Journal of Plastic, Reconstructive & Aesthetic Surgery (2019) 72, 1299–1303

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

Experimental study of pedicled subcostal artery perforator (SCAP) flap: A new application in breast reconstruction

Ophelie Delchet[a], **Laurene Majoulet**[a,b,c], **Claude Avisse**[d], **Nathaniel Stroumza**[a,b,e,*]

[a] *École de Chirurgie, 7 rue du fer à Moulin 75005 Paris, France*
[b] *Clinique La Montagne – Ramsay Générale de Santé, 53 rue Victor Hugo, 92400 Courbevoie, France*
[c] *Department of Gynaecology and Obstetrics, Centre Hospitalier de Marne-La-Vallée, Jossigny, France*
[d] *Department of Anatomy, Faculty of Medicine and University Hospital, University of Reims Champagne-Ardenne, Rue Cognacq-Jay, 51092 Reims Cedex, France*
[e] *Private Practice in Plastic, Aesthetic and Reconstructive Surgery, 110 rue La Boetie, 75008 Paris, France*

Received 14 November 2018; accepted 30 March 2019

KEYWORDS
Breast reconstruction;
Mastectomy;
Pedicle;
Subcostal artery perforator flap;
Donor site scarring;
Complications

Summary *Background:* Latissimus dorsi flap is the gold standard for pedicled breast reconstruction but is limited by donor site scarring, which is difficult to conceal, and a high rate of post-operative seroma. We investigated the anatomic characteristics and feasibility of using a subcostal artery perforator (SCAP) flap, which was taken from the flank area and vascularised by a perforator artery through a subcostal pedicle, for a breast reconstruction.
Methods: A literature review was undertaken to determine the anatomy of the SCAP flap pedicle and the vascular supply to this dermal-fat flap. Pedicled SCAP flaps were dissected on cadavers to identify the anatomy of the perforator arteries and the pedicle length. Pedicled SCAP flaps were then tunnelled through the chest area to evaluate their feasibility for breast reconstruction.
Results: Twelve SCAP flaps were prepared on six cadavers. Mean pedicle length was 17 cm (14.5–20 cm). Mean flap size was 13 × 18 cm (11.5 × 15.5–15 × 21 cm). For each flap, a pedicle of sufficient length was dissected to allow the tunnelling of the flap and to perform breast reconstruction with a dermal-fat flap of adequate size. In all cases, an SCAP flap was prepared, without taking muscle, to reduce the risk of parietal complications at the donor site in future clinical applications.

* Corresponding author: Dr Nathaniel Stroumza, Private Practice in Plastic, Aesthetic and Reconstructive Surgery, 110 rue La Boetie, 75008 Paris, France.
E-mail address: nstroumza@gmail.com (N. Stroumza).

https://doi.org/10.1016/j.bjps.2019.03.030

Conclusion: Pedicled SCAP flap is a feasible option in breast reconstruction and could represent a less arduous surgical alternative to free flaps for some patients. Donor site scarring was acceptable. Clinical application of SCAP flaps should be investigated further.

Introduction

Reconstruction using a free flap, as a deep inferior epigastric artery perforator (DIEP) flap,[1,2] requires some microsurgery during vascular anastomosis, and therefore, an experienced surgeon, microsurgery materials and prolonged operative time are required, resulting in over-cost for the hospital. During the per- and post-operative periods, an increased surveillance of the flap is also required because of the risk of thrombosis of the vascular anastomoses, resulting in partial or total necrosis of the flap. The use of pedicled flaps could decrease these types of complications, but it requires a dermal-fat flap that is vascularised through a sufficiently long pedicle. To decrease these complications, pedicled flap such as latissimus dorsi flap has been used for many years in breast reconstruction. However, it is associated with an unsightly scar on the back, a risk of chronic pain and also functional limitations due to disinsertion of the latissimus dorsi muscle. This flap has been improved by creating a perforator flap of the latissimus dorsi muscle, known as a thoracodorsal artery perforator flap.[3] The use of this flap limits the functional sequelae by sparing the muscle, but their usage does not completely resolve the aesthetic problem, with persistence of an unsightly dorsal scar and a dermal-fat flap, which is too small to assure autologous breast reconstruction.

The aim of breast reconstruction is to give the patient the best aesthetic result possible while minimising the per- and post-operative complications.

The flank region is richly vascularised with perforators originating from the intercostal and subcostal, lumbar, iliolumbar and superficial circumflex iliac arteries.[4–7] The subcostal artery, or the 12th intercostal artery, arises from the thoracic artery, of which it is the last collateral branch. It passes below the lateral border of the 12th rib and extends in an integral fashion in the anterolateral abdominal wall. It then passes into the abdomen, posterior to the lateral arcuate ligament, in front of the quadratus lumborum muscle, and winds between the internal transverse and oblique muscles. It then passes obliquely, downwards and frontwards to form an anastomosis with the epigastric artery. It is fed, like the subcostal arteries of the 7th, 8th, 9th, 10th and 11th ribs, by the musculophrenic artery, which is a branch of the internal mammary artery.

In 2007, Feneindegen et al. described a flap using a subcostal artery perforator,[8] basing this on a case report[9] in which the same flap in a pedicled form was used to fill a lumbar defect, demonstrating its constancy and highlighting its interesting diameter and length. These preliminary observations make the pedicled subcostal artery perforator (SCAP) flap a good candidate for application in breast reconstruction.

Our aims in this anatomic study were to demonstrate whether the characteristics of the subcostal pedicle are suitable for use with a dermal-fat perforator flap from the flank region and whether the subcostal artery is long enough to be used for breast reconstruction in its pedicled version.

Patients and methods

This was an experimental study using anatomic cadavers. It followed a review of the anatomic and surgical literature on the subcostal artery.

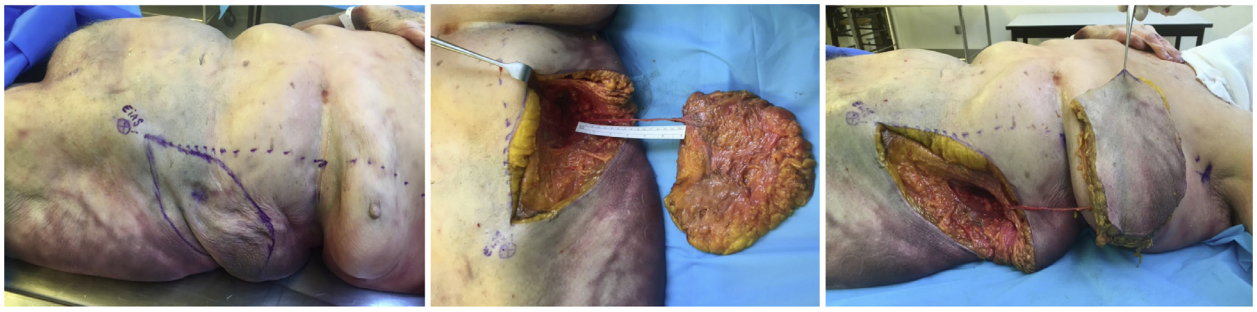
Surgical technique

Dissection was carried out in the supine position. The pedicle was initially located using the data of Feinendegen et al., who described the pedicle as constant at the lateral border of the latissimus dorsi muscle, 1–3 cm below the end of the 12th rib.[8] The contour of the flap in the form of a biconvex lens was drawn by hand with the aim of centralising the pedicle to adapt it as far as possible to the excess dermal-fat of the 'love handles' (Figure 1a).

First, the lower incision of the flap was made as far as the aponeurosis of the external oblique muscle, and then, a careful dissection was carried out to locate the perforator artery of the subcostal artery at the surface of the external oblique muscle. In order to not damage the perforator and its terminal branches, dissection was carried out from the lower region to the upper region and from the medial edge to the lateral edge. Once the perforator artery had been identified, dissection was continued until the subcostal pedicle was identified. The latter was dissected as far as the last rib to obtain the longest pedicle possible. The pedicle was measured systematically. After having individualised the pedicle, skin incisions were made to the whole of the dermal-fat flap to remove it as a whole vascular block (Figure 1b).

The second part of the intervention consisted of tunnelling the island flap and positioning it on the breast (Figure 1c). Tunnelling, towards the thoracic area, was carried out by precostal dissection, in front of the muscles of the thoracic wall. A contra-incision was made in the breast in the same shape and size as the flap previously dissected. The flap was then tunnelled and positioned in the breast, making sure that there was no significant traction on the pedicle (Figure 2).

After verification of the tension on the pedicle and the absence of torsion, the dermis of the flap was partially removed so that it could be partially buried within the breast and to leave an obvious skin flap to facilitate post-operative surveillance (Figure 3a). Finally, the donor site was closed directly, layer by layer, with absorbable sutures, leaving a scar in the area of the 'love handles'. At the breast



A B C

Figure 1 Surgical technique of a pedicled SCAP flap in breast reconstruction. (A) Location of the dermal-fat SCAP flap in the flank area and marking of the perforators. (B) Pedicled SCAP flap dissected as an island flap. Measurement of the pedicle length. (C) Pedicled SCAP flap located on the breast recipient site.

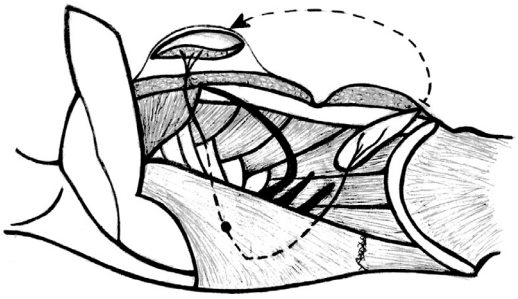


Figure 2 Drawing of the topographical anatomy of an SCAP flap.

recipient site, a multiple layer closure with absorbable sutures was performed (Figure 3b).

Results

The dissections on cadavers were carried out in the Fer à Moulin School of Surgery, Paris. A total of 12 flaps were prepared from six cadavers.

During the study, the subcostal pedicle was constant: it was found systematically and in a symmetric fashion. Mean length of the pedicle was 17 cm (14.5-20 cm), and mean flap size was 13 × 18 cm (11.5 × 15.5-15 × 21 cm). The number of perforators was between one and three per flap, with a mean of two perforators per flap (Table 1).

No muscle sacrifice was necessary when only one perforator was dissected. The decision to keep all the perforators of the pedicle during the dissection requires a partial muscle sacrifice. Furthermore, because of the sinuous path of the perforator between transverse abdominis muscle and internal oblique muscle, difficulties during the pedicle dissection were encountered in few cases, which could potentially damage the muscle.

In all cases, we were able to proceed with dissection of a pedicle of sufficient length to allow tunnelling of the flap through the thorax. The dermal-fat flap was of sufficient size to carry out autologous breast reconstruction in all subjects.

Discussion

The anterior abdominal wall is richly vascularised and has several possible pedicles that can be used for breast reconstruction.[10-12] It is the donor site of choice for surgery that requires pedicled or free flaps.[4]

Breast reconstruction using free flaps is arduous, with a significant risk of complications. Some of these complications are general and are inherent to all types of surgery as well as to general anaesthesia, and others are more regional and specific to breast reconstruction using free flaps. Among them, partial or total necrosis of the flap by thrombosis of vascular anastomoses is estimated to occur in 2-10% of cases in different studies. In the literature, loss of a DIEP flap is linked to vascular problems in most of the cases: due

Table 1 Pedicle length, size of dermal-fat flaps and number of perforators per flap.

	Pedicle lenght (cm)		Number of perforator artery		Size of the dermal-fat flap (cm)	
	Right	Left	Right	Left	Right	Left
Patient 1	15.5	16	3	2	11.5 × 15.5	12 × 16
Patient 2	18	19	3	3	14.5 × 20	15 × 21
Patient 3	15	14.5	2	1	13 × 18	13 × 17.5
Patient 4	16.5	16.5	1	1	13 × 19	14 × 19
Patient 5	19.5	20	2	3	15 × 16	15 × 15
Patient 6	17	16.5	1	2	12.5 × 19	12 × 18
	Lm = 17 cm		Nm = 2 perforators		Sm = 13.3 × 17.8 cm	

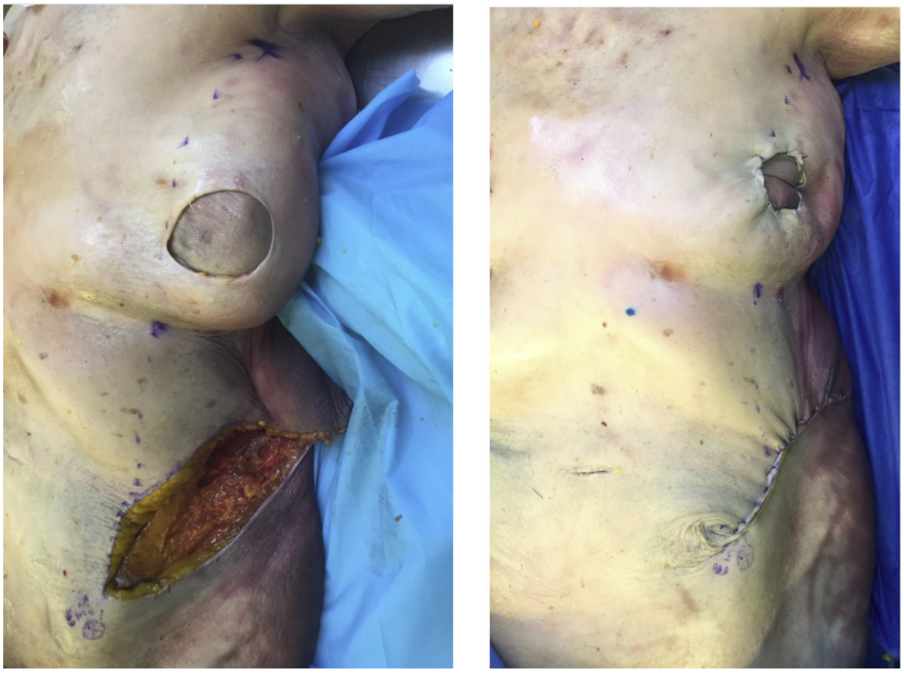


Figure 3 Result after tunnelled flap and partial removal of the dermis. (A) Skin flap is visible to allow surveillance of the flap and enable areolar reconstruction at the same time. (B) Donor site and breast reconstruction scar after closure.

to a venous cause in 40% of cases (by thrombosis or venous congestion, which is found in 5–15% of cases) and due to an arterial cause in 28% of cases.[13,14] Vascularisation of the dermal-fat flap through its pedicle by thoracic vessels is dependent on good permeability of the anastomoses, which may be small in diameter. A thrombosis in this artery or in the vein draining the flap may therefore require emergency surgery and result in partial or total necrosis of the flap. The use of a pedicled flap not only limits the occurrence of this type of complication but also reduces the duration of surgery and morbidity of the donor site (hernia or eventration) because the anterior abdominal wall is preserved.

Different pedicles of the anterolateral abdominal wall are sometimes used to repair lumbar or sacral defects, but to date, the SCAP flap has never been described for breast reconstruction. Only the deep circumflex iliac artery (DCIA) flap[8,9] has been described for breast reconstruction. The DCIA flap, described in 1979 by Taylor, uses a dermal-fat flap taken from the area of the 'love handles' and vascularised by perforators of the deep circumflex iliac artery. The technique was initially used for cervico-facial reconstruction[6,7] and was then applied to breast reconstruction.[8] However, DCIA flap can only be used as a free flap for breast reconstruction because of its localisation.

The subcostal pedicle of the SCAP flap belongs to both the thoracic and abdominal regions, and previous studies have shown the long length of this pedicle.[15] We, therefore, wanted to demonstrate the feasibility of using a lateral abdominal perforator pedicled flap in breast reconstruction.

Our anatomic study confirms the feasibility of using the SCAP flap in breast reconstruction. It is important that its clinical application is confirmed, but this new technique could decrease the risks of anastomosis complications because this flap is pedicled. In addition, in comparison with a free flap, the duration of surgery and hospitalisation may be shorter, as there is no need for microsurgery procedures and there are less serious sequelae at the donor site. A medico-economic study will be necessary to evaluate the economic impact of this flap in breast reconstruction compared to other reference techniques.

We think that the SCAP flap can offer an alternative to other reconstruction techniques not only for patients who request aesthetic management of their 'love handles' but also for subjects with a history of abdominoplasty. Indeed, Colebunders et al. showed that the DCIA flap was a favourable alternative in women who had undergone abdominoplasty or had a failed reconstruction using a DIEP flap, and in whom the scars could create unsightly 'dog ears' around the hips.[4] The position of the SCAP flap is more cephalic and lateral than the DCIA flap; its pedicle will be spared even after a previous abdominoplasty.

The size of the dermal-fat flap may permit autologous breast reconstruction, and the scar at the donor site appears more discrete than that with a latissimus dorsi flap.

In this study, we have not discussed the need to carry out paraclinical examinations. However, preoperatively, an AngioScan should be carried out to assure the integrity of the subcostal pedicle to determine its diameter and to identify the anatomy of the perforator vessels in the dermal flap from the flank. Furthermore, the use of echo-Doppler has already been described as an effective technique for preoperative location of perforator vessels,[16] facilitating the identification of perforator vessels at the time of dissection.

The main limitation of using SCAP flaps is aesthetic, with a scar at the donor site situated in the flank area. However, the aesthetic sequelae are limited because the scar

is more discrete than that with a latissimus dorsi or DIEP flap. The SCAP flap scar could easily be hidden in daily life by underwear and would be much shorter than that with a transverse rectus abdominis myocutaneous or DIEP flap. Finally, the use of excess skin-fat of the 'love handles' could have a secondary benefit to the patient and potentially result in a more pleasing figure. Another limitation of this flap is the asymmetry of the flank area triggered by this technique. However, proposing a liposuction or a dermolipectomy of the contralateral skin excess to correct the asymmetry could be an option to provide a better aesthetic result.

In this experimental study on cadavers, we have demonstrated that dissection of a pedicled dermal-fat perforator flap from the 'love handles', vascularised by a subcostal artery perforator, called a SCAP flap, was feasible and reproducible, and its clinical application in breast surgery was feasible. We think that this technique, applied in breast reconstruction, could present a less arduous surgical alternative to DIEP or another free flap for women with excess skin-fat around their 'love handles'. Furthermore, it could be an interesting second-line option for patients with a history of abdominoplasty or who have experienced failure of a DIEP flap. Clinical application of this technique is now necessary to confirm the feasibility of this flap in breast reconstruction.

Acknowledgements

The author would like to gratefully acknowledge the Fer à Moulin Surgery School of Paris.

Conflict of interest statement

None of the authors has a financial interest in any of the products, devices or drugs mentioned in this manuscript.

References

1. Allen RJ, Treece P. Deep inferior epigastric perforator flap for breast reconstruction. *Ann Plast Surg* 1994;**32**:32–8.
2. Bergeron L, Tang M, Morris SF. The anatomical basis of the deep circumflex iliac artery perforator flap with iliac crest. *Plast Reconstr Surg* 2007;**120**:252–8.
3. Mojallal A, Saint-Cyr M, Wong C, Veber M, Braye F, Rohrich R. Le lambeau de grand dorsal avec conservation du muscle. Étude anatomique et indications en reconstruction mammaire. *Ann Chir Plast Esthet* 2010;**55**:87–96.
4. Allen RJ, Heitmann C. Perforator flaps – the history of evolution. *Handchir Mikrochir Plast Chir* 2002;**34**:216–18.
5. Daniel RK, Kerrigan CL, Gard DA. The great potential of the intercostal flap for torso reconstruction. *Plast Reconstr Surg* 1978;**61**:653–65.
6. Rozen WM, Ashton MW, Taylor GI. Reviewing the vascular supply of the anterior abdominal wall: redefining anatomy for increasingly refined surgery. *Clin Anat* 2008;**21**:89–98.
7. Taylor GI. The angiosomes of the body and their supply to perforator flaps. *Clin Plast Surg* 2003;**30**:331–42.
8. Feinendegen DL, Niederhäuser T, Herrmann G, et al. The subcostal artery perforator flap; an anatomical study. *J Plast Reconstr Aesthet Surg* 2008;**61**:1496–502.
9. Feinendegen DL, Klos D. A subcostal artery perforator flap for a lumbar defect. *Plast Reconstr Surg* 2002;**109**:2446.
10. Daniel RK, Kerrigan CL, Gard DA. The great potential of the intercostal flap for torso reconstruction. *Plast Reconstr Surg* 1978;**61**:653–65.
11. Rozen WM, Ashton MW, Taylor GI. Reviewing the vascular supply of the anterior abdominal wall: redefining anatomy for increasingly refined surgery. *Clin Anat* 2008;**21**:89–98.
12. Taylor GI. The angiosomes of the body and their supply to perforator flaps. *Clin Plast Surg* 2003;**30**:331–42.
13. Lie KH, Barker AS, Ashton MW. A classification system for partial and complete DIEP flap necrosis based on a review of 17,096 DIEP flaps in 693 articles including analysis of 152 total flap failures. *Plast Reconstr Surg* 2013;**132**:1401–8.
14. Tran NV, Buchel EW, Convery PA. Microvascular complications of DIEP flaps. *Plast Reconstr Surg* 2007;**119**:1397–405 discussion 1406-1408.
15. Buchel EW. First report and case series of the perforator DCIA flap for breast reconstruction. In: Scientific paper session: Breast. ASMR Meeting - Bahamas, January 27; 2015. Available at: *http://www.microsurg.org/assets/1/7/3.pdf* .
16. Blondeel PN, Beyens G, Verhaeghe R, et al. Doppler flowmetry in the planning of perforator flaps. *Brit J Plast Surg* 1998;**51**:202–9.