

## Keystone Flap Type IV in Breast Reconstruction: A Case Report

Filippos Bekos<sup>1,2</sup>, Nikos Pappas<sup>2</sup>, Dimosthenis Chryssikos<sup>2</sup>, Epaminondas Kostopoulos<sup>1</sup>, Vasileios Karampelias<sup>2</sup>, Dimitra Daskalopoulou<sup>2</sup>, Theodore Troupis<sup>2</sup>

<sup>1</sup>Plastic and Reconstructive Surgery, Metaxa Cancer Hospital, Piraeus, Greece, <sup>2</sup>Department of Anatomy, Medical School, National and Kapodistrian University of Athens, Athens, Greece

**Correspondence:** *ttroupis@gmail.com; ttroupis@med.uoa.gr*; Tel.: + 30 210 7462388

**Received:** 12 September 2023; **Accepted:** 17 January 2024

### Abstract

**Objective.** The objective of this paper is to present and document a specific case of breast reconstruction using an adapted Type IV Keystone Flap technique, with a droplet-shaped design with a reduced flap ratio, and to identify the qualities of this method. **Case Report.** A 41-year-old woman, with a history of myocardial infarction and low ejection fraction, underwent a lumpectomy, resulting in a lower medial quadrant deficit in her left breast. After she developed skin and tissue necrosis and infection, implementing the Type IV Keystone Flap effectively addressed the deficit, ensuring sufficient coverage. The flap extended dropwise beneath the deficit, progressing anteriorly towards the upper rectus abdominis, with a ratio of 2.5:1. The flap's novel droplet shape allowed for the utilization of fewer perforators, while ensuring adequate blood supply and tissue coverage, leading to improved perfusion and aesthetic outcome. **Conclusion.** The application of the adapted Type IV Keystone Flap highlights its capacity as a versatile and effective method for breast reconstruction post-lumpectomy. With the advantages of a short learning curve, easy execution, and acceptable risk profile, it offers a valuable alternative for patients who may not be suitable for more complex surgeries. Further research is recommended to confirm its broader applicability and to conduct a comparative analysis with other techniques.

**Key Words:** Breast Cancer ■ Skin Deficit ■ Perforator Flap ■ Mastectomy ■ Lumpectomy.

## Introduction

Breast reconstruction poses significant challenges due to the complexity of addressing large defects requiring precise coverage for optimal aesthetic outcomes. Keystone Flaps (KF) have gained popularity, as they are an easy-to-perform and sophisticated technique for reconstructing deficits in various anatomical regions, benefiting from their capacity for similar tissue substitution (1). The term “Keystone Design Perforator Island Flap (KDPIF)” was introduced by Behan in 2003 to describe this curvilinear-shaped trapezoidal design. This method provides a simple and efficient solution for wound closure, presenting a practical alternative to complex flap closures or skin grafting, particularly in cases of melanoma (2). The KDPIF is a

multiperforator advancement flap, comprising two conjoined V to Y island flaps. It creates redundancy and effectively releases longitudinal tension, resulting in increased laxity within the flap, which allows for successful advancement toward the specific defect (3). Abraham and Saint-Cyr (2017), in their analysis of perforasome principles, noted that hyperperfusion through a single perforator could capture multiple adjoining perforasomes. On the basis of these principles, they acknowledged the effectiveness of the “Pedicule Perforator Flap (PPF)” and the “Keystone Perforator Island Flap (KPIF)” in facilitating the transfer of considerable volumes of soft tissue for reconstruction purposes. Furthermore, PPF and KPIF methods have decreased donor site morbidities, and have obviated the need for intricate microsurgical free-flap

reconstructions, thereby achieving improved aesthetic results (4). These advantages enable patients with significant comorbidities to undergo crucial, complex surgical reconstructions, and avoid the risks associated with prolonged general anesthesia. The implementation of these methods has also resulted in less postoperative monitoring, diminished patient-reported pain, and shorter periods of hospitalization (5). Advancements in understanding vascular anatomy will improve surgical flexibility for reconstructive flaps, enhancing patient care and outcomes (4).

In the case described below, an adapted KF technique was used for the first time in breast reconstruction.

## Case Report

A 41-year-old female patient presented with a deficiency in the lower medial quadrant of her left breast after a lumpectomy for breast cancer. The patient had undergone a cosmetic breast augmentation 15 years previously, and had a medical history of myocardial infarction one year earlier and a low ejection fraction (less than 35%). She had also previously undergone radiotherapy and chemotherapy due to her illness. Following lumpectomy, skin and underlying tissue necrosis developed, and the wound was infected with Gram-positive enterococcus (GPE). The patient was immediately treated with the appropriate antibiotics, and underwent surgical debridement, resulting in a 5 cm × 4 cm skin deficit (Figure 1).

The reconstruction was performed with a local KF, type IV, designed dropwise caudally to the deficit, anteriorly to the upper rectus abdominis, with a ratio of 2.5:1 (Figure 2).

This flap was chosen due to its suitability for providing adequate blood supply and tissue coverage. This specific design utilized fewer perforators than typically employed in such procedures. The flap was precisely dissected up to the superficial fascia of the rectus abdominis muscle, and was then mobilized in a clockwise manner towards the deficit. Part of the flap was then placed carefully into the deficit, avoiding undue tension. The suture

techniques chosen were 3-0 Monocryl single sutures for the subdermis, 4-0 Nylon single sutures for the deficit side, 4-0 Nylon running sutures for the rest of the flap (Figure 3).



Figure 1. Keystone Flap Type IV, designed dropwise caudally to the deficit, anteriorly to the upper rectus abdominis, with a ratio of 2.5:1.



Figure 2. Comprehensive view of the incision surrounding the flap, highlighting the droplet-shaped design with a ratio 2.5:1.



Figure 3. Immediate postoperative result of the adapted Keystone Flap Type IV.

The postoperative course proceeded smoothly, without any complications or signs of congestion to the flap, while wound healing progressed satisfactorily. The patient was able to continue her chemotherapy treatment, which is crucial for managing breast cancer. If not managed properly, surgical resection can lead to a significant defect that can negatively impact the patient's quality of life. However, no widely accepted or ideal approach exists for resurfacing defects in reconstructive surgery (6). The KPIF may be considered a viable method for reconstructive surgery following mastectomy. Nevertheless, more exhaustive research and well-designed prospective cohort studies will provide valuable insights into the outcomes and benefits of using the KPIF for breast reconstruction.

## Discussion

Koshima and Soeda (1989) made significant contributions to the field of reconstructive surgery by introducing the concept of perforator flaps, employing a musculocutaneous flap with an inferior epigastric artery-based skin island to restore defects in the floor of the mouth and groin (4). This influential research was pivotal in advancing our understanding of perforator flaps, vascular anatomy, and tissue transfer for reconstructive purposes.

The Keystone Flap, a perforator flap subtype, consists of two V to Y advancement flaps that move in opposite directions. This movement creates additional tissue adjacent to the defect, allowing for primary skin edge approximation (4). Initially proposed for smaller defects, it was later suggested in 2011 that KFs could also address more significant defects in the trunk and limbs (7). Various modifications have been developed to increase their transposition potential for these extensive deficiencies, including double KFs or deep fascia incisions (1, 8). The omega subtype, often overlooked, presents another modification that effectively utilizes excessive laxity in a specific area of the flap during inseting, and capitalizes on the natural laxity of the lateral skin, increasing mobility (6). Surgeons can carefully plan and execute the

flap design to advance it into the desired position, ensuring minimal tension or distortion, without compromising flap viability or causing undue complications.

The Type IV Keystone flap is a specific variation of the KF, which includes rotation and advancement of the flap, and is indicated in breast reconstruction and other more complex surgeries (9). The Type IV Keystone Flap has been previously documented for breast reconstruction; however, our case uniquely applies this technique with a specific droplet shape and reduced ratio in the lower medial quadrant. This detail, not previously described, capitalizes on the laxity of the area and minimizes the need for multiple perforators, which is particularly beneficial in patients with limited perfusion capacity.

In addition to the KF, other perforator flap techniques have emerged as valuable alternatives in breast surgery. Hamdi et al. (2006) proposed using Intercostal Artery Perforator (ICAP) flaps as valuable alternatives for breast surgery, which are particularly beneficial when addressing complex defects on the trunk without compromising the underlying muscle (10). Similarly, a study by Orabi et al. (2022) highlighted the reliability of lateral chest wall perforator flaps as a reliable technique for partial breast reconstruction, with satisfactory aesthetic results (11).

These advancements in perforator flap techniques expand the range of reconstructive options available to surgeons, increasing surgical liberty, and allowing for customized solutions in various clinical scenarios. Ongoing research and exploration of these techniques will lead to further improvements in breast reconstruction and other fields of reconstructive surgery.

## Conclusion

KPIF is a viable method for resurfacing significant skin deficits and full-thickness cutaneous defects in various anatomical regions, including the breast. Given its relatively short learning curve, acceptable risk factors, decreased operative times, broad applicability, and positive outcomes, the KF

---

technique should be considered an invaluable approach, suitable for both novices and experienced surgeons (1, 3, 12). Additionally, it is an advantageous option for more complex wounds in patients unsuited for more intricate surgical procedures, such as microsurgery. As we continue to deepen our understanding of vascular anatomy and refine surgical methods, we can expect even more significant progress in reconstructive surgery. Advanced vascular imaging techniques, such as Magnetic Resonance Angiography (MRA), will provide detailed preoperative assessments, aiding in the accurate planning and execution of reconstructive flaps (13). These advancements will enable a personalized approach, minimizing complications and optimizing patient satisfaction.

#### What Is Already Known on this Topic:

*Perforator flap techniques offer advantages such as reduced complications, diminished pain (14), and quick patient recovery. Keystone flaps (KF), including the Type IV variant, became popular due to their simplicity and effectiveness in wound closure, especially in melanoma cases. The KF Type IV represents an innovative and versatile technique for breast reconstruction following lumpectomy. It provides enhanced perfusion and favorable aesthetic results, making it a reliable option for addressing tissue deficits (15).*

#### What This Case Report Adds:

*This case report contributes valuable insights to the existing literature, providing further evidence for the Keystone Perforator Island Flap technique's viability in reconstructing significant skin deficits, including breast reconstruction. The findings underscore the positive outcomes and its suitability for complex wounds, particularly in patients who may not be candidates for more intricate surgical procedures. Additionally, the report highlights the need for further research to validate the extensive applicability of this modified technique and compare it with other approaches in breast reconstruction.*

**Acknowledgments:** The authors sincerely thank the patient for her willingness and valuable contribution to the breast reconstruction operation conducted. Results from this report hold the potential to enrich medical knowledge and the existing literature.

**Author's Contributions:** Operation and identification of the case: EK and FB; Drafting the article: VK, TT and NP; Revising it critically for important intellectual content: EK and DC; Approved final version of the manuscript: DC and TT.

**Conflict of Interest:** The authors declare that they have no conflict of interest.

#### References

1. Srivastav S, Gupta S, Sharma A. Keystone Flap as a Reconstructive Option for selected areas; A Prospective Study. *J Clin Orthop Trauma*. 2020;11(Suppl 5):S871-5. doi: 10.1016/j.jcot.2020.06.019. Epub 2020 Jun 17.
2. Behan FC. The Keystone Design Perforator Island Flap in reconstructive surgery. *ANZ J Surg*. 2003;73(3):112-20. doi: 10.1046/j.1445-2197.2003.02638.x.
3. Rini IS, Gunardi AJ, Marsaulina RP, Aryandono T, Dachlan I, Dwiprahasto I. A systematic review of the keystone design perforator island flap in the reconstruction of trunk defects. *Arch Plast Surg*. 2020;47(6):535-41. doi: 10.5999/aps.2020.00094. Epub 2020 Nov 15.
4. Abraham JT, Saint-Cyr M. Keystone and Pedicle Perforator Flaps in Reconstructive Surgery: New Modifications and Applications. *Clin Plast Surg*. 2017;44(2):385-402. doi: 10.1016/j.cps.2016.12.005.
5. Rao AL, Janna RK. Keystone flap: versatile flap for reconstruction of limb defects. *J Clin Diagn Res*. 2015;9(3):PC05-7. doi: 10.7860/JCDR/2015/12595.5631. Epub 2015 Mar 1.
6. Rini IS, Krisna MA, Kamayana J, Djarot KR, Gunardi AJ. Keystone Perforator Island Flap for Postmastectomy Defect Resurfacing in Late-stage Breast Cancer Patients. *Plast Reconstr Surg Glob Open*. 2019;7(11):e2457. doi: 10.1097/GOX.0000000000002457.
7. Khouri JS, Egeland BM, Daily SD, Harake MS, Kwon S, Neligan PC, et al. The keystone island flap: use in large defects of the trunk and extremities in soft-tissue reconstruction. *Plast Reconstr Surg*. 2011;127(3):1212-21. doi: 10.1097/PRS.0b013e318205f36f.
8. Mohan AT, Rammos CK, Akhavan AA, Martinez J, Wu PS, Moran SL, et al. Evolving Concepts of Keystone Perforator Island Flaps (KPIF): Principles of Perforator Anatomy, Design Modifications, and Extended Clinical Applications. *Plast Reconstr Surg*. 2016;137(6):1909-20. doi: 10.1097/PRS.0000000000002228.
9. Magliano J, Falco S, Agorio C, Bazzano C. Modified keystone flap for extremity defects after Mohs surgery. *Int J Dermatol*. 2016;55(12):1391-5. doi: 10.1111/ijd.13368. Epub 2016 Jul 15.
10. Hamdi M, Van Landuyt K, de Frene B, Roche N, Blondeel P, Monstrey S. The versatility of the inter-costal artery perforator (ICAP) flaps. *J Plast Reconstr Aesthet Surg*. 2006;59(6):644-52. doi: 10.1016/j.bjps.2006.01.006. Epub 2006 Mar 22.
11. Orabi A, Youssef MMG, Manie TM, Shaalan M, Hashem T. Lateral chest wall perforator flaps in partial breast reconstruction. *J Egypt Natl Canc Inst*. 2022;34(1):2. doi: 10.1186/s43046-021-00100-5.
12. Lanni MA, Van Kouwenberg E, Yan A, Rezak KM, Patel A. Applying the Keystone Design Perforator Island Flap Concept in a Variety of Anatomic Locations: A Review of

- 60 Consecutive Cases by a Single Surgeon. *Ann Plast Surg.* 2017;79(1):60-7. doi: 10.1097/SAP.0000000000000995.
13. Agrawal MD, Thimmappa ND, Vasile JV, Levine JL, Allen RJ, Greenspun DT, et al. Autologous breast reconstruction: preoperative magnetic resonance angiography for perforator flap vessel mapping. *J Reconstr Microsurg.* 2015;31(1):1-11. doi: 10.1055/s-0034-1372475. Epub 2014 May 29.
  14. Saint-Cyr M, Schaverien MV, Rohrich RJ. Perforator flaps: history, controversies, physiology, anatomy, and use in reconstruction. *Plast Reconstr Surg.* 2009;123(4):132e-145e. doi: 10.1097/PRS.0b013e31819f2c6a.
  15. Virág TH, Muntean MV, Georgescu AV. Minimising donor-site morbidity following limbs' injuries with keystone perforator island flap reconstruction. *Wound Repair Regen.* 2022;30(3):357-64. doi: 10.1111/wrr.13007. Epub 2022 Apr 8.
-