THE COMBINED TRANSVERSE UPPER GRACILIS AND PROFUNDA ARTERY PERFORATOR (TUGPAP) FLAP FOR BREAST RECONSTRUCTION

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Background: Surgical options for breast reconstruction include alloplastic and autogenous reconstructions. In autologous cases where the abdomen is not a suitable primary donor site, secondary donor sites such as the thigh or buttock are considered. The aim of this report is to describe a novel approach, the combined transverse upper gracilis and profunda artery perforator (TUGPAP) flap, aimed at medium to large volume breast reconstruction, with a single donor site used per breast. *Methods:* Between January 2011 and June 2013, 32 consecutive unilateral immediate breast reconstruction cases were performed using free flaps. In nine cases, patients had previously undergone abdominal surgery, therefore abdominal flaps were excluded and TUGPAP flaps were performed. The TUGPAP flap consisted of the combination of two well-described flaps: the transverse upper gracilis (TUG) and the profunda artery perforator (PAP) flap. All TUGPAP flaps were based on two pedicles: the ascending branch of the medial circumflex femoral artery (MCFA) for the TUG component, and the profunda artery perforator itself for the PAP component. *Results:* The mean size of the harvested skin paddle was 28.6 $\times$ 8 cm^2 (range, 27 $\times$ 7 cm^2 to 30 $\times$ 9 cm^2). The average length of the TUG flap pedicle was 7 cm (range, 6–8 cm) and the PAP flap pedicle was 9 cm (range, 8.5–10 cm). The flap survival rate was 100% with no re-exploration, and no partial flap loss. Post-operatively there was one case of persistent donor site seroma, which was managed conservatively. *Conclusion:* With appropriate patient selection and surgical technique the TUGPAP flap could be a valuable option as an alternative method for autologous breast reconstruction. © 2015 Wiley Periodicals, Inc. Microsurgery 00:000–000, 2015.

BACKGROUND

Breast cancer is the malignancy with the highest prevalence and incidence in women in Western countries.[1] Surgical options for breast reconstruction include alloplastic and autologous reconstructions, the latter comprising soft tissue flaps from various donor sites.[2,3] Autologous reconstruction allows for the creation of a naturally textured breast, which generally does not change with time, achieves the consistency of the native breast, and becomes softer as the patient ages.[4] There are no implant-associated complications requiring additional surgeries in the future. The evolution of microsurgical technique has also broadened donor site options for breast reconstruction.

Nowadays there are several free flaps described for autologous breast reconstruction, with the abdomen as the primary donor site. However, in patients who have undergone previous abdominal surgery or in whom there is insufficient abdominal tissue to achieve the goals of reconstruction, alternative donor sites are selected. In these situations, flaps from the thigh or from the buttock are valuable alternative donor sites. Focusing on the thigh, the transverse upper gracilis (TUG)[5–11] and the profunda artery perforator (PAP)[12–14] flaps are well-described options for breast reconstruction.

The aim of this report is to present an alternative option for breast reconstruction using a combined TUG and PAP flap, the TUGPAP flap. The inclusion of a second flap pedicle (PAP), has been recently described by Bodin et al.,[10] and the authors suggested that this technique could increase the vascular reliability of extended transverse musculo-cutaneous gracilis (TMG) flaps. Here we present the clinical outcomes of the TUGPAP flap technique, which we used in nine patients requiring medium to large volume breast reconstruction.

PATIENTS AND METHODS

Between January 2011 and June 2013, 32 consecutive patients with unilateral breast cancer underwent mastectomy

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Table 1. Data of Patients Who Underwent the TUGPAP Flap for Breast Reconstruction

	No. of patients	Min	Max	Mean	SD
Age (year)	9	35	68	54.2	10.83
BMI (kg $m^{-2)}$	9	18.8	31.2	22.4	3.57
Smokers (active)%	9	0	0	0	0
Operating time of flap harvest (min)	9	95	115	102.5	8.6
Total operating time (min)	9	240	425	319.32	28.07
Lengths of stay (days)	9	8	13	9.3	1.2
Follow-up (months)	9	12	15	13.22	0.9

BMI, body mass index; SD: Standard Deviation.

Figure 1. Design of the flap and marking of the pedicle of the transverse upper gracilis and the profunda artery perforator (TUG-PAP) flap. The cutaneous perforators from the PAP component were identified, Dopplered, and marked. . The perforator from the PAP component was centered on the TUGPAP flap. It was not mandatory to identify the perforator of the TUG, since the TUG was raised with the gracilis muscle and not as a perforator flap.

Figure 2. The flap was harvested in the frog-leg position. Dissection of the flap showing both pedicles. The vascular pedicle lengths were ~6 cm (TUG component) and 9 cm (PAP component).

and reconstruction with free flaps. Nine patients with unilateral breast cancer underwent mastectomy and immediate reconstruction with TUGPAP flap. Patient data are summarized in Table 1. The inclusion criteria for this technique included patients aged 30–70 years with a non-suitable donor abdomen—whether it be due to inadequate size, previous abdominal surgery including liposuction, or abdominal trauma—and patients with a large breast size who were not interested in a balancing breast reduction on the normal side. The exclusion criteria were previous bilateral thigh surgery or donor site trauma, active smokers and small breast size. The mean age of the patients was 54.2 ± 10.83 years (range, 35–68 years).

Surgical Technique

All patients underwent preoperative computed tomographic angiography (CTA) to identify perforator size, location, and course. A handheld Doppler device was used to confirm and mark the dominant perforator of the PAP flap, as described by Allen et al.[12] The PAP flap was centered over the Doppler red vessel, on the posteromedial aspect of the thigh. The perforator of the TUG flap could be identified as well, but doing so was not deemed as important because the TUG portion on the flap is harvested as a musculo-cutaneous flap and not a perforator flap, both for volume and reliability.

Preoperatively, flap design was marked with the patient in the frog-leg position (Fig. 1). The anterior border of the flap was drawn medial to the femoral vessels. The posterior border of the flap was approximately the posterior midline of the inferior gluteal fold, depending on the location of the marked perforator. The superior border of the skin paddle was marked 1–2 cm below the inguinal crease and extended superiorly to 1 cm inferior to the gluteal fold.

The width of the flap was estimated by pinching the proposed skin paddle to ensure tension-free closure. The inferior border was marked ~8 cm below the superior marking, connecting the markings as a horizontal ellipse of maximum length of 30 cm.

In the frog-leg position, harvest of the flap was performed from the ipsilateral side, the superior and lateral incisions were made as drawn in Figure 2. Anterior TUG flap dissection proceeded superficial to the muscle fascia until the posterior edge of the adductor longus muscle

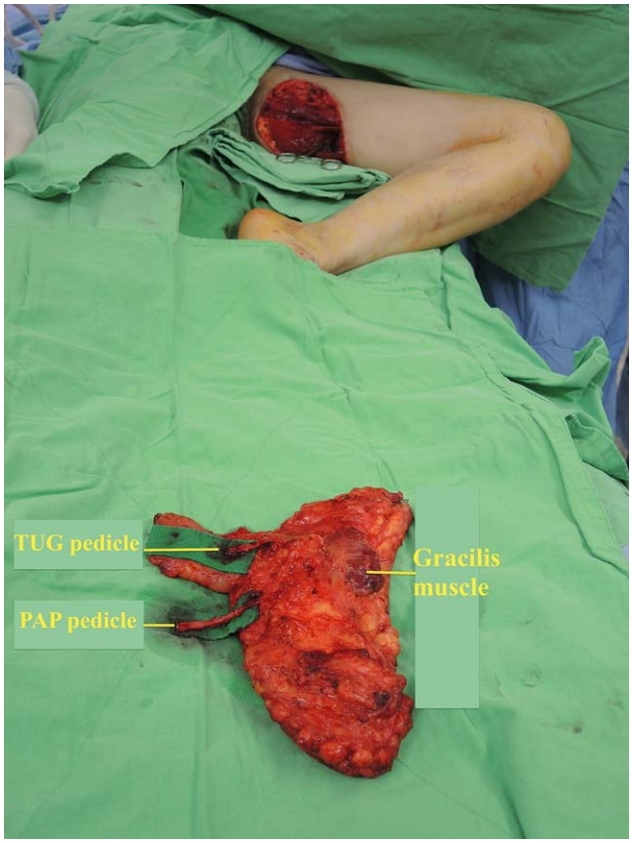

Figure 3. Intraoperative donor site and TUGPAP flap.

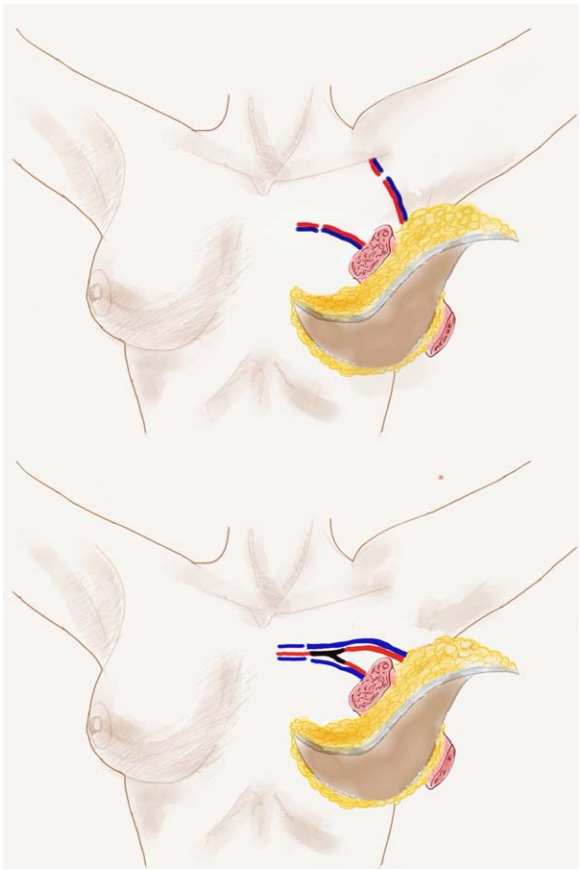

Figure 4. (Above) A combination of the internal mammary and thoracoacromial vessels for the microanastomosis was selected. (Below) Microsurgical anastomosis to the internal mammary vessels was performed. A YVG was used to join the arterial pedicles of the transverse upper gracilis and the profunda artery perforator flap to the internal mammary artery.

was encountered. The deep fascia was incised longitudinally and the space between the adductor longus and gracilis muscle was separated, the gracilis muscle was included in the flap, and the vascular pedicle to the gracilis was identified on its deep surface and skeletonized proximally to its origin. The greater saphenous vein was spared and not included within the flap. The gracilis muscle was transected superiorly and inferiorly. The remaining marked incisions were made, and dissection proceeded in the suprafascial plane to identify the pedicle of the PAP flap, usually running 3 cm posterior to the gracilis muscle. Careful perforator dissection was performed just distal to the origin of the profunda femoris artery for maximal length. During harvest, the thigh skin was undermined below the superficial fascia to safely include larger amount of fat to augment flap volume, as needed (Figs. 2 and 3).

Microanastomosis was performed an in end-to-end fashion in all cases, using the internal mammary (IM) vessels in five patients and a combination of the IM and thoracoacromial (TA) vessels in four patients. In cases where only the IM vessels were used, a "Y" vein graft (YVG) harvested from the dorsum of the foot or hand was used to join the two arterial pedicles of the TUGPAP flap with the IM artery. Venous anastomoses were performed in end-to-end fashion with each of the IM veins joining the best PAP and the best TUG vein, as evaluated visually by flow (Fig. 4).

The inset of the flap was done by first establishing an ideal breast pocket to match the normal side. Care was especially taken to redefine the IMF, the medial breast fold to prevent synmastia, and the lateral breast fold at the anterior axillary line if required, with suturing, to prevent flap migration and breast deformity. Orthotopic vessel orientation was judiciously maintained as the flap was transposed to the breast pocket. The flap was allowed to rest well in the pocket and positioned to fill it as much as possible to define contour and reduce dead space. After microanastomosis and evaluation of perfusion, the flap was deepithelialized to match the skin requirements of the reconstruction, and hemostasis was ensured. Final check of anastomotic patency and safe vessel course was done. Incremental rib or muscle excision was performed to avoid compression on the vessels,

as required. A suction drain was left in the breast pocket away from the vessels, and a suction drain was placed in the donor site. Closure was performed in layers. Postoperative follow-up was performed at 2 weeks and subsequently every 3 months for the first year.

RESULTS

The mean size of the harvested skin paddle was 28.6 × 8 cm^2 (range, 27 × 7 cm^2 to 30 × 9 cm^2). The mean flap harvest time was 102.5± 8.6 minutes (range, 95 to 115 minutes) and mean total operative time was 319 ± 28 min (range, 240–425 min). All TUGPAP flaps were based on two pedicles as shown in Figure 3. The average length of the TUG flap pedicle was 7.02 cm (range, 6–8 cm) and the PAP flap pedicle was 9.25 cm (range, 8.5–10 cm). Recipient vessels were the IM (five cases) and IM and TA (four cases). YVGs were harvested from the dorsal foot (2) or hand (3) after carefully noting the flow direction. The average length of the stems of the YVGs used to bridge the arterial gap was 2.5 cm (range, 2–3 cm). Seroma occurred at the donor site in only one patient, and was successfully managed with aspiration and compression. Except for this single case, minimal donor site morbidity was encountered at the period of follow-up, with no patient complaints or delayed healing. The flap survival rate was 100% with no re-exploration, and no partial flap loss. There was no fat necrosis noticed clinically in postoperative follow up visits. In the current report, the average length of hospital stay was 9.3 ± 1.2 days (range 8–13 days) and the mean follow-up was 13.22 ± 0.9 months. The results are summarized in detail in Table 2 and showed in the Figures 5–7.

Table 2. TUGPAP-Flap: Patients, Breast, Pedicles, Donor and Recipient Vessels Characteristics

					TUGPAP flap							Complications	
							Pedicle length (cm)		Perforators number				
Patients	Breast site	Breast cancer histology	Timing of reconstruction	Mastectomy weight (g)	Flap weight (g)	Skin paddle size (cm)	TUG	PAP	TUG	PAP	Recipient vessels	Thigh	Breast
1	Right	Lobular Carcinoma	Immediate	415	450	27 × 9	7.8	10	1	1	IM	0	0
2	Right	Ductal Carcinoma	Immediate	450	480	30 × 8	6.3	9	1	2	IM	0	0
3	Left	Lobular Carcinoma	Immediate	465	500	29 × 8	6.2	8.6	1	1	IM-TA	0	0
4	Left	Ductal Carcinoma	Immediate	362	390	27 × 7	6	10	1	2	IM	0	0
5	Right	Ductal Carcinoma	Immediate	425	460	27 × 9	7.3	9.8	1	1	IM-TA	0	1 Seroma
6	Left	Lobular Carcinoma	Immediate	450	490	30 × 7	7.7	9.2	1	2	IM-TA	0	0
7	Left	Ductal Carcinoma	Immediate	440	450	28 × 9	8	9.4	1	1	IM	0	0
8	Left	Ductal Carcinoma	Immediate	450	520	30 × 9	6.4	8.8	1	1	IM	0	0
9	Right	Ductal Carcinoma	Immediate	415	455	29 × 7	7.5	8.5	1	1	IM-TA	0	0
Mean	44.44% R	33.3% LC		430.22	466.1	28.6 × 8	7.02	9.25	1	1.3	IM:55.56% IM-TA: 44.44%		
	55.56% L	66.6% DC											

IM: Internal Mammary vessels; IM-TA: internal mammary-thoracoacromial vessels.

DISCUSSION

Abdominal tissue remains the gold standard donor site for autologous breast reconstruction. [15–20] Thigh-based flaps such as the transverse upper gracilis (TUG),[5–9] the gracilis perforator flap,[21] the vertical upper gracilis (VUG),[22] and the profunda artery perforator flap (PAP),[12–14] as well as gluteal-based flaps[23–26] are also very useful secondary options for autologous breast reconstruction.

In this report, we used a combined TUG and PAP flap from the thigh, as a secondary donor site instead of the buttocks, due to several distinguishing advantages. The TUGPAP flap provides more soft tissue, does not affect buttock contour, has an easier pedicle dissection, is more pliable during the inset, and avoids intraoperative patient repositioning.

The independent harvesting technique of the TUG and PAP flaps are well described as cited. In this article, we have described the possibility to combine these flaps and have focused on the volume increase for unilateral breast reconstruction, to overcome problems with the moderate flap volume of each individual flap. The TUG-

Figure 5. (Left) Preoperative and (right) 13-month postoperative views of the patient after breast reconstruction using TUGPAP flap following mastectomy.

Figure 6. (Left) Immediate postoperative donor site, (right) and at 13 month follow up.

Figure 7. Anterior (left) and posterior (right) postoperative views showing TUGPAP flap donor site.

PAP is a combination of two well-described flaps: the transverse upper gracilis (TUG) and the profunda artery perforator (PAP) flap. Despite both flaps pedicles originating from the profunda femoral artery system, they however provide different substantial skin territory perfusion, as showed in several anatomical and clinical studies for the TUG[6,8,21,27–29] and PAP[13,14,30,31] flaps.

The vascular anatomy of the TUG flap was investigated by Yousif et al.[5] in 1992. The TUG is perfused by the ascending branch of the medial circumflex artery and its venae comitantes that reliably perfuse the gracilis muscle and the transverse upper thigh skin. The pedicle enters the gracilis muscle between 8 and 12 cm below the pubic tubercle. The pedicle length is 6–8 cm.[27,28] The average flap volume harvested reported is ~350 mL.[7]

The TUG flap offers a relatively easy dissection, is often in virgin territory, requires no intramuscular dissection, offers minimal functional deficit, and provides a concealed donor site scar. It is indicated for thin patients with small to moderate size breasts with minimal lower abdominal tissue.[32] Disadvantages of the TUG flap include a relatively short pedicle, possible donor site problems, wound breakdown, poor scarring, sensory disturbance, loss of volume due to post-denervation muscle atrophy and a small to medium flap volume.[33] Some modifications of the TUG flap to increase flap volume have been described such as inferior or vertical extension.[34] More recently Bodin et al.[10] described the inclusion of an additional flap pedicle (PAP), in an effort to increase the reliability of the TMG flap. They used this method in four patients in which a more posterior extended TMG approach was adopted. They concluded that inclusion of the PAP pedicle may prevent partial flap necrosis. However, despite the inclusion of the second pedicle, the authors did not achieve larger volume reconstructions compared to the standard TMG flap technique used in their study.

Allen et al.[12] have described the PAP flap for breast reconstruction. The PAP flap is based on the profunda artery perforator and utilizes the tissue of the posterior thigh. The pedicle length is 9 cm,[12] located 3 cm posterior to the gracilis. Preoperative imaging is useful to identify the dominant perforator and the flap can be centered over it. The upper border of the flap is 1 cm inferior to the gluteal fold and can be harvested to dimensions of 7 cm longitudinally by 27 cm transversely.

The advantages of the PAP flap relative to the TUG flap as cited by the authors are increased pedicle length,[6,12] and avoidance of inguinal lymphatic disruption.[12,28] Average volume of the flap was similar to the TUG at 385 mL. Other advantages of the PAP flap are a concealed scar in the crease of the thigh and lower buttock, and an elliptical design that provides an ideal shape for coning to create a natural breast mound. Furthermore, the PAP flap is an adipocutaneous flap, thus muscle-sparing, for reduced donor site morbidity.

In some situations, large unilateral breast reconstructions can demand use of bilateral flaps from the thigh. Even though the flap outline of the TUG and PAP seems to be virtually identical, breast reconstruction either with a TUG or PAP flap has a size limitation not only due to inability to close, but also due to the inability to perfuse the full flap reliably. As such, a wide skin paddle and fat harvest to increase volume leads to more frequent donor site complications. To avoid such complications, each individual flap should not be pushed to the absolute limits of harvest and reliability, although our maximum flap size for the TUGPAP flap was 30×9 cm^2. The use of this bipedicled flap increases the flap dimension reliably perfused by the combined angiosomes, leading to a safe increase in volume. The TUGPAP flap offers the advantage of a large soft tissue transfer from a unilateral donor site. In cases of bilateral large breast reconstruction, both sides could be reconstructed with TUGPAP flaps instead of seeking alternate donor sites and also achieving a better symmetry of the donor site. As well, harvest can proceed beyond the cutaneous boundaries of the flap to recruit more adipose tissue, while allowing the same donor site closure and the added benefit of additional thigh contouring, when desired.

Perforator mapping of the PAP component of the TUGPAP flap is a key point. The perforator should be centered on the PAP component. In the TUGPAP harvest, it is not mandatory to identify the perforator of the TUG, nor should it be explored, since the TUG is raised with the gracilis muscle and not as a perforator flap.

It is well known that longer operating times under general anesthesia increase perioperative risks and complications, including venous thrombosis, pulmonary embolus, pressure sores, nerve injury, and airway compromise, as well as surgeon fatigue. The TUGPAP flap is a novel approach that curtails operating time for large breast reconstruction, largely through the benefits of one donor site, straightforward dissection, no patient repositioning, and the option to use a two-team approach for breast reconstructions. It does however require the dissection of a second vessel, albeit in the same field, increasing the harvest time by 15 min in our series, which is very acceptable. As well, time for anastomosis of this second vessel is required. A possible complication of the TUGPAP is potential damage to the lymphatic drainage of the leg, as mentioned in some reports for the TUG flap component.[34] In our series of patients after one-year follow-up, there were no such issues.

We also evaluated the perfusion of each of the two flap components of the TUGPAP flap in our report. Specifically, we used a micro clamp to obstruct blood flow through the TUG pedicle initially, and evaluated the perfusion of the flap distally and proximally for few minutes. We observed that the flow in the proximal part of the skin and muscle of the flap was reduced. This was followed by release of the clamp from the TUG pedicle and obstruction of the PAP artery making the same evaluation—in essence, a flap Allen's test. Obstruction of the

PAP pedicle resulted in reduced blood flow for a larger area of the flap. We thus concluded that a two pedicled harvest was the safest option.

Microanastomosis were performed using the IM vessels (five patients) and the IM and TA vessels (four patients). In five cases the TA vessels were found to be inadequate due to significant vessel size discrepancy, or insufficient pedicle length, hence we used a YVG from the foot or hand to join the TUG and PAP pedicles with the IM vessels, making sure to orient it properly in case valves were present (Fig. 4). In all cases, we performed two venous anastomoses using one vein of each pedicle. We suggest performing a second vein anastomosis to help prevent congestion for such a large flap volume.

Disadvantages of the TUGPAP included the requirement of additional microanastomoses for the second pedicle and the possible need to use a YVG to connect the IM with the TUG and PAP vessels. The use of a YVG is a simple technique with low donor site morbidity that provide another source of blood flow and could be very useful when a second artery is not available or is inadequate for use.[35,36] Disadvantages of the use of a YVG include the increase in the number of the anastomosis, which can be timing consuming and increase the risk of thrombosis and potential revision or failure. In our report we had no complications associated with the use of a YVG.

In all the nine cases in this report the reconstruction was immediate and the TUGPAP dimensions were based on the weight of the mastectomy specimen. With the TUGPAP technique we achieved the reconstructive goals in all cases, not only in terms of volume match, but also in obtaining a satisfactory breast shape and contour. All our patients were satisfied with the effect of the thigh lift of the donor thigh (Figs. 6 and 7). A balancing contralateral thigh lift could be performed upon patient request, but no patients requested such an additional procedure during the follow-up period. In cases of bilateral breast reconstruction, this flap could potentially offer the contouring benefits of a medial thigh lift in properly selected patients.

CONCLUSION

TUGPAP flap provides a reliable secondary autologous reconstructive solution for medium to large unilateral breast reconstruction as evidenced in this report, with potential application for bilateral reconstructions. Advantages include achieving reconstructive volume goals with one donor site over two, and improved reliability of these large volumes with a bipedicled flap design, still allowing direct closure in the inconspicuous groin area. The pedicles are of constant anatomy and of large diameter, and can be readily joined with a YVG if required. A two-team approach is feasible in immediate reconstructions, and like the abdominal and buttock donor sites, the TUGPAP flap can provide the added benefit of body contouring, akin to a medial thigh lift, and low donor site morbidity. In properly selected patients, the TUGPAP flap could be a reliable and safe new solution in autologous breast reconstruction.

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