

The PUG Flap: Conjoined Profunda Artery Perforator and Upper Gracilis Flap for Breast Reconstruction

Isra Abdulwaddood, BS*
 Lacey R. Pflibsen, MD†‡§
 Nicholas R. Jarvis, MD*
 Sebastian Winocour, MD¶
 Alanna M. Rebecca, MD§
 William J. Casey, MD§
 Edward M. Reece, MD, MBA§

Summary: Abdominal-based free flaps are the mainstay of autologous breast reconstruction; however, the region may not be ideal for patients with inadequate soft tissue or history of abdominal surgery. This case describes the use of a novel conjoined flap based on the profunda artery perforator and upper gracilis pedicles, named the perforator and upper gracilis (PUG) flap. This flap design aims to maximize medial thigh flap volume while ensuring robust tissue perforation. Here, we present our experience with the PUG flap in a breast cancer patient undergoing autologous reconstruction. The patient was a 41-year-old woman seeking nipple-sparing mastectomy and immediate autologous reconstruction with the PUG flap due to limited abdominal tissue availability. The gracilis and profunda artery perforator flaps were elevated using one boomerang-style skin paddle. Once harvested, the flaps were inset with antegrade and retrograde flow off the internal mammary arteries and both respective internal mammary veins. The donor site was closed in a V-Y pattern resulting in a thigh lift-type lift and concealed scar. In conclusion, the boomerang-style PUG flap maximizes medial thigh free tissue transfer volume, offers internal blood flow redundancy, and maintains good cosmesis of the donor site. (*Plast Reconstr Surg Glob Open* 2024; 12:e5544; doi: 10.1097/GOX.0000000000005544; Published online 25 March 2024.)

The deep inferior epigastric artery perforator flap is well recognized as the gold standard for autologous reconstruction, though it is not a universal option.¹ In patients with insufficient abdominal volume or previous abdominal surgery, the upper medial thigh can serve as a dependable donor site via options such as the transverse upper gracilis (TUG) musculocutaneous flaps and profunda artery perforator (PAP) flaps. The TUG flap, first described by Yousif et al, is a common secondary option due to its consistent anatomy and ease of harvest, but surgeons often encounter

limited tissue volume.² The PAP flap, a true perforator flap first described in 2010 by Allen et al, allows for longer skin paddles and slightly larger volumes.¹

While the benefits and challenges of these flaps have been compared broadly in the literature, in 2016, Ciudad et al presented the TUGPAP, a conjoined flap combining the TUG and PAP flaps.¹ The TUGPAP flap provides increased tissue volume and pliability during inset when compared with the individual TUG or PAP flaps; however, it also increases the number of anastomoses required, subsequently increasing the operation time and risk of thrombosis and flap failure.¹ In this report, we expand upon past modifications and describe the novel PAP and upper gracilis (PUG) flap. A “boomerang” style conjoined skin paddle flap based on both the PAP and the vertical upper gracilis flaps, the PUG flap design attempts to maximize flap volume and improve outcomes when compared with previous designs.³

OPERATIVE TECHNIQUE

A 41-year-old female patient presented for planned immediate autologous reconstruction due to malignant

From *Mayo Clinic Alix School of Medicine, Phoenix, Ariz.; †Department of Surgery, Mayo Clinic Health Systems, Eau Claire, Wis.; ‡Department of Orthopedic Surgery, Mayo Clinic Health Systems, Eau Claire, Wis.; §Division of Plastic and Reconstructive Surgery, Mayo Clinic, Phoenix, Ariz.; and ¶Division of Adult Plastic Surgery, Baylor College of Medicine, Houston, Tex.

Received for publication August 17, 2023; accepted November 27, 2023.

Presented at the American Society for Reconstructive Microsurgery 2023 Annual Meeting, January 20–24, 2023, Miami, Florida.

Copyright © 2024 The Authors. Published by Wolters Kluwer Health, Inc. on behalf of The American Society of Plastic Surgeons. This is an open-access article distributed under the terms of the [Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 \(CCBY-NC-ND\)](https://creativecommons.org/licenses/by-nc-nd/4.0/), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

DOI: 10.1097/GOX.0000000000005544

Disclosure statements are at the end of this article, following the correspondence information.

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.



Fig. 1. The boomerang-style flap pattern.

neoplasm of the right breast and ductal carcinoma in situ of the left breast. Immediately following mastectomy, markings for the PUG flap were made and confirmed with Doppler ultrasound to ensure perforators would be captured in the boomerang-style flap with a transverse skin paddle superiorly at the groin crease transitioning to a vertical component centered over the gracilis muscle (Fig. 1). The gracilis portion was harvested by dissecting the medial circumflex femoral/medial circumflex femoral pedicle to the profunda femoris artery and vein. The obturator nerve was then dissected proximally and transected to allow for coaptation to maintain muscle bulk. A regenerative peripheral nerve interface was used to prevent donor-site neuroma formation.⁴ The gracilis muscle was transected proximally and distally. PAPs were carefully dissected through the abductor magnus muscle to the profunda femoris artery to develop an adequate pedicle for the cutaneous portion of the flap (Fig. 2). Skin markings were further confirmed and incorporated into the boomerang flap. (See figure, Supplemental Digital Content 1, which displays intraoperative view of the right PUG flap demonstrating the length of the PAP pedicle. <http://links.lww.com/PRSGO/D138>.) The donor sites were closed in a V-Y pattern bilaterally (Fig. 3). (See figure, Supplemental Digital Content 2, which displays donor site results 6 months postoperation. Donor site is well-concealed. <http://links.lww.com/PRSGO/D139>.)

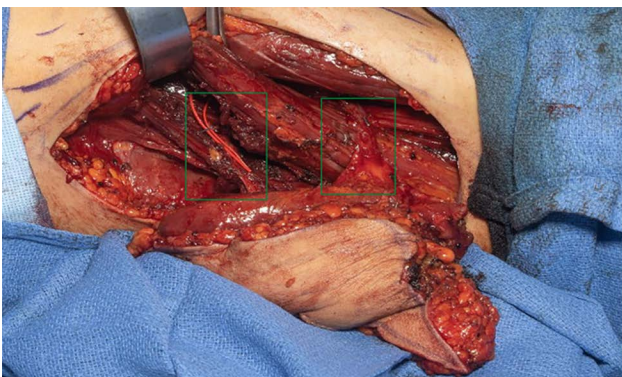


Fig. 2. The right PUG flap in situ demonstrating upper gracilis pedicle proximally and PAP pedicle distally.



Fig. 3. The donor site was closed in a V-Y pattern, resulting in a thigh lift-type lift and concealed scar.

The recipient sites were prepared in the typical fashion by accessing the internal mammary arteries and two venae comitantes via the fourth intercostal space after rib cartilage resection. The venae comitantes were anastomosed using venous couplers followed by the medial circumflex femoral artery anterograde anastomosis and PAP artery retrograde anastomosis to the internal mammary arteries. An implantable Cook-Swartz Doppler probe was placed on the anterograde anastomosis. The obturator nerve was coapted to the fourth intercostal nerve to maintain muscle bulk. The PUG flaps were inset to the chest wall after deepithelialization and coning for projection (Fig. 4). The breast flaps were closed primarily over the deepithelialized portion with two drains bilaterally. There was an arterial thrombosis of the gracilis flap pedicle in the first 24 hours that was subsequently revised without complication.

DISCUSSION

Although several options exist for nonabdominal-based autologous breast reconstruction, no option is without

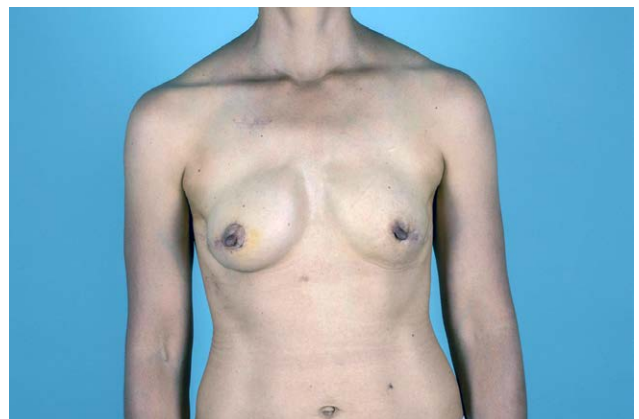


Fig. 4. Breast results 6 months postoperation. Both PUG flaps survived, with satisfactory coning and contours.

limitations. The posteromedial thigh is largely considered a safe and dependable option. Nevertheless, reports of nerve injury and donor-site morbidity with thigh-based flaps have been increasingly reported in the literature.^{4,5} Numerous alterations and refinements to the classic thigh flaps have been proposed to overcome these limitations, such as supine positioning,⁵ flap markings below the groin creases,⁵ and breast mound coning for more convenient nipple reconstruction.⁶ Although each adjustment aids in improving outcomes, PAP and TUG flaps still only permit a limited flap volume.^{6,7} Even the bipediced TUGPAP flap, which has been demonstrated to add an average of 113.6g and 90.1g when compared with the TUG and PAP flaps, respectively, only offers a modest increase in breast size.^{1,6} In 2021, Karir et al compared TUG, PAP, and TUGPAP outcomes and argued that such modest increases in volume may not be worth the added harvest time and dual anastomoses.⁶

The conjoined PUG flap presented here alternatively uses a novel boomerang incision to increase flap volume through maximum tissue harvest. The mastectomy specimens measured 13.5 cm and 13 cm (right and left, respectively), whereas the paddles measured 20 cm medial to lateral. The boomerang shape of the flap increased the surface area of the skin island, which optimized breast volume and allowed for enhanced projection of the breast via coning. Additionally, coapting the obturator nerve in the gracilis flap also contributed to maintaining muscle bulk.⁸ To note, coaptation was performed to limit atrophy of the muscle and maintain bulk to maintain stable breast volume. We do appreciate that this could lead to an animation deformity; however, the muscle was not resuspended to a new origin and insertion, rather the muscle was used in the shaping of the breast mound. Furthermore, at 1-year follow up, the patient's breast volume was maintained and there was no significant animation deformity. We suspect the muscle is reinnervated, but the intercostal nerve coaptation is enough to maintain volume but not enough to provide significant contraction due, in part, to the difference in axonal densities between the obturator and fourth intercostal nerves.^{9,10}

The PUG flap does require two anastomoses, which can increase intraoperative time and anastomotic complications, which is frequently discussed with stacked free flaps.¹¹ We did experience an arterial anastomotic issue with this patient. This was identified by implantable and transcutaneous Doppler monitoring quickly; however, the conjoined skin paddle remained surprisingly of similar color and capillary refill throughout the return to the operating room. The subdermal plexus of this conjoined flap, we hypothesize, provided a more robust circulation to the tissues. As described by Mohan et al, PAP flaps possess a strong, redundant vascular supply in the posterior thigh via linking vessels and the subdermal plexus, contributing to reduced perfusion-related complications.¹²

CONCLUSIONS

The PUG flap is a strong option for thigh-based autologous breast reconstructions due to the unique combination of the boomerang paddle and the reliable vascularity of the PAPs. The PUG flap should be considered for autologous reconstruction in patients with smaller breasts or frames who wish for a modest increase in cup size, though an expanded case series is necessary to determine the average PUG flap volume and weight.

Edward M. Reece, MD, MBA

Division of Plastic and Reconstructive Surgery
Mayo Clinic, 5777 E. Mayo Blvd
Phoenix, AZ 85054
E-mail: reece.edward@mayo.edu

DISCLOSURES

The authors have no financial interest to declare in relation to the content of this article.

REFERENCES

1. Ciudad P, Maruccia M, Orfanoti G, et al. The combined transverse upper gracilis and profunda artery perforator (TUGPAP) flap for breast reconstruction. *Microsurgery*. 2016;36:359–366.
2. Yousif NJ, Matloub HS, Kolachalam R, et al. The transverse gracilis musculocutaneous flap. *Ann Plast Surg*. 1992;29:482–490.
3. Skochdopole AJ, Mentz JA, Gravina P, et al. Maximizing volume from the medial thigh: introducing the PUG flap. *Plast Reconstr Surg*. 2021;148:329e–331e.
4. Wu J, Zhang Y, Zhang X, et al. Regenerative peripheral nerve interfaces effectively prevent neuroma formation after sciatic nerve transection in rats. *Front Mol Neurosci*. 2022;15:938930.
5. Craggs B, Vanmierlo B, Zeltzer A, et al. Donor-site morbidity following harvest of the transverse myocutaneous gracilis flap for breast reconstruction. *Plast Reconstr Surg*. 2014;134:682e–691e.
6. Karir A, Stein MJ, Zhang J. The conjoined TUGPAP flap for breast reconstruction: systematic review and illustrative anatomy. *Plast Reconstr Surg Glob Open*. 2021;9:e3512.
7. Allen RJ, Haddock NT, Ahn CY, et al. Breast reconstruction with the profunda artery perforator flap. *Plast Reconstr Surg*. 2012;129:16e–23e.
8. Zhang F, Lineaweaver WC, Ustüner T, et al. Comparison of muscle mass preservation in denervated muscle and transplanted muscle flaps after motor and sensory reinnervation and neurotization. *Plast Reconstr Surg*. 1997;99:803–814.
9. Mohan AT, Suchyta M, Vyas KS, et al. A cadaveric anatomical and histological study of recipient intercostal nerve selection for sensory reinnervation in autologous breast reconstruction. *J Reconstr Microsurg*. 2021;37:136–142.
10. Yount M, Peruri A, Morgan A, et al. Morphology and morphometry of the human obturator nerve in males and females. *Anat Histol Embryol*. 2023;52:490–499.
11. Haddock NT, Cho MJ, Teotia SS. Comparative analysis of single versus stacked free flap breast reconstruction: a single-center experience. *Plast Reconstr Surg*. 2019;144:369e–377e.
12. Mohan AT, Zhu L, Sur YJ, et al. Application of posterior thigh three-dimensional profunda artery perforator perforasomes in refining next-generation flap designs: transverse, vertical, and s-shaped profunda artery perforator flaps. *Plast Reconstr Surg*. 2017;139:834e–845e.