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Evolution from the TUG to PAP flap for breast reconstruction: Comparison and refinements of technique☆

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Summary *Background:* Limitations of the transverse upper gracilis (TUG) flap for autologous breast reconstruction include: short pedicle, modest volume, muscle sacrifice and a problematic donor site. The Profunda Artery Perforator (PAP) flap utilises large perforators posterior to the gracilis muscle. We describe our preliminary experience of its use and compare it to our large series of TUG flaps.
Method: Our technique has evolved from frog-leg to lithotomy position, and from an anterio-posterior to cranio-caudal raise. This allows either the descending branch of the inferior gluteal artery perforators (IGAP) or the TUG flap as alternatives should PAP perforators be unsuitable intra-operatively. A prospective database was utilised to compare TUG and PAP flaps undertaken 2010–2013.
Results: 54 TUG and 22 PAP flaps were performed. 4 PAP flaps were converted to IGAP flaps and 1 to TUG intra-operatively. 97% of all flaps were successful. Mean flap weight was 295 g (TUG) and 242 g (PAP). Donor site complications for both series included seroma (4 TUG, 1 PAP) sensory disturbance (2 TUG, 1 PAP) and scar revision (3 TUG, 1 PAP).
Conclusion: Our preliminary experience of the PAP flap has not been universally favourable compared to the TUG flap. It is a more challenging flap to raise, which carries with it a learning curve, especially if raised in the supine position; we present our learning points for safer flap harvest, allowing the TUG as a bail out option. The benefits of the PAP include a longer pedicle, without the need to sacrifice muscle; the perforators should have a more defined and larger

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perfusion zone. The scar is better hidden, but we have not yet proven significant improvements to the donor site compared to the TUG flap.

Level of Evidence: III

Background

For patients requiring autologous breast reconstruction after mastectomy, abdominal based free flap reconstruction, utilising the deep inferior epigastric perforators (DIEP) is a popular choice. However, not all patients have sufficient abdominal tissue either because of low body mass index, scars, poor perforator pattern or because the site has already been harvested as a previous DIEP or abdominoplasty.

An alternative donor site is upper thigh tissue in the form of a transverse upper gracilis (TUG) flap.[1–3] The TUG flap is recognised as having several disadvantages. The volume obtainable from the inner thigh is modest,[4] the pedicle length short at 6–7 cm[5] and the donor site is prone to breakdown and seromas.[6,7] These limitations have been addressed variously in the literature to some success,[3] but perhaps the most interesting recent advance has been the description by Allen of the Profunda artery perforator (PAP) flap.[8]

The PAP flap is based on musculocutaneous or septocutaneous perforators from the second or third perforating branch of the profunda femoris; these are encountered posterior to the gracilis muscle and supply skin and adipose in the 'banana roll' under the buttock crease. According to clinical observation and pre-operative imaging studies around 98% of thighs have at least one suitable perforator in this region, with average size 1.9 mm. Medial perforators are close to adductor magnus, on average 3.8 cm from midline and 5 cm below the gluteal fold and lateral perforators are near biceps femoris and vastus lateralis, 1.2 cm from the midline and 5 cm below the gluteal fold.[9,10] This flap provides soft, pliable tissue from a relatively plentiful donor site in even those with inadequate abdominal tissue. As such, it could be seen as an evolutionary step from the TUG flap as it is likely to be offered to the same cohort of patients.

In theory the PAP flap should offer several advantages to the TUG flap both in terms of the resultant breast and the donor site.[8] In terms of reconstruction, the flap can be centred around the perforator resulting in potentially a better vascularised flap. The volume should be larger, typically 3–400 g, similar to mastectomy weight in most patients for whom this flap is suitable. A long skin paddle can be taken, around 7 × 27 cm, which may have advantages for delayed and salvage reconstructions. The pedicle is longer, averaging 9.9 cm, allowing flexibility of inset and the calibre of these vessels are a good match for the internal mammary recipients (average artery size 2.2 mm, average vein size 2.3 mm). With regard to the donor site, the scar should be well hidden in the gluteal crease and less visible than the more anterior scar from TUG harvest. Unlike TUG flaps, no muscle is sacrificed, and the dissection is more distant from the lymphatics, potentially reducing the risk of seroma. The price paid for these advantages is a more challenging flap raise and possible turning of the patient if raised in the prone position.

If the PAP is truly to replace the TUG flap, we need to compare results of these two forms of reconstruction. We introduced the PAP flap at our institutions in April 2013. We describe our modifications to the technique and compare our preliminary PAP flap series to our large TUG flap series to see whether these potential advantages are borne out.

Method

Surgical technique

The senior author raised all flaps in the TUG and PAP series. TUG harvest has been well described elsewhere. The PAP flaps were raised broadly according to Allen's method[8] but with several modifications. Pre-operative imaging was obtained using computed tomography angiography (CTA). The superior border of the flap was marked 1 cm above the gluteal crease rather than 1 cm below and a pinch test was used to delineate the width of flap harvested. An elliptical flap was designed which did not extend beyond the visible lateral or medial thigh beyond the gluteal fold. The first cases Allen performed were raised in the prone position. This allowed dissection from posterolateral to anterior, maintaining the TUG as a bail out. His later cases have been performed supine in the frog-leg position, negating intraoperative turning but sacrificing the TUG flap before visualising the PAP perforators. We have followed this latter approach using a supine modified lithotomy position (Figure 1), but have been able to use perforators from the descending branch of the inferior gluteal artery (IGAP) if inadequate PAP vessels were seen[11] (Figure 2). As our technique has evolved, we have started to raise our flaps from caudal to cranial, thus allowing both the TUG or IGAP flaps as bailouts, even in the supine position (Figure 3). All flaps were anatomosed to the internal mammary axis in the chest. Donor sites for TUG and PAP flaps were closed in layers over a drain, ensuring the superficial fascia was repaired robustly. All patients were allowed to mobilise form day 1 post operatively but asked to avoid strenuous activity for 4 weeks.

Case series

A prospective database of all breast reconstructions performed by the senior author was completed. This detailed breast reconstructions undertaken at St Thomas' hospital,

Figure 1 Supine modified lithotomy position for PAP harvest.

Figure 2 Intra-operative photograph of PAP raise.

London, UK and those undertaken at the Pyramid clinic at the Lake, Zurich, Switzerland. Patient demographics were recorded, along with flap and mastectomy weights, length of procedure, intra- and post-operative complications. This allowed comparison of those patients who had TUG flap reconstructions and those who had PAP flaps between January 2010 and December 2013. In general TUG flaps were performed in the earlier part of the series, whilst the PAP flaps were not introduced until April 2013.

Students t test was used to compare means of the two groups, whilst Fisher's exact test was used to compare complication rates.

Results

A large series of 54 TUG flaps was available for comparison to the preliminary series of 22 PAP flaps (Table 1). The two groups were similar in terms of mean age and body mass index (BMI) ($p = 0.31$). Most flaps were offered in the immediate setting for both types of flap, although there was a higher proportion of delayed reconstructions in the PAP series; this is partly because many of the PAP flaps were salvage procedures after implant failure. Mastectomy weights and flap weights were modest as expected for both series; smaller mastectomies and reconstructions were performed in the PAP patients ($p = 0.15$ and 0.04 respectively). One of the TUG flaps had significant fat necrosis requiring revisional surgery, whilst so far none of the PAP flaps have demonstrated significant fat necrosis.

16.7% of the TUG flaps had donor site complications compared to 13.6% of PAP flaps, ($p = 1.00$). The types of complications and their frequency are shown in Table 2; so far one PAP flap donor site has developed a seroma, one wound has required re-suturing and one patient experienced nerve type pain at the donor site (Figures 4 and 5).

All TUG flaps have been successful with two flap failures in the PAP group. Four of the 22 PAP flaps have been intra-operatively converted to flaps based on IGAP vessels and one to a TUG flap due to a lack of adequate PAP vessels in the flap. The skin paddle remained as pre-operatively marked and all flaps continued to be raised in the supine position.

Discussion

The Profunda artery perforator (PAP) flap has been described by Allen[8] as a potential replacement to the Transverse upper gracilis (TUG) flap in those ladies requiring autologous breast reconstruction who are unable to have, or choose not to have, an abdominal based free flap. The TUG flap is a robust reconstruction, supplying soft pliable adipose, similar in nature to breast tissue. It is a well established flap with well documented limitations in

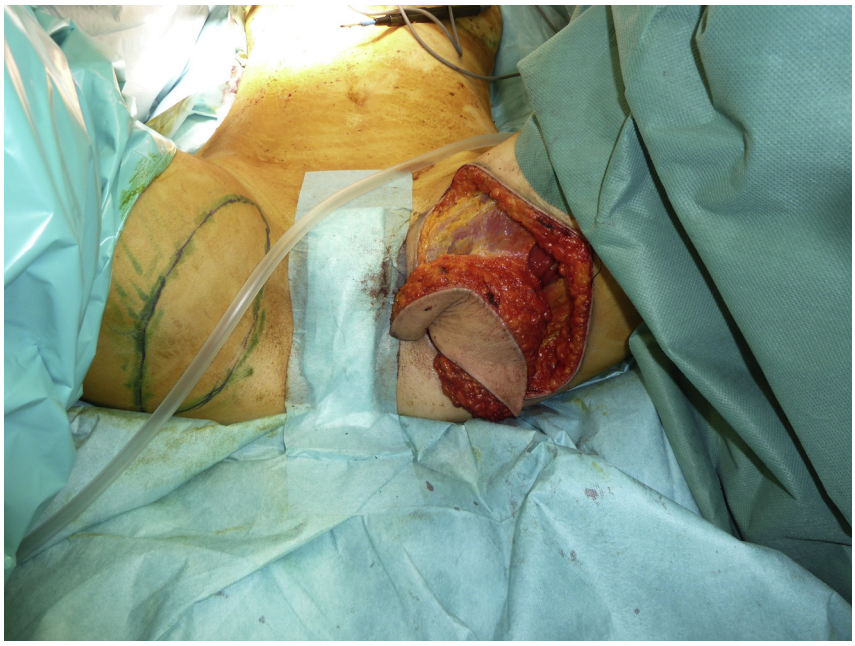

Figure 3 Intra-operative photograph of cranial to caudal raise.

Table 1 Patient demographics, flap characteristics; values in brackets show range of data.

	TUG flaps	PAP flaps
Flaps	54	22
Patients	39	13
BMI (kg/m^2)	22.3 (19.4–27.0)	21.6 (19.0–31)
Age (years)	48 (35–61)	48 (32–61)
Delayed:Immediate	13:41	9:13
Mastectomy weight (g)	299.4 (69–649)	227.0 (30–632)
Flap weight (g)	294.9 (149–500)	242.0 (132–455)
Flap failure	0	2
Donor site complications	9	3

Table 2 Donor site complications, percentage of all flaps in brackets.

	TUG flaps	PAP flaps
Seroma	4 (7%)	1 (4.5%)
Sensory disturbance	2 (4%)	1 (4.5%)
Wound breakdown/scar revision	3 (6%)	1 (4.5%)

terms of volume, pedicle length and donor site morbidity. The PAP flap should be appropriate in the same cohort of patients, and is argued to have several advantages over the TUG. We therefore set out to compare our preliminary series of PAP flaps to our larger series of TUG flaps to see whether these advantages were obvious.

As expected, our TUG series was much larger than our PAP series, as we had only offered PAP flaps since April 2013. There are therefore limitations to conclusions that can be drawn due to the small numbers in one group. We did however feel that we should be auditing our results when introducing this new procedure before adopting it as a replacement to the TUG, especially as it is more technically demanding.

We would agree that there are certain benefits to the PAP flap. If an adequate perforator is found, it is usually more central to the flap than the eccentric location of the gracilis pedicle in the TUG flap. The pedicle is certainly longer and we have not yet had to revise our reconstructions due to fat necrosis, supporting the hypothesis that the flap is potentially better vascularised. Unlike Allen, however,[8] we have not found that the flap we have harvested is significantly larger in volume than the average TUG flap; in fact in our series the converse is true. Interestingly, though, our ladies undergoing PAP flaps were slimmer than their TUG counterparts ($p = 0.31$), had smaller mastectomy weights ($p = 0.15$), and smaller flaps ($0 = 0.04$). This may not mean that larger flaps could not have been harvested, simply that they were not required.

We did not always find an adequate perforator in our flap that arose from the profunda axis, despite performing imaging pre-operatively. This may be due a learning curve with interpreting the CT angiograms in the thigh region. We now use the scan to determine whether a PAP perforator is readily available within the proposed skin paddle or not; if it is too far below the gluteal crease then we would elect to perform a TUG rather than a PAP flap as a low scar we feel is unsightly.

Regardless of what was seen on imaging we were keen to raise the flaps in the supine position, as turning the patient we felt would be a real disadvantage. Raising the flap in this way from anterior to posterior meant that a TUG flap was not a possible bail out; we were however able to raise flaps based on perforators from the descending branch of the inferior gluteal artery when a decent PA perforator was not found. This branch is found in the midline of the thigh, travelling with the posterior cutaneous nerve of the thigh. This flap has previously been described for breast

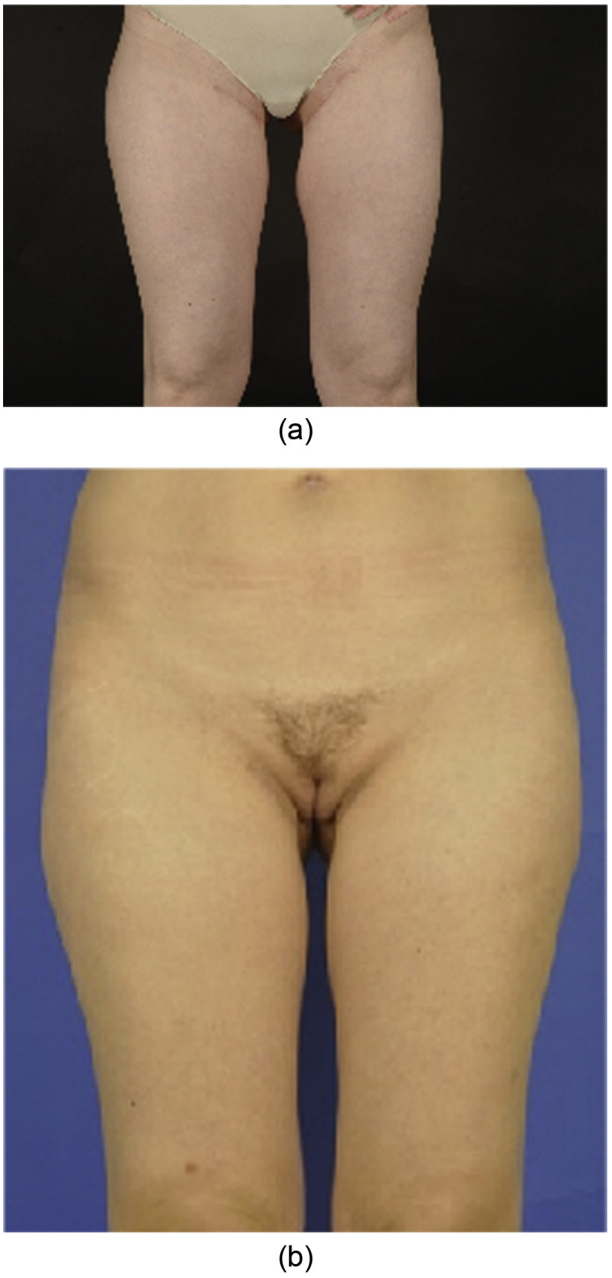

Figure 4 a. Anterior TUG donor site; b. Anterior PAP donor site.

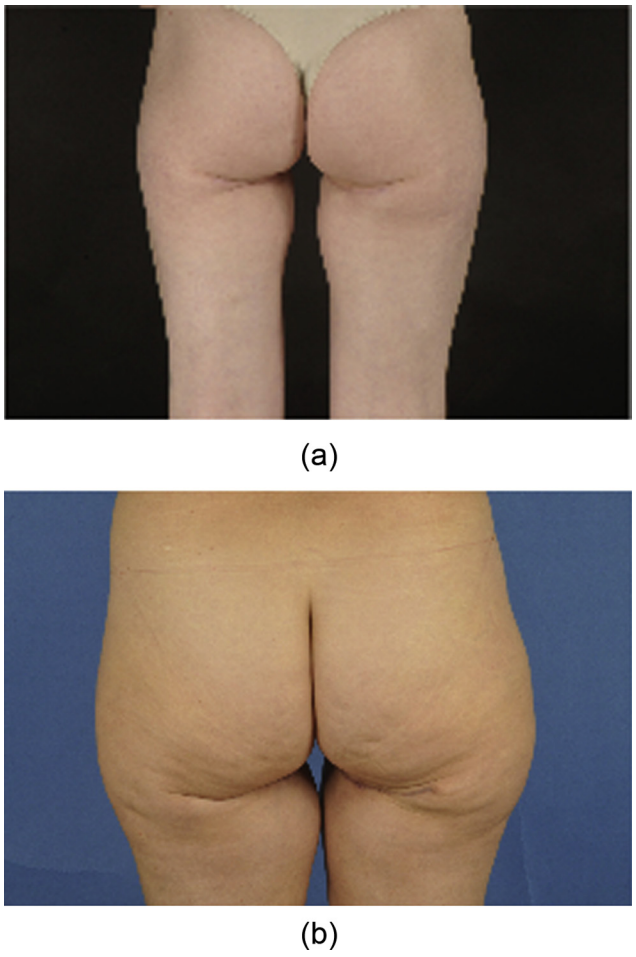

Figure 5 a. Posterior TUG donor site; b. Posterior PAP donor site.

reconstruction by Papp et al., in 2007,[11] but was raised in the prone position. In the supine position, this presented challenging dissection requiring good assistance, but did allow us a bail out option. Interestingly 4 of our 22 PAP flaps have had to be converted to these IGAP flaps. As we have become more proficient with these flaps we have used a modified lithotomy position which provides good access even without an assistant. In addition we have started to raise the flaps from caudal to cranial rather than anterior to posterior allowing both IGAP and TUG flaps as alternatives. We have converted one PAP to a TUG in this way, and this is now our preferred bail out option.

The two flap failures in the PAP series are of concern. One was due to a technical anastomosis error. The other was in a PAP which was converted to an IGAP and had an extremely short pedicle. It suffered an irretrievable avulsion injury during inset. Problems such as this are less likely if the TUG is the bail out option rather than the IGAP; we have moved toward this in the later parts of our series by raising from caudal to cranial rather than anterior to posterior. We present conversion to an IGAP as a learning point that we have since abandoned.

Our donor site complications in our TUG flaps compare favourably with that described in the literature. Whilst our seroma rate was 7% and wound breakdown 6%, Buntic et al.[12] describes rates of seroma as high as 20% with delayed healing of 40% in their series of 32 TUG flaps. Saint-Syr et al., in 2012[13] describe 1 seroma in their series of 13 extended TUGs and 2 donor site dehiscences.

As regards the PAP donor site, the scar is slightly more posterior and we have had some good aesthetic results from these patients (Figures 4 and 5). We have not formally assessed quality of scarring between the groups, although the PAP scar is designed more posteriorly than the TUG and is therefore less visible to the patient. In addition, no muscle was sacrificed in the PAP series compared to the TUG series. Apart from more elegant dissection, this potentially means less dead space for seroma accumulation. The harvest is also further away from the inguinal

lymphatics than in the TUG flap, possibly further decreasing seroma risk. We did however see one seroma, one wound dehiscence and one neuralgia amongst the 22 thighs operated on in the PAP patients, meaning that our donor site complications were not significantly different to the TUG series. Whether this is the effect of small numbers is difficult to know. These figures are however similar to that quoted by Allen in his 2012[8] paper, where he experienced 1 seroma and 1 donor site haematoma in his series of 27 flaps.

Conclusions

The PAP flap is a potential evolution from the TUG flap. No muscle is sacrificed during its harvest and it has a longer pedicle with a potentially larger, more flexible flap and a possibly better hidden scar, with perhaps less fat necrosis. In our preliminary experience however, the PAP flap requires advanced microsurgery skills as it involves a more complex dissection and longer raise. Good assistance or a lithotomy holding device is required to raise the flap in the supine position and we have not uniformly found adequate perforators from the profunda axis in our flaps despite imaging beforehand. In these cases we have been able to raise a flap on IGAP or gracilis vessels; it is now our practice to plan for a TUG flap when the PAP perforators are inadequate or poorly positioned. Due perhaps to small numbers there was an inconclusive improvement in donor site complications and we therefore urge further sharing of results before abandoning the TUG flap in favour of the PAP.

Ethical approval

Not required.

Funding

None.

Conflicts of interest

None declared.

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