

# The Conjoined TUGPAP Flap for Breast Reconstruction: Systematic Review and Illustrative Anatomy

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**Background:** Although abdominally based flaps continue to be the gold standard for autologous breast reconstruction, alternative donor sites are necessary when the abdominal region is unavailable or inadequate for flap harvest. In this case, thigh-based flaps, such as the profunda artery perforator (PAP), transverse upper gracilis (TUG), or newly described TUGPAP, are thought to be reliable with low morbidity and satisfactory cosmesis. The objective of this study was to perform a systematic review of breast reconstruction with PAP, TUG, or TUGPAP, and present anatomy and surgical techniques through illustrative examples.

**Methods:** A systematic review of the literature was conducted using PubMed, Embase, and Cochrane Library. Articles were included if they used a PAP, TUG, or TUGPAP flap for oncologic, traumatic, or congenital breast reconstruction in patients 18 years or older.

**Results:** Forty-nine studies met inclusion criteria. Seven hundred five patients underwent 906 breast reconstructions with 1037 flaps (755 TUG, 230 PAP, and 52 TUGPAP). Mean patient age was 45.9 years. The mean flap weight for TUG, PAP, and TUGPAP flaps were 323.4, 346.9, and 437.0g, respectively. The most common recipient vessel was the internal mammary artery in 821 flaps. The overall flap survival rate was 97.2% (1008/1037). TUG flaps had a significantly higher recipient and donor complication rate compared with both PAP (recipient: 18.1% versus 7.8%,  $P = 0.0001$ ; donor: 25.8% versus 7.0%,  $P < 0.00001$ ) and TUGPAP flaps (recipient: 18.1% versus 2.0%,  $P < 0.001$ ; donor: 25.8% versus 7.7%,  $P < 0.01$ ).

**Conclusion:** The TUGPAP flap is a safe and effective alternative for autologous breast reconstruction when the abdominal donor site is unavailable. (*Plast Reconstr Surg Glob Open* 2021;9:e3512; doi: [10.1097/GOX.0000000000003512](https://doi.org/10.1097/GOX.0000000000003512); Published online 20 April 2021.)

## INTRODUCTION

Abdominal flaps based on the deep inferior epigastric artery perforators (DIEPs) continue to be the gold standard for women undergoing autologous breast reconstruction. However, not all women are candidates for DIEP flap reconstruction due to a paucity of abdominal adiposity, previous abdominoplasty, abnormal scarring,

or previous DIEP flap harvest. For women seeking autologous reconstruction, alternative options include donor sites from: the trunk, such as the latissimus dorsi (LD),<sup>1</sup> lumbar artery perforator (LAP),<sup>2,3</sup> and deep circumflex iliac artery (DCIA);<sup>4,5</sup> the buttock, such as the superior gluteal artery perforator (SGAP)<sup>6,7</sup> and inferior gluteal artery perforator (IGAP);<sup>7-9</sup> and the thigh, such as the transverse upper gracilis (TUG),<sup>10-16</sup> profunda artery perforator (PAP),<sup>17-22</sup> lateral thigh perforator,<sup>23,24</sup> and antero-lateral thigh (ALT).<sup>25,26</sup>

Each second-line flap has its inherent limitations. The LD flap is limited by volume and typically requires an implant, predisposing the patients to implant-associated complications.<sup>27,28</sup> The LAP flap is limited by a tedious dissection, frequent seromas, short pedicle requiring a vein

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graft, unfavorable scar location, and requirement of interoperative position changes.<sup>29–31</sup> The SGAP and IGAP flaps are limited by contour abnormalities and a potentially visible scar.<sup>7</sup> The ALT and lateral thigh perforator flaps have the potential for sensory abnormalities and contour abnormalities.<sup>23,24,32</sup> The TUG flap usually has a short pedicle, is prone to donor-site wound healing issues, has an increased risk of lower extremity lymphedema, and may require sacrificing the gracilis muscle.<sup>20,33</sup> The PAP flap is also prone to donor-site wound healing issues and contour abnormalities.<sup>34</sup> Most notably, however, the inadequate volume of these flaps commonly limits them to a very modest breast mound reconstruction or necessitates two flaps for one breast reconstruction.<sup>11,35</sup> When two flaps are used, they are referred to as stacked flaps, the combination of which can incorporate both regional and distant flaps.<sup>36,37</sup>

Although modifications in the harvesting technique have limited the incidence of lymphedema and wound healing complications, both TUG and PAP flaps continue to be approached with reluctance due to the paucity of tissue. In 2015, however, Bodin et al<sup>15</sup> and Ciudad et al<sup>38</sup> both described the conjoined TUGPAP flap for breast reconstruction when abdominal flaps are not available, demonstrating the substantial overlapping perforasomes provided by each pedicle, allowing the creation of a larger breast mound.

There is a lack of consensus regarding the surgical outcomes of these flaps. The objective of the current study was to perform a systematic review of TUG, PAP, and TUGPAP flaps to characterize the flap size, weight, pedicle length, and complication profile. In addition, we review anatomy, markings, and surgical techniques of the conjoined TUGPAP flap through an illustrative case.

## METHODS

The systematic review was conducted according to the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” guidelines (see appendix, **Supplemental Digital Content 1**, which displays the flowchart of study inclusion using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, <http://links.lww.com/PRSGO/B613>). The study protocol was registered with PROSPERO (CRD42020177798). A comprehensive electronic database search was performed using PubMed (MEDLINE), Embase, and the Cochrane Central Register of Controlled Trials from inception to December 2019 (see appendix, **Supplemental Digital Content 2**, which displays the systematic search strategy for MEDLINE, <http://links.lww.com/PRSGO/B614>). Article abstracts were filtered based on predetermined inclusion and exclusion criteria and full-text articles were reviewed. Primary research articles were included if they used a TUG [or equivalent flap such as transverse myocutaneous gracilis (TMG), vertical upper gracilis (VUG), and diagonal upper gracilis (DUG)], PAP [or equivalent flap such as diagonal profunda artery perforator (DPAP), vertical posteromedial thigh (vPMT), and inverted-L posteromedial thigh (L-PMT)], or TUGPAP flap for oncologic, traumatic, or congenital breast reconstruction. Only studies

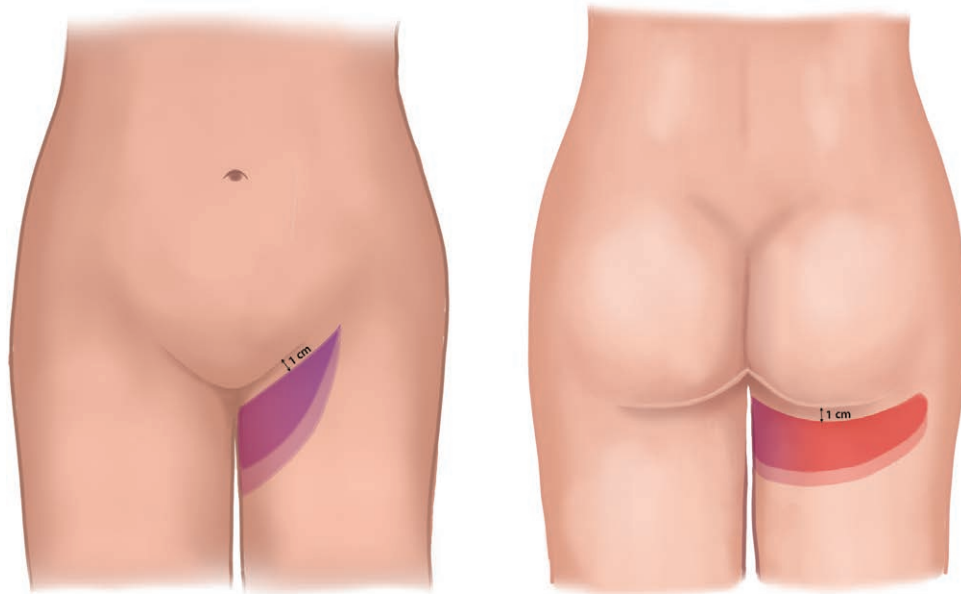
with patients 18 years and older were included. Articles were excluded if they included chimeric flaps other than PAP or TUG, were not in English, did not have any extractable data, or if they were cadaveric studies.

Two reviewers extracted data independently and in duplicate from each eligible study, populated a standardized template, and resolved disagreements by discussion. Data extracted included study design, surgical technique, complication rates, and outcomes. Complications were separated into recipient-site and donor-site complications. Variables that were not clearly described were considered missing and excluded. The risk of bias and methodological quality assessment was not performed for studies as they were all retrospective case series, for which there are no validated tools for quality assessment. The Fisher exact test was used to compare categorical variables. A *P* value of less than 0.05 was considered statistically significant.

## Anatomy

The TUG and PAP flaps merge neighboring angiosomes from the medial thigh. The TUG flap is supplied by the ascending branch of the medial circumflex femoral artery (MCFA) and its venae comitantes, which are situated approximately 10 cm from the pubic tubercle. The pedicle is relatively short (approximately 6 cm) but usually has a reasonable caliber, between 1 and 2 mm.<sup>39</sup> Flap dimensions are typically determined by a pinch test with the vertical component marked at the point the surgeon believes will allow primary closure. The horizontal component typically extends anteriorly from the femoral neurovascular bundle to the middle of the gluteal fold posteriorly. Flap elevation should remain superficial to the inguinal nodes to reduce the risk of seroma and lymphocele.<sup>40</sup> The branches of the posterior femoral cutaneous nerve should also be identified and preserved to avoid sensory deficits postoperatively.<sup>11</sup> The PAP flap is typically supplied by 1–3 perforators off of the profunda femoris artery. Pedicle lengths are variable but have been reported up to 13 cm and pedicle diameters range from 0.8 to 2 mm in size.<sup>17</sup> Like the TUG, flap dimensions in the vertical direction are determined by the patient’s anatomy to allow for primary closure. Transversely, the flap can safely extend from the lateral gluteal crease to the adductor longus muscle medially.

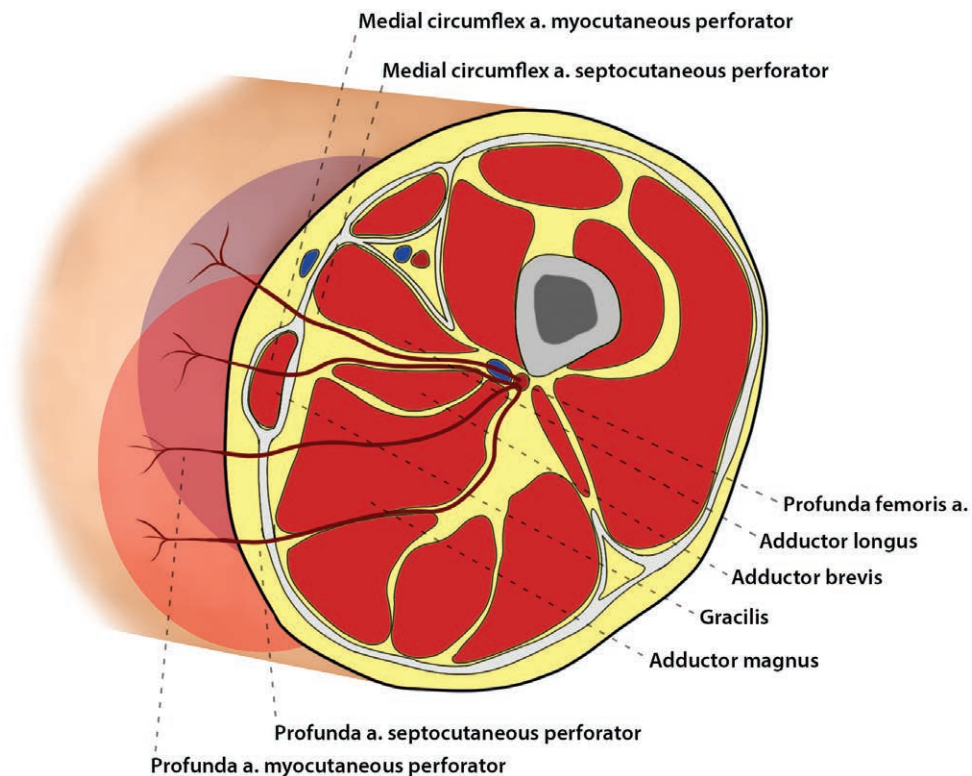
Patients undergoing a conjoined TUGPAP flap are marked in the preoperative holding area in standing position. The overlapping domains included in the markings of a TUGPAP flap are shown in **Figure 1**. The superior marking is drawn 1 cm below the inguinal crease, starting from the femoral pulse anteriorly and extending posteromedially along the inner thigh and parallel to the gluteal crease to its lateral extent. A pinch test is then performed at the midline of the gluteal crease and over the gracilis muscle to mark out the horizontal dimensions of the flap. These marks are then incorporated in the semielliptical inferior marking that tapers off at anterior and posterior aspects of the flap. Radial marks along the inferior incision signify beveling of the subcutaneous dissection to recruit more bulk into the flap.



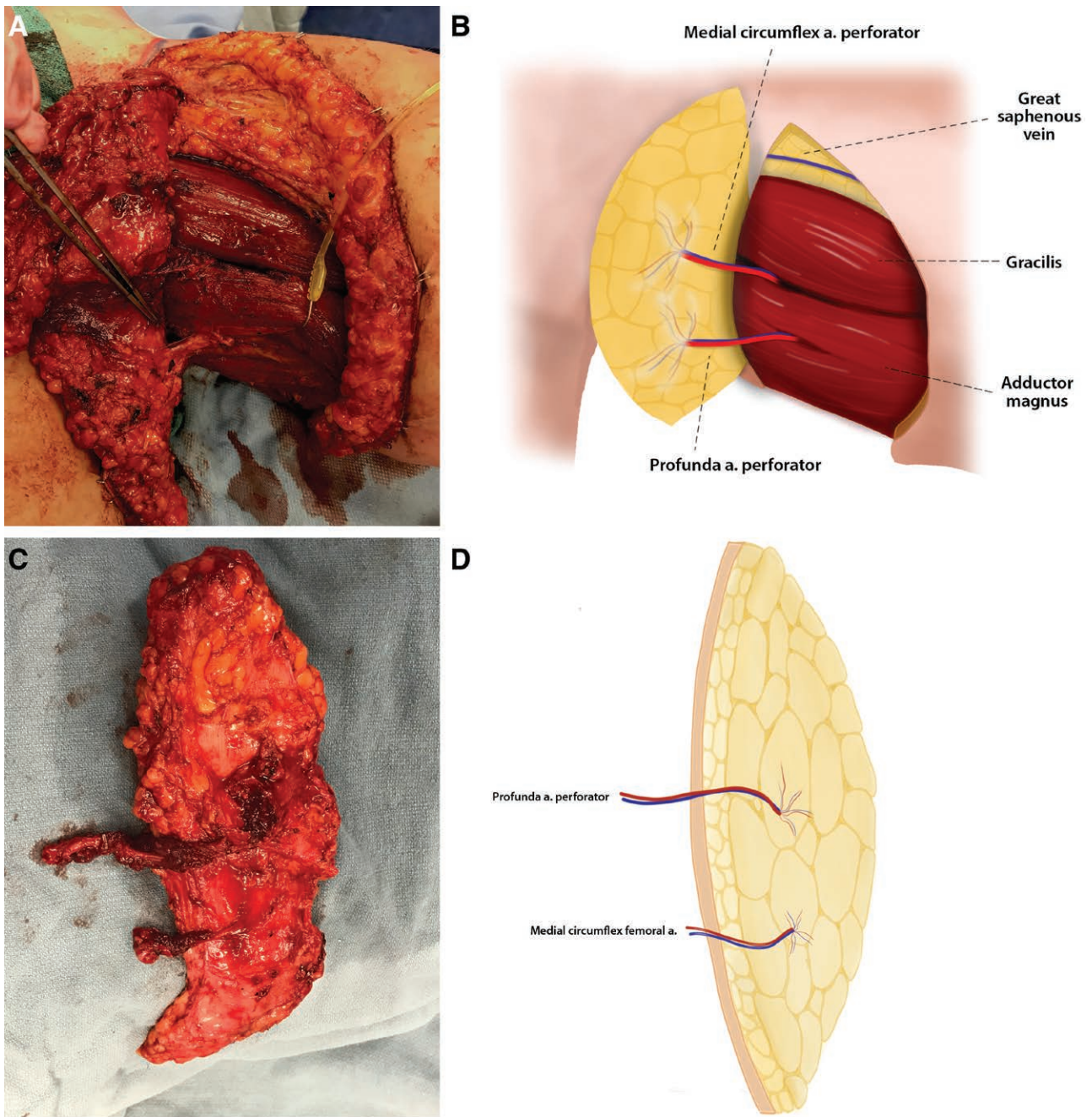
**Fig. 1.** Markings for TUGPAP Flap. The purple shaded area designates the TUG flap territory while the red shaded area designates the PAP territory. Corresponding faded areas designate additional tissue recruited by a beveled dissection.

The patient is then brought into the operating room and positioned supine in the frog-leg position. A sterile bump is placed under the sacrum for optimal access to the posterior thigh. Markings are confirmed and a

hand-held Doppler is used to determine the location of the PAPs. Once the skin markings are incised with a scalpel, monopolar cautery is used to dissect straight down to the fascia for the superior incision. For the inferior



**Fig. 2.** Cross-section of upper thigh. Perforators from the medial circumflex femoral artery and first perforator from the profunda femoris artery are usually myocutaneous, but can also be septocutaneous as shown.



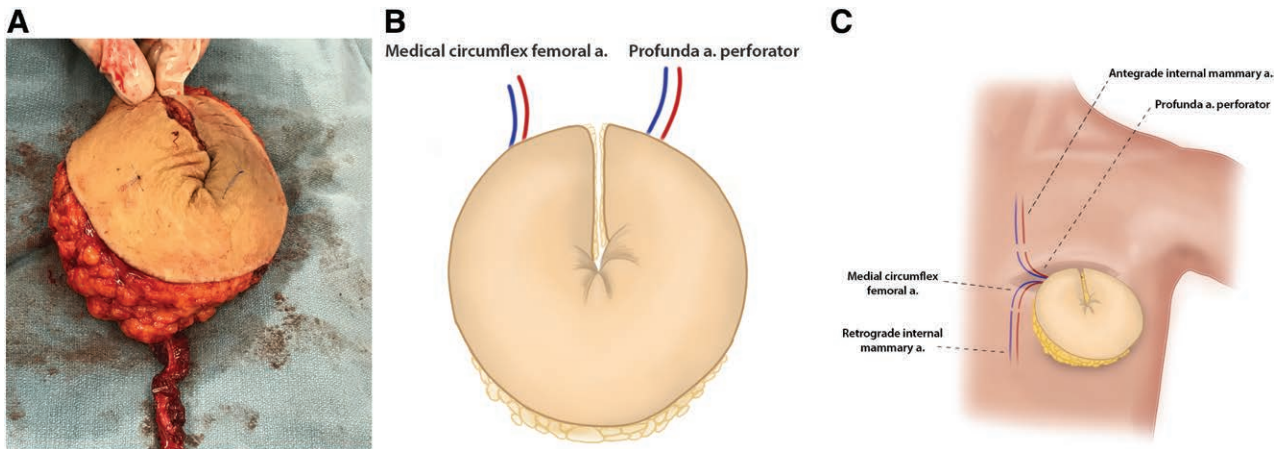
**Fig. 3.** TUGPAP anatomy and flap contouring. A, Left conjoint TUGPAP elevation demonstrating superficial anterior Appe dissection to preserve the greater saphenous vein with associated lymphatics. B, Corresponding illustration demonstrates a musculocutaneous profunda femoris perforator through the adductor magnus muscle and the less common septocutaneous MCFA perforator. C-D, A conjoint TUGPAP flap in another patient demonstrating maximal muscular preservation when dissecting out musculocutaneous MCFA and PAP perforators.

incision, the dissection is beveled inferiorly to capture more subcutaneous tissue. Dissection begins anteriorly in the suprafascial plane and the saphenous vein is located and protected. The MCFA pedicle is visualized between the adductor longus and adductor magnus entering the gracilis muscle (Fig. 2). Figure 3 illustrates the raising of the flap. An intramuscular dissection through the gracilis muscle then frees the pedicle from the bulk of the muscle distally. Pedicle dissection then proceeds

proximally to the origin of the MCFA. At this point, the pedicle can either be clamped or transected to allow an anterior approach to the PAP pedicle. Alternatively, it may be kept intact and the PAP pedicle approached posteriorly. Our technique is typically to approach the PAP pedicle posteriorly. Next, dissection begins posteriorly suprafascially along the semitendinosus and semimembranosus muscle until the PAP, previously identified by Doppler, is encountered. The chosen perforator is then

dissected proximally through the adductor magnus to the profunda femoris artery proper. Both pedicles are then ligated and brought up to the chest for anastomosis. Significant undermining is usually required inferiorly to facilitate donor-site closure. Undermining of the buttock, however, is avoided to maintain gluteal fold. After quilting and fascial suspension, the thigh donor sites are closed in layers over a Jackson-Pratt drain and an incisional vacuum-assisted closure (VAC) dressing is placed.

Figure 4 demonstrates inseting of the flap. As the profunda femoris perforator perfuses the greater bulk of the flap, it is anastomosed to the antegrade internal mammary artery (IMA), whereas the MFCA is anastomosed to the retrograde IMA. The final contouring is achieved by folding the flap to create a sling and de-epithelializing margins to create a complementary skin paddle to the mastectomy skin. Patients are subsequently admitted to hospital for postoperative monitoring. Figure 5 demonstrates the postoperative result in one of our patients.



**Fig. 4.** Insetting of the TUGPAP flap. A-C, Coning of a right TUGPAP flap before inset via internal sutures between flap apices. PAP is usually anastomosed to the antegrade IMA and MCFA to retrograde IMA.



**Fig. 5.** A 40-year-old BRCA woman with right-sided cT2N0 invasive ductal carcinoma who underwent right TUGPAP flap breast reconstruction on November 2018 and left prophylactic mastectomy with left TUGPAP flap breast reconstruction on August 2019. A, Preoperative photograph. B, 6 months postoperative. The right donor site had a widened scar which is being treated conservatively. The left donor site had superficial epidermolysis which was successfully treated conservatively.

**RESULTS**

The search yielded 2226 studies, of which 116 underwent primary screening (see appendix, Supplemental Digital Content 1, which displays the flowchart of study inclusion using preferred reporting items for systematic reviews and meta-analyses guidelines, <http://links.lww.com/PRSGO/B613>). Full-text screening resulted in 49 studies which met inclusion criteria. Forty-eight studies were retrospective case series or case reports, and one study was a prospective case series. Aggregate data from the 49 studies meeting inclusion criteria were collected (Table 1)

and specific study characteristics provided in Supplemental Digital Content 3. (See appendix, Supplemental Digital Content 3, which displays the specific study characteristics, <http://links.lww.com/PRSGO/B615>.)

In total, 705 patients underwent 906 breast reconstructions with 1037 flaps. Seven hundred fifty-five flaps were TUG (or a variant such as VUG, DUG), 230 were PAP (or a variant such as DPAP, vPMT, LPMT), and 52 were conjoined TUGPAP flaps. Mean follow-up time was 17.5 months (range 2–52). The mean patient age was 45.9 years (range 18–65) and mean BMI 23.6 kg/m<sup>2</sup> (range 19–28 kg/m<sup>2</sup>).

**Table 1. Characteristics of Included Studies**

Variable	Total	TUG	PAP	TUGPAP
Studies, n	49	31	16	3
Patients, n	705	526	155	24
Breasts, n	906	684	196	26
Flaps, n	1037	755	230	52
Mean age, y (range)	45.9 (18–65)	44.5 (18–56)	48.9 (24–65)	53.5 (52–54)
Mean BMI, kg/m <sup>2</sup> (range)	23.6 (19–28)	23.4 (22–26)	24.4 (19–28)	22.2 (22–22)
Flap dimensions				
Mean length, cm (range)	25.8 (17–31)	24.3 (22–31)	26.2 (17–28)	27.6 (23–29)
Mean width, cm (range)	9.7 (6–25)	10.7 (7–15)	9.6 (6–25)	8.0 (8–8)
Mean flap weight, g (range)	341.5 (125–466)	323.4 (125–435)	346.9 (193–420)	437.0 (303–466)
Mean pedicle length, cm (range)	8.9 (5–13)	6.4 (5–8)	11.1 (9–13)	7.97 (6.9–9.3)
Recipient vessel				
IMA	821	606	172	43
Thoracodorsal	28	14	14	0
Serratus	13	0	13	0
Side branch of PAP	11	0	11	0
Thoracoacromial	9	0	0	9
Circumflex scapular	7	0	7	0
Intercostal	7	7	0	0
Axillary	3	3	0	0
Pectoral	2	2	0	0
Lateral thoracic	1	1	0	0
Mean artery diameter, mm (range)	1.6 (1.2–2.2)	1.5 (1.2–2.2)	1.8 (1.4–2.2)	2.2 (2.2–2.2)
Mean vein diameter, mm (range)	2.6 (1.7–3.2)	2.7 (1.7–3.2)	2.4 (2.2–2.8)	—
Total complications	371/1037	332	34	5
Recipient-site complications	156/1037 (15.0%)	137/755 (18.1%)	18/230 (7.8%)	1/52 (2.0%)
Fat necrosis	29	27	2	0
Partial flap loss/necrosis	28	26	1	1
Total flap loss	18	15	3	0
Hematoma	13	13	0	0
Contour irregularity	13	13	0	0
Vessel thrombosis	12	12	0	0
Venous congestion	9	9	0	0
Dehiscence	9	1	8	0
Seroma	7	7	0	0
Infection	7	6	1	0
Delayed wound healing	4	4	0	0
Wound retraction	3	0	3	0
Palpable/tender venous coupler	2	2	0	0
Arterial insufficiency	1	1	0	0
Pseudocyst	1	1	0	0
Donor-site complications	215/1037 (20.7%)	195/755 (25.8%)	16/230 (7.0%)	4/52 (7.7%)
Sensory deficit posterior thigh	52	52	0	0
Wound dehiscence	56	50	6	0
Delayed wound healing	42	42	0	0
Seroma	22	16	4	2
Dysesthesia	8	8	0	0
Abnormal scarring	8	6	1	1
Hematoma	10	10	0	0
Infection	6	6	0	0
Transient lymphedema	4	0	4	0
Skin tightness	2	1	0	1
Fistula	2	2	0	0
Compartment syndrome	1	0	1	0
Neuroma	1	1	0	0
Skin necrosis	1	1	0	0
Flap survival	1008/1037 (97.2%)	729/755 (96.6%)	227/230 (98.7%)	52/52 (100.0%)
Mean follow-up time, months (range)	17.5 (2–52)	21.5 (2–52)	9.4 (3–12)	13.4 (13–14)

IMA, internal mammary artery; PAP, profunda artery perforator.

The mean dimensions for TUG and PAP were 24.3 cm × 10.7 cm and 26.2 cm × 9.6 cm, respectively. For TUGPAP flaps, the mean dimensions were 27.6 cm × 8.0 cm. The mean flap weight was 323.4 g (125–435 g) for TUG, 346.9 g (193–420 g) for PAP and 437.0 g (303–466 g) for a conjoined TUGPAP. Mean pedicle length varied from 5 to 8 cm for TUG and 9 to 13 cm for PAP flaps. The most common recipient vessel was the IMA in 821 flaps, followed by the thoracodorsal artery in 28 flaps. Among the conjoined TUGPAP flaps, the recipient vessel was either the IMA in 43 (82.7%) flaps or the thoracoacromial artery in 9 (17.3%) flaps.

The overall flap survival rate was 97.2% (1008/1037). The most common recipient-site complication was fat necrosis (2.9%, 29/1037), followed by partial flap necrosis (2.7%, 28/1037). The most common donor-site complication was wound dehiscence (5.4%, 56/1037), followed by posterior thigh sensory deficit (5.0%, 52/1037). TUG flaps had a significantly higher recipient and donor complication rate compared to both PAP (recipient: 18.1% versus 7.8%,  $P = 0.0001$ ; donor: 25.8% versus 7.0%,  $P < 0.00001$ ) and TUGPAP flaps (recipient: 18.1% versus 2.0%,  $P < 0.001$ ; donor: 25.8% versus 7.7%,  $P < 0.01$ ). PAP and TUGPAP flaps had similar recipient and donor complication rates (recipient: 7.8% versus 2.0%,  $P = 0.22$ ; donor: 7.0% versus 7.7%,  $P = 0.77$ ).

## DISCUSSION

The posteromedial thigh has emerged as a reliable, safe, and consistent donor site for patients who are poor candidates for abdominally-based breast reconstruction. Since the first descriptions of the TUG and PAP flaps by Yousif et al<sup>10</sup> and Allen et al,<sup>17</sup> respectively, their popularity has been tempered by concerns with respect to donor-site morbidity,<sup>41</sup> risk of sensory nerve and lymphatic injury,<sup>42</sup> and, most importantly, inadequate volume.<sup>17,41</sup> Over the years, multiple technical refinements were introduced to optimize outcomes. The transition from prone to supine positioning for PAP flaps improved the speed and ease of harvest.<sup>17</sup> Flap markings 1–2 cm below the groin creases and fascial suspension sutures reduced the incidence of wound dehiscence and labial spreading while maintaining scar aesthetics.<sup>33,40,41</sup> Keeping the anterior flap dissection superficial and medial to the femoral vessels avoided injury to the greater saphenous vein and associated lymphatics, decreasing the risk for lymphedema.<sup>40,43</sup> Coning of the breast mound allowed modification of the standing cone deformity for immediate nipple reconstruction.<sup>31</sup>

Although these refinements continued to reduce complication rates following PAP and TUG harvest, volume inadequacy remained a significant problem. For this reason, both PAP and TUG flaps are reserved only for small breast reconstructions. Notable attempts to improve flap volume included those by Vega et al,<sup>13</sup> whose beveled dissection recruited more subcutaneous fat, by Dayan and Allen,<sup>44</sup> whose diagonal orientation along lines of tension increased flap width, and by McKane and Korn,<sup>45</sup> whose fleur-de-lis orientation incorporated more soft tissue vertically. Despite the success of these efforts to increase flap dimensions, they

were all limited by increased scarring, inferior aesthetics, and increased risk for wound healing complications.

In 2015, both Ciudad et al<sup>48</sup> and Bodin et al<sup>15</sup> described the conjoined TUGPAP flap for breast reconstruction. This flap took advantage of the overlapping perforasomes of the MCFA and first PAP to augment flap volume while maintaining the well-concealed scarring pattern. This bipedicle flap has proven to be a reliable and safe second-line flap, which creates a softer and more natural appearing breast mound compared to buttock donor sites. However, despite the increase in volume of this flap, the experience at our center is that this flap still remains limited to small and moderate size breast reconstruction. For this reason, we sought to systematically review flap size and weight for conjoined TUGPAP flaps, as well as each flap in isolation, to corroborate our findings that this flap is still of insufficient volume for large breast reconstruction.

The present systematic review demonstrates that a conjoined TUGPAP flap adds, on average, 113.6 g compared to a TUG and 90.1 g compared to a PAP flap for breast reconstruction. Furthermore, the TUGPAP added 3.3 cm in length compared to TUG flaps and 1.5 cm in length compared to PAP flaps. In light of these results, one can legitimately question whether the additional harvest time and second anastomosis is worth the modest increase in size. Our review of 52 TUGPAP, 755 TUG, and 230 PAP flaps supports the safety and efficacy of all 3 breast reconstructive modalities, with a survival rate upward of 97% and complication rates in keeping with other second-line breast flap options. Interestingly, we found that TUG flaps had a significantly higher recipient- and donor-site complication rate compared to both PAP and TUGPAP flaps. This may reflect that learning curve in harvesting TUG flaps and the fact that a large portion of the TUG flaps included in this review were published before technical refinements for flap harvest were implemented.

Furthermore, we show that the width of TUGPAP flaps were, on average, 2.7 cm and 1.6 cm narrower than TUG and PAP flaps, respectively. This may have contributed to the decreased donor-site complication rate. It is our practice to harvest conjoined TUGPAP flaps strictly based on perforators from the MCFA leaving the gracilis muscle largely undisturbed. We believe this helps to decrease the dead space and decrease subsequent seroma formation.

The present study is limited by the quality of the included articles and the inability to assess risk of bias for included studies. This review demonstrates that the present data on PAP, TUG, and conjoined TUGPAP flaps are limited by small sample sizes, heterogeneous outcome definitions, incomplete reporting of outcomes, lack of data on secondary surgeries, and publication bias with regards to flap survival and complication rates. Although this limits the external validity of our study, it consolidates existing literature on these flaps and thus may be used to assist in flap choice and planning.

## CONCLUSIONS

The conjoined TUGPAP flap is a safe and effective second-line option for breast reconstruction. The present review demonstrates that the overlapping perforasomes

of PAP and TUG flaps effectively increase size and weight without affecting donor or recipient-site morbidity. The conjoined TUGPAP flap should continue to remain in the plastic surgeon's reconstructive armamentarium, albeit for small and moderately sized breasts.

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