Use of the Keystone Perforator Flap Closure for the Anterolateral Thigh Free Flap Donor Site

Pallavi A. Kumbla, MD¹, Ashley Q. Thorburn, MD, Maj.², Shreyas Makwana, MD¹, Matthew Mino, MD³, Joseph Zakhary, MD⁴, and René P. Myers, MD¹

Abstract

Objective: The anterolateral thigh (ALT) flap is a workhorse in microsurgical reconstruction. However, a flap width greater than 8 centimeters limits primary closure and discourages some surgeons from using this flap for larger defects to avoid a large and unsightly skin grafted donor site. ALT donor site closure can be made even more challenging when a more circular shaped flap is required.

Methods: This study examines the use of the keystone perforator flap to close large ALT free flap donor sites in 6 patients who underwent reconstruction for various purposes who otherwise would have required donor site skin grafting.

Results: Average flap dimensions were 10.5 cm x 17 cm and mean keystone flap dimensions were 12.2 cm x 22.5 cm. Average operative time of cases was 528.3 minutes and average BMI of patients was 24.8 kg/m². There was 1 case of partial keystone flap dehiscence that required local wound care, and 1 case of drain replacement for thigh seroma.

Conclusions: This series demonstrates that keystone perforator flap closure allows the thigh to maintain a relatively normal appearance, reduces postoperative pain associated with skin grafting, and can be performed in higher BMI patients with minimal complications and without increasing operative time or sensory or motor deficits. This series to date also has the largest defects closed with keystone flaps demonstrating the feasibility of this type of closure in very large ALT donor sites.

Keywords

perforator flap, donor site, microsurgical free tissue transfer, keystone design, anterolateral thigh flap

Received: 31 January 2021; accepted: 13 May 2021

Introduction

In 1984, Song et al described the design of 3 thigh based flaps including the anterolateral thigh flap. At the time, they found that large and variable shapes could be designed to cover large defects. They noted that if the donor site was small, it could be closed primarily, or otherwise would require a split-thickness skin graft to achieve closure.¹ Since that time, numerous studies have emerged to analyze the donor site morbidity of the free ALT flap. In 1 systematic literature review by Agostini et al in 2012, they found that complications such as compartment syndrome and muscle herniation occurred

¹ Division of Plastic and Reconstructive Surgery, University of Alabama at Birmingham, Birmingham, AL, USA
² David Grant Medical Center, Travis Air Force Base, CA, USA
³ Plastic Surgery Associates, Fort Worth, TX, USA
⁴ Elite Plastic Surgery and Restorative Breast Center, Phoenix, AZ, USA

Corresponding Author:
René P. Myers, MD, UAB Division of Plastic Surgery, Division of Pediatric Plastic Surgery, 1600 7th Avenue South Suite 322, Birmingham, AL 35233, USA.
Email: rmyers@uabmc.edu
with elevation of larger skin paddles (10–12 cm). In another study by Hanasono et al, they evaluated donor site complications in 220 patients that underwent reconstruction with the free ALT flap. Their average flap dimensions were 7.8 cm × 19.2 cm. Primary closure was achieved in 85% of patients while split-thickness skin grafting was performed in 15% of patients. The average width that allowed for primary closure was 7.4 cm while the average width requiring a skin graft for closure was 9.5 cm, which they found to be statistically significant. As they did not find increased complications with skin grafting, they advocated its use if a tension free closure could not be obtained to avoid wound dehiscence, muscle necrosis, or compartment syndrome. This is in direct opposition of a review of ALT donor site complications and morbidity by Kimata et al in which range of motion at the hip and knee was limited in patients who had undergone skin grafting versus primary closure due to adhesions between the skin graft and fascia in wider flaps that could not be closed primarily. All of these findings have led to different techniques to be developed to allow for primary closure of larger donor sites. This allows for improved aesthetics and decreased donor site pain and functionality from the use of a split-thickness skin graft, while avoiding complications such as dehiscence, muscle...
necrosis, and compartment syndrome. These have included using the flap width to thigh circumference ratio as advocated by Boca et al, and the anteromedial thigh perforator-assisted closure described by Visconti et al.5,6 However, both of these techniques are also limited by very large donor sites such as in our series. The purpose of this series is to demonstrate that the keystone perforator flap can be used in very large and irregularly shaped ALT donor sites to achieve closure of the donor site with no risk of major complications as seen in prior studies.

Methods

Six patients were identified between January to July of 2018. All patients underwent free ALT reconstruction of scalp, neck, upper, or lower extremity defects. A keystone designed perforator flap was used to close all donor sites. The width of the defect was measured. This width was used to design the width of the keystone flap. The limbs of the keystone flap were designed at 90° angles to the lateral edges of the defect. We consistently were able to doppler multiple signals on the medial thigh to confirm medial based perforator perfusion to the keystone flap prior to proceeding. The keystone flap was incised down to deep fascia on all limbs and closure of the lateral limbs as VY advancement flaps allowed for a widening of the keystone flap and subsequent complete closure of the defect (Figures 1 to 5). Drains were left under all keystone closures.

Results

Two patients underwent scalp reconstruction, 1 patient underwent neck reconstruction, 2 patients had lower extremity reconstruction, and 1 patient had upper extremity reconstruction utilizing the free ALT flap. Average age of patients was 44.7 years. Average BMI of patients was 24.8 kg/m². Average ASA class was 2.7. Average operative time was 528.3 minutes. Mean hospital stay was 11.7 days. Average flap width was 10.5 cm × 17 cm

![Figure 5. Illustration of use of ALT free flap in neck reconstruction following harvest and closure of donor site with keystone perforator flap.](image)

![Figure 6. Intraoperative markings for large (10 × 14 cm) free ALT flap used for neck reconstruction.](image)

| Patient | Type of Reconstruction | Age (Years) | BMI (kg/m²) | ASA | Operative Time (Minutes) | Donor Defect Dimensions (cm) | Keystone Flap Dimensions (cm) | Hospital Length of Stay (Days) | Donor Site Complications |
|---------|------------------------|-------------|-------------|-----|--------------------------|-----------------------------|------------------------------|------------------------------|--------------------------|
| 1       | Scalp                  | 71          | 14.53       | 3   | 439                      | 9 × 14                      | 14 × 25                      | 8                            | Thigh seroma requiring drain placement |
| 2       | Scalp                  | 61          | 22.68       | 4   | 596                      | 10 × 14                     | 14 × 25                      | 7                            | None                     |
| 3       | Neck                   | 38          | 25.49       | 3   | 436                      | 10 × 14                     | 11 × 25                      | 6                            | Partial wound dehiscence treated with negative pressure therapy |
| 4       | Lower Extremity        | 47          | 40          | 2   | 475                      | 11 × 20                     | 11 × 20                      | 21                           | None                     |
| 5       | Lower Extremity        | 24          | 21.46       | 2   | 557                      | 10 × 20                     | 10 × 20                      | 19                           | None                     |
| 6       | Upper Extremity        | 27          | 24.51       | 2   | 667                      | 13 × 20                     | 13 × 20                      | 9                            | None                     |
| Average |                        | 44.7        | 24.8        | 2.7 | 528.3                    | 10.5 × 17                   | 12.2 × 22.5                  | 11.7                         |                          |

Table 1. Demographics of Patients Undergoing Keystone Perforator Flap Closure of Large ALT Donor Sites.
(Figure 6) and average keystone flap was 12.2 \times 22.5 \text{ cm}. One patient did develop a thigh seroma requiring the replacement of a drain with resolution of seroma. Another patient did develop partial wound dehiscence at the donor site that healed with negative pressure therapy. No patients required revisions for contour irregularities to the donor site and no patients reported chronic pain at the donor site. No patients reported any sensory or motor deficits at long term follow up (Table 1).

**Discussion**

To date, our series of patients undergoing keystone perforator flap closure of the free ALT donor site is the only study with the largest donor defect size closed in this manner. This technique was described by Turin et al in 2018 as a trapezoid based perforator flap with VY advancement at the corners to mobilize the middle of the flap to cover the defect.\(^7\) However, unlike the Turin study, where the average width was 7 to 8 cm, which potentially could be closed primarily, our average width was 10.5 cm (Figure 7), which could not be closed primarily. The keystone flap technique was used to achieve closure successfully in all 6 patients (Figure 8). Only 2 complications were identified. One was a thigh seroma requiring the replacement of a drain and this resolved the seroma. The other was a partial wound dehiscence that resolved with negative pressure therapy. However, this second patient was found to be smoking postoperatively and likely would not have had dehiscence if he had been nicotine free. In addition, all patients reported no long term sensory or motor deficits at their donor sites. No donor site revisions had to be performed. Thus, we postulate that the keystone perforator flap closure for large ALT donor sites is a powerful tool that can allow for excellent contour and aesthetic outcomes with reduced morbidity compared to skin grafting of the donor site without adding increased operative time. To date we have not defined the upper limit of closure of the ALT donor site with the keystone flap which has allowed us to harvest progressively larger flaps for reconstruction while utilizing this technique for donor site closure with acceptable results.

**Acknowledgments**

The authors would like to acknowledge Jason Patel, BS for his assistance with illustrations provided for this manuscript.

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

**References**

1. Song YG, Chen GZ, Song YL. The free thigh flap: a new free flap concept based on the septocutaneous artery. *Br J Plast Surg*. 1984;37(2):149-159.
2. Agostini T, Lazzeri D, Spinelli G. Anterolateral thigh flap: systematic literature review of specific donor-site complications and their management. *J Craniomaxillofac Surg*. 2013; 41(1):15-21.
3. Hanasono MM, Skoracki RJ, Yu P. A prospective study of donor-site morbidity after anterolateral thigh fasciocutaneous flap closure. *J Plast Reconstr Aesthet Surg*. 2014; 67(6):694-700.

**Figure 7.** Intraoperative photo depicting use of large ALT (10 \times 14 \text{ cm}) for neck reconstruction.

**Figure 8.** Final keystone perforator flap (11 \times 25 \text{ cm}) closure of large (10 \times 14 \text{ cm}) free ALT flap used for neck reconstruction.
and myocutaneous free flap harvest in 220 patients. *Plast Reconstr Surg*. 2010;125(1):209-214.

4. Kimata Y, Uchiyama K, Ebihara S, et al. Anterolateral thigh flap donor-site complications and morbidity. *Plast Reconstr Surg*. 2000;106(3):584-589.

5. Boca R, Kuo Y, Hsieh C, Huang E, Jeng S. A reliable parameter for primary closure of the free anterolateral thigh flap donor site. *Plast Reconstr Surg*. 2010;126(5):1558-1562.

6. Visconti G, Salgarello M. Anteromedial thigh perforator-assisted closure of the anterolateral thigh free flap donor site. *J Plast Reconstr Aesthet Surg*. 2013;66(7):e189-e192.

7. Turin S, Spitz J, Alexander K, Ellis M. Decreasing ALT donor site morbidity with the keystone flap. *Microsurgery*. 2018;38(6):621-626.