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Breast

Salvaging Breast Reconstruction: Profunda Artery Perforator Flaps Using Thoracodorsal Vessels

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Background: Over the years, the choice of recipient vessels for free flap autologous breast reconstruction has shifted from the thoracodorsal to the internal mammary vessels due to ease of flap inset and predictability of anatomy. However, thoracodorsal vessels are still great recipient vessels, and can be useful, especially in the previously failed or staged autologous breast reconstruction. In this study, we present our experience using thoracodorsal or serratus vessels for profunda artery perforator flaps.

Methods: Of the 792 autologous free flap breast reconstruction performed, we identified 12 patients (21 flaps) who underwent reconstruction using thoracodorsal or serratus vessels from 2012 to 2017. Flap, patient characteristics, and demographic data and perioperative details were collected.

Results: Twenty-one flaps were used to reconstruct 14 breasts in 12 patients. The mean age of patients was 49.6 years old (range, 42–54), the mean flap weight was 354.7 g (range, 170–540 g), the mean body mass index was 28 (range, 23.2–34.4), and the average operative time was 496.1 minutes (266–680). Majority of these patients underwent additional staged free flap reconstruction (following previous deep inferior epigastric perforator flaps) for severe breast contour defects (58%) and for failed previous breast reconstruction (42%). The anastomosis was performed using thoracodorsal (43%), serratus (43%), and profunda artery perforator side branch (14%) vessels.

Conclusion: Determining appropriate flap and recipient vessels in a previously failed or staged breast reconstruction is very challenging. Thoracodorsal and serratus vessels are excellent recipient vessels in patients who already have exhausted internal mammary vessels for previous breast reconstruction. *(Plast Reconstr Surg Glob Open 2018;6:e1837; doi: 10.1097/GOX.0000000000001837; Published online 5 September 2018.)*

INTRODUCTION

Trend in the choice of recipient vessels for autologous breast reconstruction has changed in the past decades. Previously, thoracodorsal vessels were the gold-standard recipient vessels for breast reconstruction, given that the vessels are readily accessible once axillary node dissection has been performed.[1–3] However, as the surgical management of breast cancer underwent a paradigm shift from routine axillary node dissection to sentinel lymph node biopsy, plastic surgeons were presented with new set of challenges.[4–7]

With the shift away from the axillary lymph node dissection, it became technically challenging and inconvenient to use thoracodorsal vessels as recipient vessels.[3] Given the challenges, plastic surgeons started to use the internal mammary vessels.[1,2,8] The internal mammary vessels were previously neglected, given the small caliber of its veins, but they are found to be superior alternatives to thoracodorsal vessel, given the caliber of artery, higher flap survival rates, and the location away from the scarring secondary to radiation or previous surgeries.[2,3,8] The internal mammary vessels are preferred recipient vessels of choice in the autologous breast reconstruction now. This phenomenon is evident in the study by Saint-Cyr et al.,[1] which shows an increase of internal mam-

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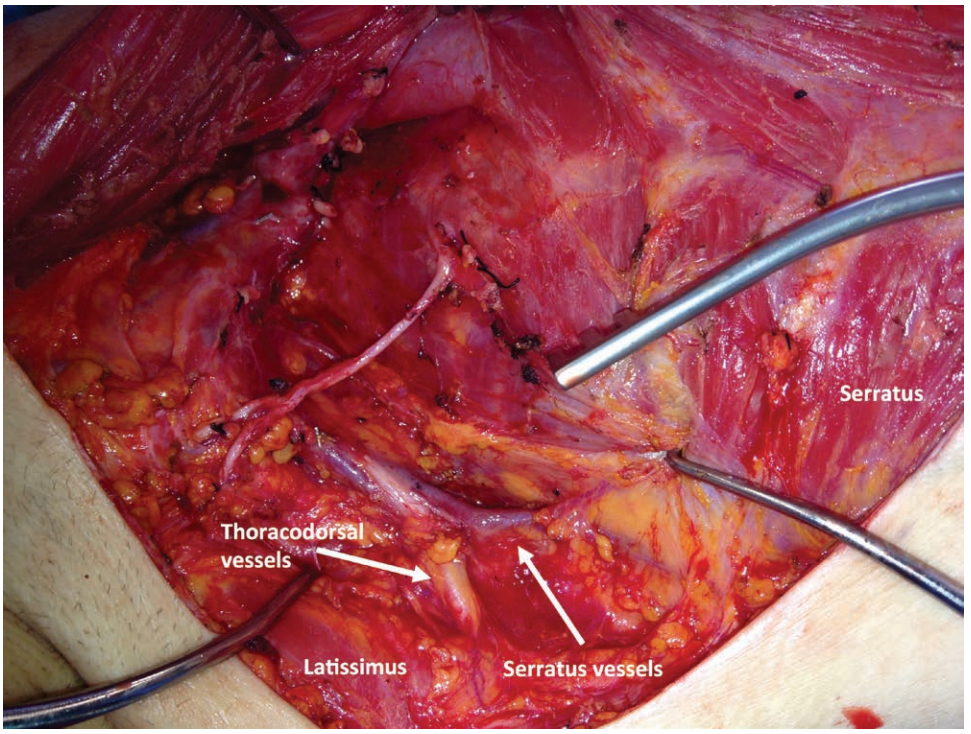

Fig. 1. Thoracodorsal and serratus vessels.

mary vessels usage from 0% to 90% with a concurrent decrease in the use of thoracodorsal artery from 100% to 10%.

Despite decreased popularity of thoracodorsal vessels in the autologous breast reconstruction, they are valuable lifeboat vessels in patients who have exhausted internal mammary vessels for previous autologous free flap breast reconstruction. Most of these patients lack adequate donor sites for another free flap, given that deep inferior epigastric perforator (DIEP) flaps have been already

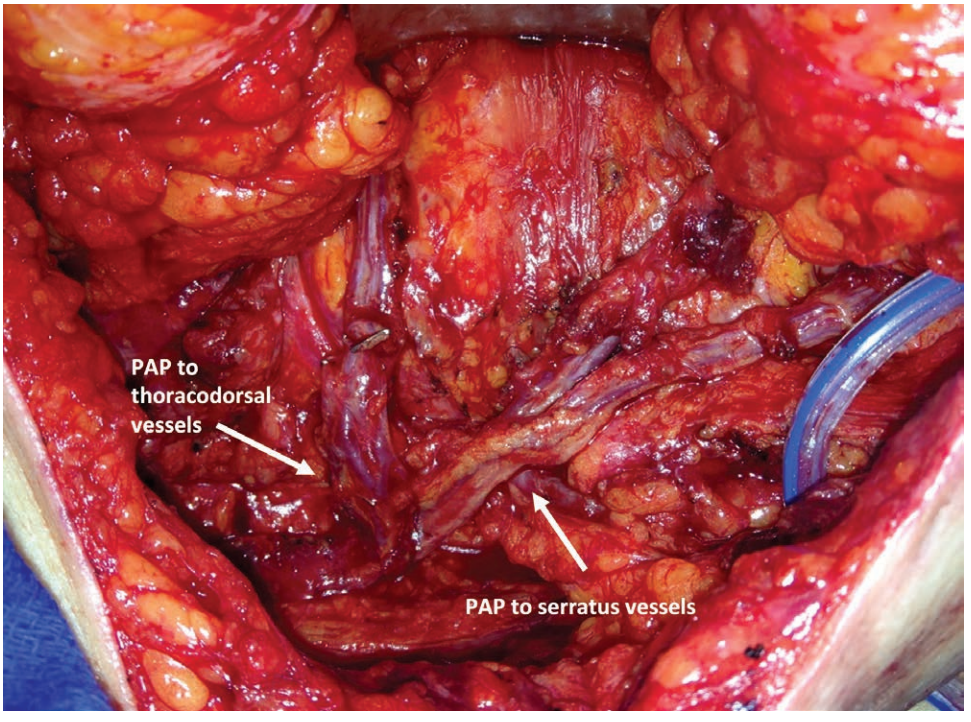

Fig. 2. Anastomoses of flaps to the thoracodorsal and serratus vessels.

performed. Profunda artery perforator (PAP) flaps have risen as one of the second choice for autologous breast reconstruction due to sufficient amount of tissue available in thighs (172–695 g).[9–12] In our institution, we have performed 12 staged breast reconstructions (21 flaps) using thoracodorsal or serratus vessels in patients who had experienced a previous primary flap loss or dissatisfaction with prior breast reconstruction using internal mammary vessels. The purpose of this study was to evaluate our outcomes and determine factors that lead to successes or failures in this unique subset of patients.

PATIENTS AND METHODS

Retrospective review of patients who underwent staged autologous breast reconstruction at out institution from 2012 to 2017 was performed after obtaining an approval from institutional review board. A total of 12 patients (21 flaps) were identified. Demographic data, patient characteristics, flap size, vessel size, anastomosis location, and postoperative complications were collected from the database.

Surgical Technique

All patients in our study had previous autologous breast reconstruction using the deep inferior epigastric perforator flap (82%), latissimus dorsi flap (9%) or superior gluteal artery perforator flap (9%). In these patients, the internal mammary vessels, which are our first recipient choice of vessels, were already used. PAP flaps were recommended in these patients, given the previous use or paucity of abdominal tissue, and the ample amount of tissue available in their thighs for autologous breast reconstruction. All these patients underwent preoperative imaging to assess perforator location and size. The flap dissection was performed in a 2-team approach[13] while the patient was placed in a supine position with the arm out on the operating table. The flap harvest team performed PAP flap harvest while the flap recipient team prepared the recipient vessels.

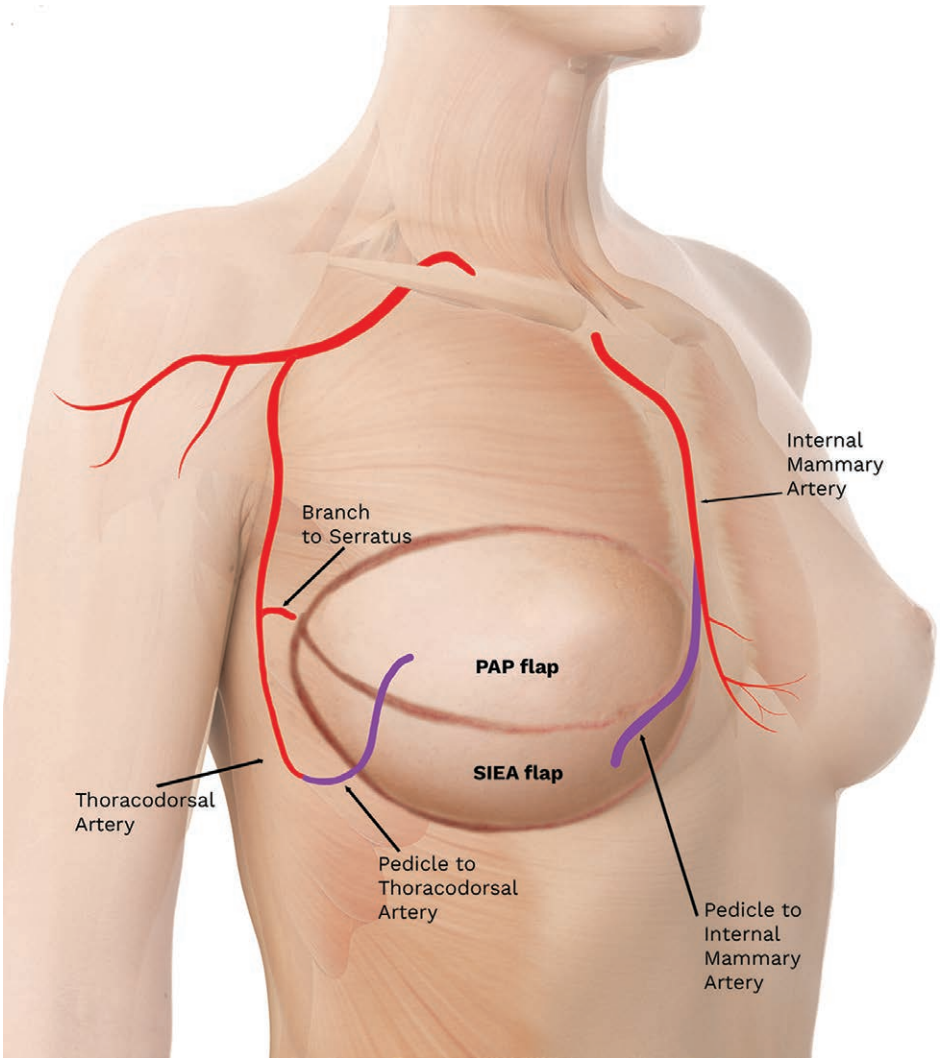

Fig. 3. Anastomosis of PAP flap to thoracodorsal vessels in setting of existing SIEA flap.

In patients with previous free flap, the breast skin was incised toward the axillary region using the previous incision. For an adequate exposure, previous free flap was mobilized and freed on its pedicle. Then, the anterior border of latissimus muscle was identified, and serratus branch on the top of the serratus fascia was identified. Once the serratus branch was found, it was followed cranially toward the axilla to identify the thoracodorsal vessels (Fig. 1). When thoracodorsal and serratus vessels were identified, the caliber of each vessel was assessed to determine the most appropriate vessel for the anastomosis. Outflow was assessed using a routine spurt test of the vessel. Generally, serratus vessels were excluded if early spasm occurred after vessel preparation.

In stacked PAP flaps for unilateral breast reconstruction, most anastomoses were performed using thoracodorsal and serratus vessels (Fig. 2). If the patient had previous flap using the internal mammary vessels, we used either thoracodorsal or serratus vessels depending on their caliber (Figs. 3, 4). For the serratus vessels, they were used only if the artery was at least 1 mm and the vein was at least 1.5 mm. Given the small caliber of serratus vessels, we used 10-0 nylon suture and supermicrosurgery instruments. If the patients had either diminutive thoracodorsal or serratus vessels that are not suitable for anastomoses with profunda artery perforator vessels, we connected 1 flap to the thoracodorsal or serratus vessels while the other flap was parasitic into the first flap via the side-branch of the profunda artery perforator vessels (Fig. 5). In these patients, the size of side branch of the PAP vessel was at least 1 mm.

RESULTS

A total of 12 patients who underwent salvage breast reconstruction after previous flap loss or dissatisfaction with previous autologous breast reconstruction were included in the study. Overall, 21 flaps were performed to reconstruct 14 breasts in 12 patients. Of the 12 patients, 1 patient had superior gluteal artery perforator flap, 1 patient had latissimus dorsi flap, and 10 patients underwent DIEP flaps previously. The majority of patients were undergoing salvage reconstruction for breast contour that did not

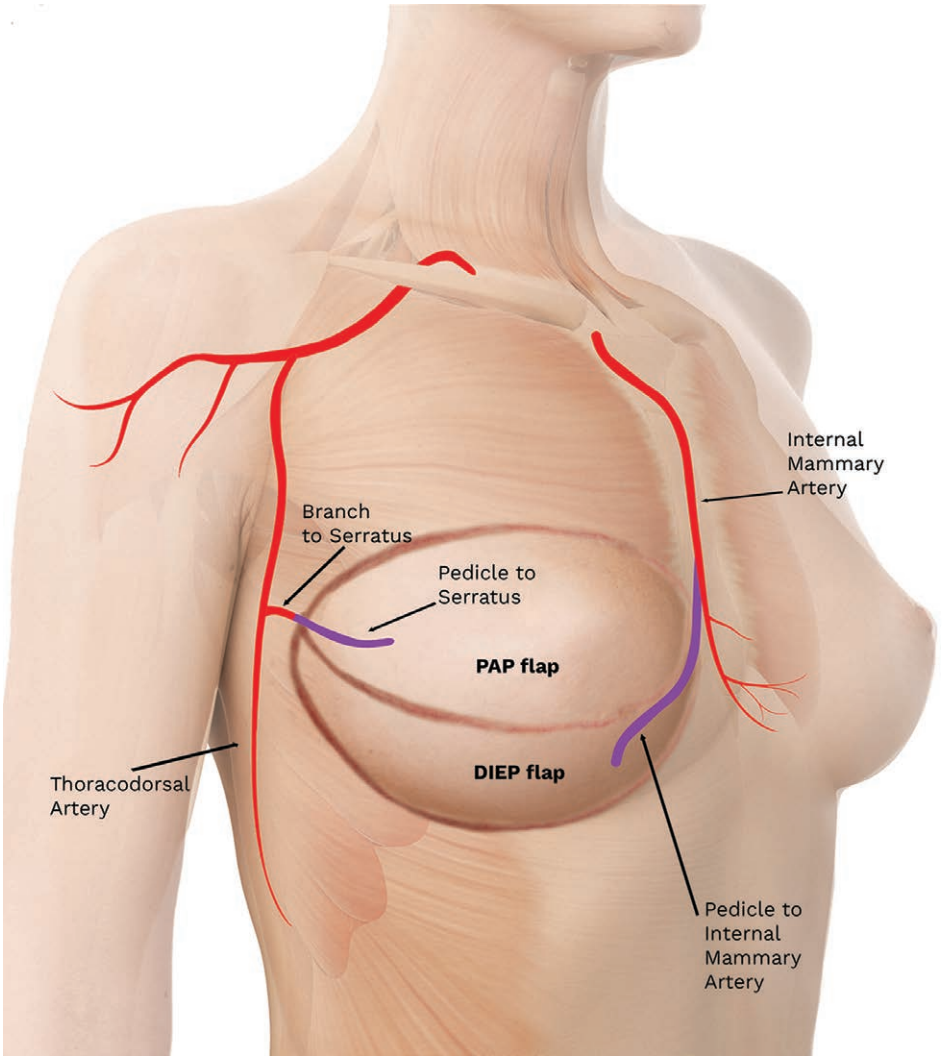

Fig. 4. Anastomosis of PAP flap to thoracodorsal and serratus vessels in a stacked fashion.

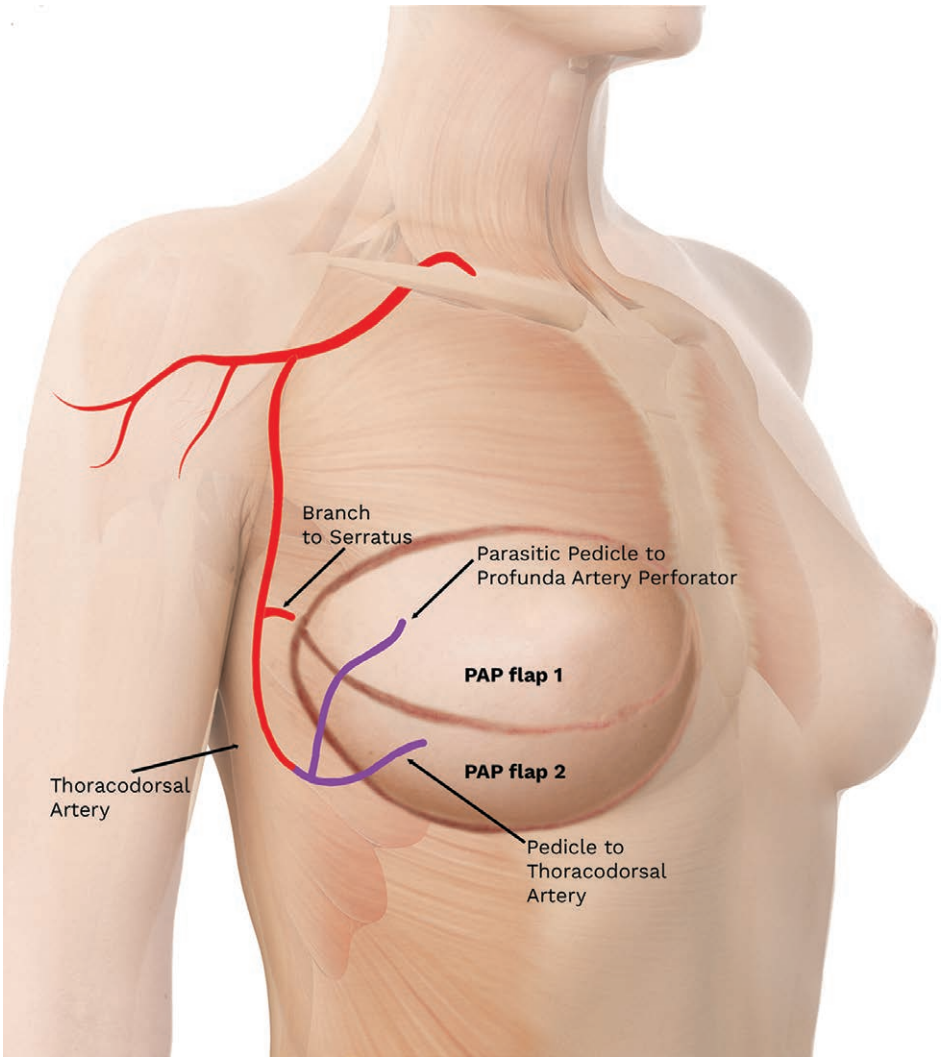

Fig. 5. Anastomosis of 1 PAP flap to another side branch of PAP flap and ultimately to thoracodorsal vessels.

improve with fat grafting (58%) or for failed autologous breast reconstruction (43%). The mean age of patients was 49.6 years old (range, 42–54), the mean BMI was 28 (range, 23.2–34.4), and the average length of stay was 3.8 days (Table 1).

Flap Characteristics

The mean flap weight was 354.7 g (range, 170–540 g), the mean pedicle length was 12.2 cm (range, 8–18 cm), and the average operative time was 496.1 minutes (266–680). A total of 21 anastomoses were performed using thoracodorsal (47%), serratus (42%), and side branch of profunda artery perforator (11%) vessels. Average artery size for thoracodorsal was 1.4 mm (range, 1–2 mm), and serratus artery was 1.5 mm (range, 1–2 mm). For the veins, it was 2.3 mm (range, 2–2.5 mm) and 2.1 mm (range, 1.5–2.5 mm) for thoracodorsal and serratus veins, respectively. The average size of profunda artery perforator for artery was 1.1 mm (range, 1–1.25 mm) and for vein was 2.25 mm (range, 2–2.5 mm).

Of the 21 flaps, various insets were performed based on patient's need for volume to achieve symmetric breasts and presence of previous flaps in the breast pocket. In patients with failed breast reconstructions, stacked PAP flaps were performed (7 patients). For the patients with

Table 1. Patient Characteristics and Flap Data

	Mean	Minimum	Maximum
Patient characteristic			
Age (y)	49.6	42	54
BMI	28	23.2	34.4
Flap data			
Operative time (min)	496.4	266	680
Flap weight (g)	354.7	170	540
Pedicle length (cm)	12.2	8	18
Thoracodorsal arterial diameter (mm)	1.4	1	2
Thoracodorsal vein diameter (mm)	2.3	2	2.5
Serratus arterial diameter (mm)	1.5	1	2
Serratus vein diameter (mm)	2.1	1.5	2.5

BMI, body mass index.

unsatisfied autologous breast reconstruction, PAP flap was placed in a stacked fashion to previous free flap for unilateral (33%) and bilateral breast reconstruction (25%).

Complications

Although 7 flaps were anastomosed to irradiated vessels, vessels were easily identified. There were no cases of lymphedema. There were no total or partial flap losses. There were no donor-site complications.

CASE PRESENTATION

Case 1—Thoracodorsal Vessel Anastomoses

First case is a 53-year-old female who had bilateral superficial inferior epigastric artery (SIEA) perforator flap breast reconstruction after delayed-immediate reconstruction. Patient experienced bilateral breast reconstruction deformity (right greater than left) postoperatively due to the effects of radiation changes on the right breast. Moreover, she had slight atrophy of the SIEA flaps, which resulted in bilateral medial/superior pole hollowing. Contour matching procedures such as fat grafting or additional free flaps were discussed with the patient. However, patient desired autologous breast reconstruction, using PAP flaps. At the time of flap dissection, her serratus vessels were found to be diminutive in both breasts. Therefore, the thoracodorsal vessels were selected as recipient vessels (Fig. 3). The right PAP flap (1 perforator, 260 g) was anastomosed in an end-to-end fashion using a 1.5 mm coupler. The left PAP flap (3 perforators, 300 g) was also anastomosed end-to-end using 2.5 mm coupler. Each flap was placed in the superior and medial portion of each breast to provide medial and superior pole fullness. Patient did well postoperatively (Fig. 6).

Case 2—Thoracodorsal and Serratus Vessel Anastomoses

Second case is a 48-year-old lady who had bilateral DIEP flap breast reconstruction at outside hospital after bilateral mastectomy and radiation to the left breast. Patient suffered loss of her right DIEP flap postoperatively and underwent implant-based breast reconstruction for the right breast. However, she was not satisfied with the result and presented to our institution for autologous conversion. Given the breast asymmetry, stacked PAP flaps were offered to the patient. At the time of flap dissection, the thoracodorsal and serratus vessels were evaluated. Both vessels had an adequate caliber. The right PAP flap (570 g) was anastomosed to the right serratus vessels using 2.0 mm coupler, and the size of artery was 1.25 mm after a full dilation. Then, we anastomosed the left PAP flap (420 g) to thoracodorsal vessels using 2.5 mm coupler, and 10-0 nylon suture for the artery (1.5 mm diameter). The flaps were insetted in a stacked fashion to achieve matching contour and volume to the left breast (Fig. 4). Patient did well postoperatively and was satisfied with her results (Fig. 7).

DISCUSSION

Surgical management of breast cancer underwent paradigm shift from maximally to minimally invasive treatment since the landmark study by Giuliano et al.[4] in 1995. Surgical oncologists moved away from performing axillary dissection to sentinel lymph node biopsy, and thoracodorsal vessels were no longer easily available in immediate breast reconstruction.[1] Prompted by this change, plastic surgeons started to move away from thoracodorsal vessels as the preferred choice for recipient vessels. Among different choices, internal mammary vessels were selected as the new preferred recipient vessels for autologous breast reconstruction.

Internal mammary vessels offer several distinctive advantages over thoracodorsal vessels. Studies show that internal mammary artery is larger than thoracodorsal (2.4 mm versus 1.8 mm), allows more aesthetically pleasing inset of flap due to more medial location of internal mammary vessels, and has lower flap failure rates using transverse rectus abdominis flaps.[2,8,14,15] Moreover, thoracodorsal vessels have higher vessel conversion rates (range, 7–26%) due to axillary scarring in delayed reconstruction while internal mammary vessels have 2% conver-

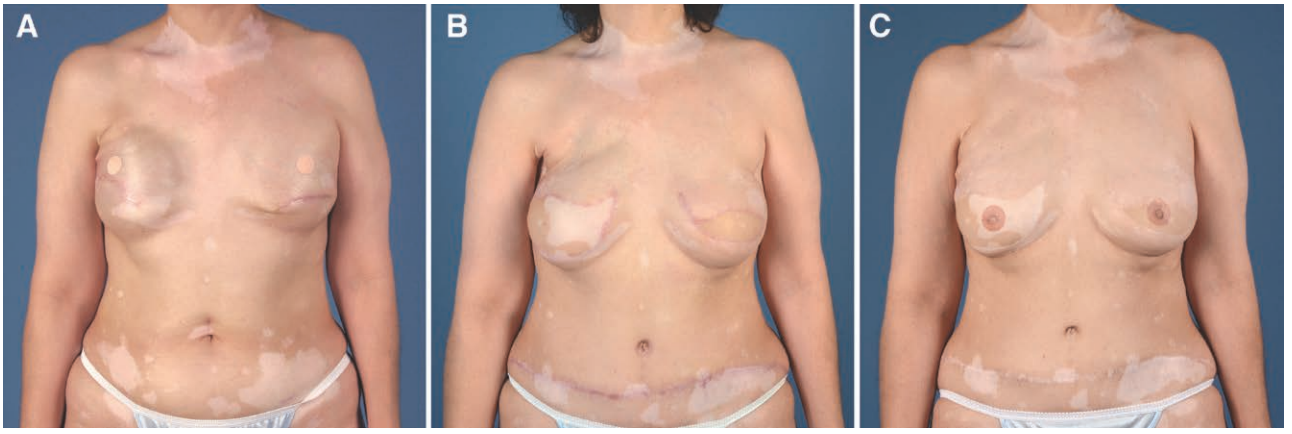

Fig. 6. Staged breast reconstruction using PAP flap anastomosed to thoracodorsal vessels in setting of existing SIEA for improved breast contour. Preoperative photo with a tissue expander(A), postoperative photo with a SIEA (B), and final photo with a PAP flap at the upper pole of the breast (C).

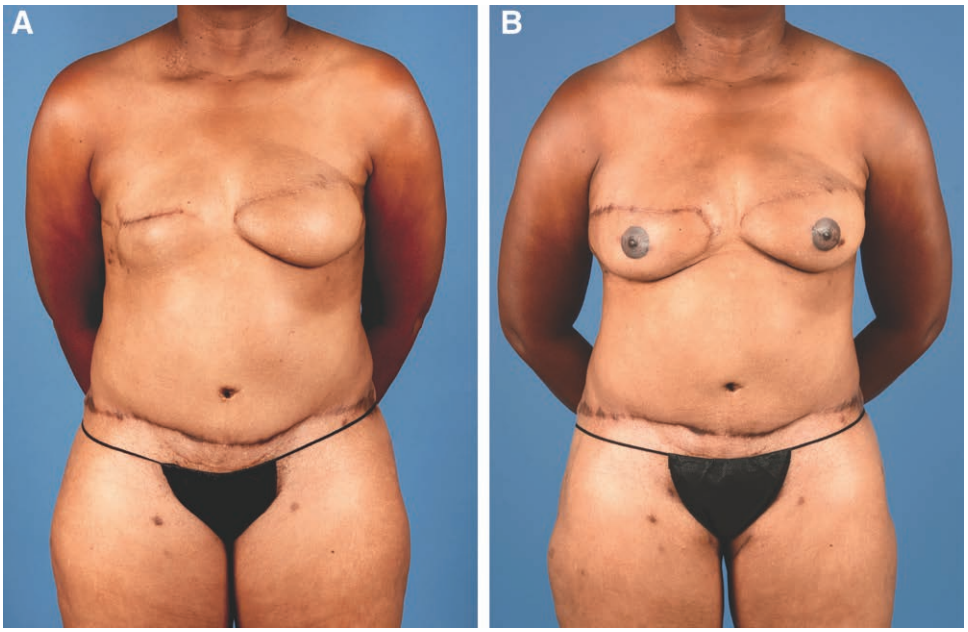

Fig. 7. Bilateral DIEP flap breast reconstruction with failed right DIEP (A-Preoperative), and salvage Right stacked PAP flaps to Thoracodorsal and Serratus vessels (B-postoperative).

sion rate.[1,3,8] Given these advantages and the introduction of sentinel lymph node biopsy, internal mammary vessels are now the first choice for recipient vessels.[1]

In patients who already have exhausted internal mammary vessels, thoracodorsal vessels are excellent alternative vessels for salvage breast reconstruction. The average length of the thoracodorsal artery is 8.4 cm (range, 5.9–14 cm), and the diameter of the vessel at its origin is 3 mm (range, 2–5 mm).[14] A single serratus branch from the thoracodorsal artery is found 72% of the time, and the caliber of this vessel is 2 mm in diameter with the length of 5.5 mm.[14] In our experience, the thoracodorsal vessels and the serratus branch get smaller distally with the approximate size of 1.5 mm. They are usually good size match to profunda artery perforator. We were able to find adequate thoracodorsal and serratus vessels for PAP flaps in all patients except 3 patients. In these patients, we performed anastomoses to a side branch of the profunda artery perforator dominant flap, which was connected to thoracodorsal vessels (Fig. 5). Given that the axilla is located lateral to the breast footprint, we harvested a longer length of pedicle (12.2 cm) than the known average length of 10.2 cm for PAP flaps[10] in attempt to go distal on the recipient vessels for medial positioning.

In addition, we have found that thoracodorsal vessel can be still used in patients who had undergone a pedicled latissimus flap for breast reconstruction. We have performed stacked PAP in a patient who underwent latissimus flap but continued to be dissatisfied with a unilateral placement of implant. In this patient, we identified the descending branch of thoracodorsal vessel and used it as a recipient of one of PAP flap while the other PAP flap was anastomosed to the side branch of the first flap as a parasitic flap. We recommend that in patients who wish to convert from latissimus flap and implant to fully autologous reconstruction. In these patients, the thoracodorsal system can be a suitable recipient site but only after exploration before flap harvest.

Although we did not experience any partial or total flap losses, combination of profunda artery perforator flap anastomosed into thoracodorsal/serratus vessels is a technically challenging operation. In our study, we chose profunda artery perforator as the flap of choice for our salvage reconstruction, given its advantages including the amount of available tissue, length of pedicle, vessel size match to thoracodorsal/serratus, and relative ease of flap harvest. Although PAP flaps offer myriad of advantages over other second choice flaps, both PAP flap and thoracodorsal arteries are small, and anastomoses often required use of the 10-0 or 11-0 nylon suture and super microsurgery instruments. Frequently, the microsurgeon would sit between the patient's arm and trunk while the assistant would sit next to the other side of the patient's arm (Fig. 8). This positioning makes it more difficult for another surgeon to assist.

CONCLUSIONS

Choosing appropriate recipient vessel and flap in a salvage breast reconstruction is challenging. From our experience, we have found that despite presence of axillary scarring related to previous flap surgery, sentinel node biopsy, axillary dissection or radiation, the thoracodorsal, and serratus vessels are excellent recipient vessels. Overall patient satisfaction was high with successful additive flaps and donor-site morbidity was low. Among various flap choices, we believe there is an increased potential for combination of PAP flaps using thoracodorsal/serratus vessels in the setting of salvage breast reconstruction. Posterior thigh tissue is an excellent secondary donor site in many

Fig. 8. Positioning of surgeons for microanastomosis.

patients and provides sufficient amount of tissue for breast reconstruction. In addition, thoracodorsal/serratus vessels are excellent match to the size of PAP vessels, and various creative insets can be performed using these vessels.

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REFERENCES

1. Saint-Cyr M, Youssef A, Bae HW, et al. Changing trends in recipient vessel selection for microvascular autologous breast reconstruction: an analysis of 1483 consecutive cases. *Plast Reconstr Surg.* 2007;119:1993–2000.
2. Dupin CL, Allen RJ, Glass CA, et al. The internal mammary artery and vein as a recipient site for free-flap breast reconstruction: a report of 110 consecutive cases. *Plastic Reconstr Surg.* 1996;98:685–689; discussion 690-682.
3. Moran SL, Nava G, Behnam AB, et al. An outcome analysis comparing the thoracodorsal and internal mammary vessels as recipient sites for microvascular breast reconstruction: a prospective study of 100 patients. *Plast Reconstr Surg.* 2003;111:1876–1882.

4. Giuliano AE, Dale PS, Turner RR, et al. Improved axillary staging of breast cancer with sentinel lymphadenectomy. *Ann Surg.* 1995;222:394–399; discussion 399–401.
5. Ferrari A, Rovera F, Dionigi P, et al. Sentinel lymph node biopsy as the new standard of care in the surgical treatment for breast cancer. *Expert Rev Anticancer Ther.* 2006;6: 1503–1515.
6. Smeets A, Christiaens MR. Implications of the sentinel lymph node procedure for local and systemic adjuvant treatment. *Curr Opin Oncol.* 2005;17:539–544.
7. Goyal A, Mansel RE. Recent advances in sentinel lymph node biopsy for breast cancer. *Curr Opin Oncol.* 2008;20:621–626.
8. Feng LJ. Recipient vessels in free-flap breast reconstruction: a study of the internal mammary and thoracodorsal vessels. *Plast Reconstr Surg.* 1997;99:405–416.
9. Allen RJ, Haddock NT, Ahn CY, et al. Breast reconstruction with the profunda artery perforator flap. *Plast Reconstr Surg.* 2012;129:16e–23e.
10. Allen RJ Jr, Lee ZH, Mayo JL, et al. The profunda artery perforator flap experience for breast reconstruction. *Plast Reconstr Surg.* 2016;138:968–975.
11. Haddock N, Nagarkar P, Teotia SS. Versatility of the profunda artery perforator flap: creative uses in breast reconstruction. *Plast Reconstr Surg.* 2017;139:606e–612e.
12. Haddock N, Gassman A, Cho M, et al. 101 Consecutive profunda artery perforator flaps in breast reconstruction—lessons learned with our early experience. *Plast Reconstr Surg.* 2017;140(2):229–239.
13. Haddock NT, Greaney P, Otterburn D, et al. Predicting perforator location on preoperative imaging for the profunda artery perforator flap. *Microsurgery.* 2012;32:507–511.
14. Rowsell AR, Davies DM, Eisenberg N, et al. The anatomy of the subscapular-thoracodorsal arterial system: study of 100 cadaver dissections. *Br J Plast Surg.* 1984;37:574–576.
15. Majumder S, Batchelor AG. Internal mammary vessels as recipients for free TRAM breast reconstruction: aesthetic and functional considerations. *Br J Plast Surg.* 1999;52:286–289.