cases it was used for coverage of the back. The size and orientation of the skin islands were planned according to the defect size and orientation. The parameters recorded were patient characteristics, flap dimensions, the number location and type of perforators, operative time and complications.

The average age of the patients was 38 years (range 28 –52 years). 6 were male patients and 2 were female patients.

SURGICAL ANATOMY
The thoracodorsal artery constitutes the latissimus dorsi muscle main pedicle. This artery originates in the subscapular axis. The thoracodorsal artery penetrates the latissimus dorsi muscle about 8–14 cm from the bifurcation of the subscapular artery into the circumflex scapular and thoracodorsal. Shortly before it enters the muscle, the vascular bundles send a branch to the serratus anterior muscle.

The latissimus dorsi muscle is nourished by two main muscular branches from the thoracodorsal artery: a lateral branch running parallel to the anterior border and a horizontal branch passing obliquely to the dorsal and medial part of the muscle. They give multiple terminals to the skin as perforators through the muscle along the course of branches and these musculocutaneous perforators are located at intervals in the back area. 

Septocutaneous perforators arise from the branch to the serratus anterior or other cutaneous branches and they reach the skin between the latissimus dorsi and serratus anterior muscles.

Cutaneous branches originate from the main thoracodorsal artery or from the branch to the serratus anterior. They also supply septocutaneous perforators or direct cutaneous perforators.

SURGICAL TECHNIQUE:
Prior to surgery, the anterior border of the latissimus dorsi muscle and the centre of the axillary fossa were marked. The anterior border of the muscle was made prominent by upward traction of the arm in the lateral decubitus position. The perforator arteries were located using 10 MHz Pencil Doppler along the muscle border.

The expected area for a musculocutaneous perforator is 8–10 cm from the centre of the axillary fossa and within 2 cm posterior to the anterior border of the muscle; the next is seen 2–5 cm inferior to the first. At the same level, anterior to the muscle border, the septocutaneous or direct cutaneous perforators can be found. A reliable perforator was defined as a perforator arising from the carrier muscle with a visible pulsation and diameter > 0.5mm. Perforator dimension was taken using a metallic scale after application of lignocaine spray.

As the identification of this reliable perforator was critical, the flap design was modified intraoperatively based on its size and location. In case more than one good calibre perforators were identified the single best perforator was identified by clamping the other perforators and looking for perfusion in the flap. The design of the flap was oriented mostly either longitudinally or horizontally based on the site of the defect and on the position of the single best perforator. Size of the flap was tailored according to the defect size, taking into account the distance.
of the perforator from the defect edge and giving an allowance of 1 cm for primary contracture.

The patient was positioned in the lateral decubitus position with 90 degrees of shoulder abduction and 90 degrees of elbow flexion. Flap dissection was done under loupe magnification. The anterior incision was usually made first up to the deep fascia. The dissection continued in the same plane until a reliable perforator was found. The dissection of the pedicle then proceeded through the muscle until adequate length of the pedicle was obtained. The thoracodorsal nerve was identified and separated from the vascular pedicle. For the septocutaneous or direct cutaneous perforator, dissection proceeded through the subcutaneous layer to the source artery.

The entire dimension of the flap was outlined after complete visualization of the perforator pedicle and peri-perforator dissection, after which the preoperative design was modified. Flap thickness was modified according to the recipient defect. Before inset, rotation was attempted in clockwise and anti-clockwise manner by trial and error method. Direction in which venous congestion increased was abandoned. The flap was then propelled and transferred to cover the defect and flap inset was given.

Donor site was chosen in such a way that the scar would lie in a relaxed skin tension line. Donor site was closed primarily after inserting a suction drain. Post operatively flap was monitored for congestion or ischemia. The drain was removed on the 5th post-operative day. Patient was discharged on the 7th post-operative day with suture removal done on an out-patient basis on the 10th post-operative day.

Case 1:
A 36 year old female was diagnosed to have dermatofibrosarcoma in the back and underwent wide excision with a 5 cm margin. The resulting defect was covered using a thoracodorsal artery perforator based propeller flap of size 25x10 cm raised based on a single musculocutaneous perforator of 0.8 mm from the thoracodorsal artery. Patient suffered minimal venous congestion leading to minimal distal necrosis.

Dermatofibrosarcoma back:

Post wide excision defect
Thoracodorsal artery perforator flap

Flap inset given
Minimal distal necrosis
Case 2:

A 28 year old male with a gunshot injury to his back. After debridement the resulting defect was covered with a thoracodorsal artery perforator based propeller flap based on a single musculocutaneous perforator of size 0.7mm.
Flap inset
After suture removal
Case 3:

A 29 year old male with a post burn contracture of the axilla underwent contracture release followed by thoracodorsal artery perforator based propeller flap cover. A 12x7 cm flap was raised on a single musculocutaneous perforator from the thoracodorsal artery.

Perforator flap raised: Flap inset done:

Donor site closed primarily

Postburn contracture axilla with flap markings
RESULTS

In this series of patients the largest dimensions of perforator flap used was 25 x 10 cm. The smallest dimension used was 10 x 6 cm. All the flaps were based on a single perforator. The average perforator diameter was 0.7 mm (range 0.5 mm to 0.9 mm). The perforator was a musculocutaneous perforator in 4 cases, cutaneous perforator in 2 cases and a septocutaneous perforator in 2 cases. The lattisimus dorsi muscle was not included in any of the cases. The thoracodorsal nerve was spared in every case. The mean operating time was 120 minutes (range 90 to 150 minutes). The average hospital stay was 8 days. Average follow up period was 18 months (range 6 to 24 months).

The results in all cases were satisfactory, with complete viability of the transferred flaps, except in one case which developed minimal distal necrosis which was managed conservatively. Minimal venous congestion was noted initially in one case which settled later. There was no donor site complication in any of the cases.

DISCUSSION:

The perforator flap depending on muscle perforators without including the underlying muscle was first described by Koshima and Soeda in 1989. The possibility of the thoracodorsal perforator flap was described by Angrigiani et al. Spinelli et al reported the presence of a predictable row of perforators from the lateral intramuscular branch of the thoracodorsal artery. Mun G H et al. reported the cutaneous vascular supply of the thoracodorsal artery and the number and type of perforators by means of human cadaver dissection.

The thoracodorsal artery perforator flap is a versatile tool in reconstructive surgery. Flaps as large as 25X15 cm can be safely harvested. The present series of patients presents multiple versatile uses of thoracodorsal artery perforator flaps, according to experiences at our institution. The thoracodorsal artery perforator flap is a versatile tool in reconstructive surgery. Flaps as large as 25X15 cm can be safely harvested. The present series of patients presents multiple versatile uses of thoracodorsal artery perforator flaps, according to experiences at our institution.

The reliability of the Thoracodorsal artery perforator flap will depend on the presence and size of the perforating vessels. The first perforator artery reaches the subcutaneous tissue at a point located 2 or 3 cm behind the lateral edge of the latissimus dorsi muscle and 8-10 cm below the posterior axillary fold. The second perforator artery is located 1-2 cm below the previous one. All these perforator arteries give off numerous muscular branches before penetrating the fascia to supply the overlying skin and subcutaneous fat layers.

Even though the distribution of perforators varies widely, a good understanding of the entire perforator anatomy is essential for safe and efficient harvesting of the thoracodorsal artery perforator flap. Thoracodorsal artery perforator flap has the common advantages of perforator flaps. While harvesting the flap, preservation of the innervation and vascularization of the latissimus dorsi muscle provide less donor site complications. In addition, this flap offers distinct advantages, including a large flap dimension, a long pedicle length and excellent contour restoration. It provides good colour match, thickness match and texture match to the recipient site in the trunk. It has all the advantages of a musculocutaneous flap but without a muscle harvest.
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<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Defect situation</th>
<th>Indication</th>
<th>Flap size</th>
<th>Type of perforator</th>
<th>Size of perforator</th>
<th>Complication</th>
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<tr>
<td>1</td>
<td>29</td>
<td>M</td>
<td>Axilla</td>
<td>Postburn contracture</td>
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<td>Axilla</td>
<td>Postburn contracture</td>
<td>18x8</td>
<td>Cutaneous</td>
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<td>36</td>
<td>F</td>
<td>Back</td>
<td>Sarcoma</td>
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<td>Musculocutaneous</td>
<td>0.8 mm</td>
<td>Minimal distal necrosis</td>
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<td>Hidradenitis supparativa</td>
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<td>0.6 mm</td>
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<td>Back</td>
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<td>Back</td>
<td>Sarcoma</td>
<td>17x10</td>
<td>Musculocutaneous</td>
<td>0.7 mm</td>
<td>Temporary venous congestion</td>
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<td>Axilla</td>
<td>Post Burn Contracture</td>
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<td>Back</td>
<td>Sarcoma</td>
<td>16x9</td>
<td>Septocutaneous</td>
<td>0.8 mm</td>
<td>None</td>
</tr>
</tbody>
</table>

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the surgical time as it is a microvascular flap without the requirement for a microvascular anastomosis.

Despite lots of advantages and versatility as mentioned above, there are also some disadvantages of thoracodorsal artery perforator flap. These include a variable number of large (>0.5 mm) perforators; difficulty mapping these perforators preoperatively because of the proximity of the main thoracodorsal pedicle; and poorly described, sometimes tedious dissection techniques.12

Multiple cadaveric dissection studies have focused on determining the relationship between topographic landmarks and the thoracodorsal perforators.13 The location of the majority of perforators 8 cm distal to the posterior axillary fold remains a valid and important anatomical landmark. At this point, the first perforator emerges from the descending branch of the thoracodorsal pedicle.

The scapular tip was used by Heitmann et al to locate the bifurcation of the thoracodorsal vessel into its respective horizontal and lateral branches.5 The neurovascular hilus was found 3 to 6 cm inferior to the scapular tip and 1 to 4 cm posterior to the anterior border of the latissimus dorsi muscle. These landmarks help to determine an area in which large perforators can be found consistently. In the present study the location of the perforators correlated with these anatomical landmarks. However, this area depends on the position of the patient and laxity of the skin and may not correspond to intraoperative findings.14

Doppler examination is a simple and inexpensive method for mapping perforators. Placing the patient in an operative position is recommended, to increase the accuracy of all perforator mapping techniques.

In the present study Doppler probe was used in all cases with high reliability. The venous drainage of the thoracodorsal perforator flap has been described as poor and insufficient. Flap-related complications in this study were limited. One patient developed temporary venous congestion which resolved later.

Even though our largest flap 25x10 cm was based on a single musculocutaneous perforator that effectively recruits most of the adjacent perforomes, the farthest perforomes of the dorsal rami intercostal perforators suffer from venous congestion. This patient developed minimal distal necrosis which was managed conservatively.

**CONCLUSION:**
From the present study it can be concluded that thoracodorsal perforator based propeller flap has many advantages in comparison with other perforator flaps, including the following:

The flap width may reach up to 712 cm, and the donosite wound may be primarily closed without the need for skin grafting. The Thoracodorsal artery perforator based propeller flap contains no muscle, allowing more reconstructive precision, and morbidity is minimised by preserving the function of the latissimus dorsi muscle.

Thoracodorsal artery perforator based propeller flap provides stable coverage with an acceptable aesthetic appearance for both the donor and reconstruction sites. The subcutaneous fat tissue at the back region is relatively thinner and thus may provide a thinner skin. The flap complication rates are minimal and despite the perceived variation in the number and size of perforators, flap can be harvested reliably by the techniques used in the present study.


