

Vessel Loop Shoelace Technique followed by Keystone Flap to Treat a Large Mid-back Defect

Chia-Chun Lee, MD*
Tien-Hsiang Wang, MD, PhD*†
Ching-En Chen, MD*†

Summary: The keystone design perforator island flap has been gaining popularity for reconstructing large cutaneous defects with sufficient soft tissue laxity. However, for a defect with insufficient local tissue and tense laxity such as upper to mid-back, a single keystone flap may not be so suitable for advancement and mobilization. Instead of an additional flap or double-opposite-designed keystone flaps, we attempted to apply the vessel loop shoelace technique for external expansion before proceeding with only one keystone flap reconstruction for a 15 × 15 cm skin and soft tissue defect on the mid-back. The outcome was a viable flap, with no ischemic flap edge, wound dehiscence, or infection. In our opinion, external expansion with vessel loops followed by a keystone flap might yield fairly good results for the reconstruction of mid-back defects; furthermore, this method may be ideal for defects located in regions lacking sufficient skin laxity. (*Plast Reconstr Surg Glob Open* 2022;10:e4049; doi: 10.1097/GOX.0000000000004049; Published online 24 January 2022.)

Reconstruction of large posterior mid-thoracic soft tissue defects is a difficult issue for plastic surgeons. The drawback of these defects is the insufficient local tissue available for rearrangement, owing to its specific anatomical limitations.¹⁻³ Although microsurgery has undergone significant advancements and allows the application of versatile free tissue transfers, it is time-consuming and requires a steep technical learning curve, with an associated risk of donor site morbidity. In addition to free tissue transfers, the locoregional flaps have been recommended as the first choice for back reconstruction because of their shorter operative time, tissue similarity, and high reproducibility.^{1,4,5}

The keystone design perforator island flap, first described by Behan in 2003, has been gaining popularity as a local reconstructive option primarily used for the trunk and extremities.⁵⁻⁸ However, according to the basis of the keystone flap, the width should be at least equal to the defect; otherwise, for larger defects, a single local advanced keystone flap may not be extensively mobilized for adequate coverage, and an additional flap or double-opposite

keystone flaps may be considered.^{9,10} To obtain sufficient soft tissue coverage with a simply designed flap for a large mid-back defect, we present a strategy combining a well-established shoelace technique for decreasing tissue gap utilizing a periodically tightened elastic tension applied on the wound edges, followed by a keystone flap.

CASE

A 57-year-old previously healthy man presented with a gradually enlarged subcutaneous tumor on the mid-back for 1 year; he had a previous surgical history of an excision for a lipoma in the same location 4 years before. An approximately 10 × 7 cm, well-defined, fixed, solid mass with no tenderness or erythema on his mid-back was noted in physical examination. Images for further tumor survey were shown in Supplement Digital Content 1. (See **figure, Supplemental Digital Content 1**, which displays a magnetic resonance imaging illustrating a heterogenous lobulated soft tissue mass about 4.9 × 2.2 × 3.7 cm at upper back (arrows), deep to muscle layer, demonstrating mass effect with some dark fibrous bands. (a) Axial plane. (b) Sagittal plane. <http://links.lww.com/PRSGO/B900>.)

Incisional biopsy of the tumor was performed, and the pathology report suggested soft tissue sarcoma. Thereafter, wide excision with a safe margin of at least 2 cm was achieved. A 15 × 15 cm skin and soft tissue defect with depth to muscle layer resulted, exposing serratus posterior and erector

From the *Division of Plastic and Reconstructive Surgery, Department of Surgery, Taipei Veterans General Hospital, Taiwan; and †School of Medicine, Department of Surgery, National Yang-Ming University, Taiwan.

Received for publication July 7, 2021; accepted November 9, 2021.

Copyright © 2022 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.0000000000004049

Disclosure: The authors have no financial interests to declare in relation to the content of this article.

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

spinae muscles (Fig. 1). Due to indeterminate pathologic margins under frozen-section evaluation between similar-appearing lesions, such as a benign lipoma or an atypical lipomatous tumor,¹¹ the wound remained open. External expansion with vessel loops was applied in the following four steps: (1) staples were placed longitudinally along the edges of the wound at 2 cm intervals (Fig. 1); (2) two vessel loops were inserted through skin staples at mirrored locations on both sides of the wound, crossing over each other in an interlacing fashion, resembling corset or shoelaces of a shoe (Fig. 2); (3) the vessel loops were then tied with knots on both angles; (4) after careful stretching of interlacing vessel loops, one extra staple was anchored in the longitudinal axis of both angles, allowing for the vessel loop knots to be fixed to maintain tension. A standard wet gauze dressing was placed beneath the loops.

After operation, we then fastened the loops and repositioned a new knot 2–3 cm proximal to the original one in each end at the bedside every 2–3 days (Fig. 3). Mild discomfort and distension were alleviated by oral pain-killers. A course of total 10 days was needed until the defect diminished to 4 × 15 cm before reconstruction. The patient was hospitalized during the entire duration. The definitive pathology of a dedifferentiated liposarcoma with myogenic differentiation, FNCLCC grade 2, was observed a week later. After confirming safe surgical margins and a base, a type IIa keystone flap was performed with a width half of the initial diameter of

the defect (8 cm). The recovery was uneventful. The 3-month postoperative follow-up showed optimal outcomes (Fig. 4).

DISCUSSION

The back is formed by thicker and stiffer skin with dense fibrous septa connecting to deeper tissues,⁷ which can sustain greater tension during body movements. Therefore,



Fig. 1. A 15 × 15 cm mid-back defect after wide excision, with skin staples applied every 2 cm at the edges.

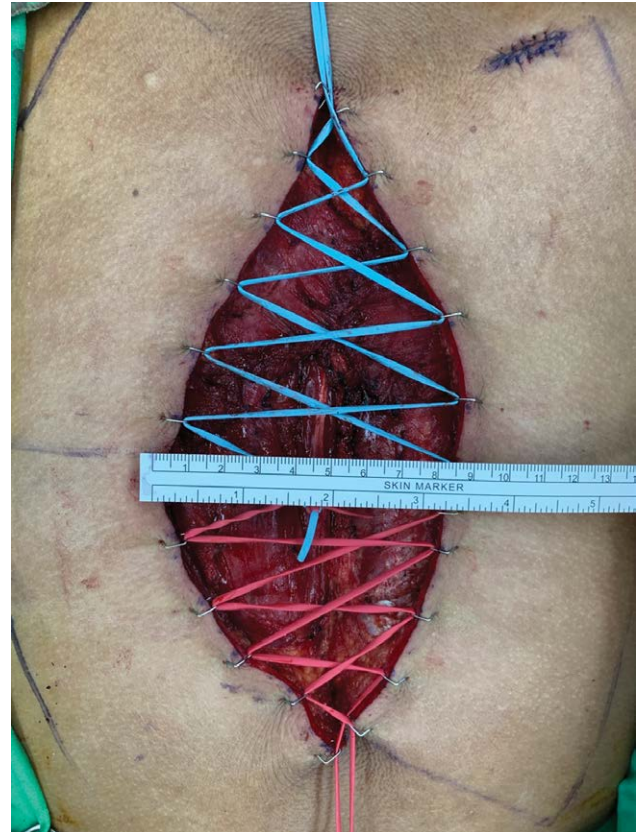


Fig. 2. Shoelace technique with vessel loops passing through skin staples alternatively.



Fig. 3. The loops were tightened every 2–3 days at bedside, with new knots tied at both angles for fixation.



Fig. 4. Results at three months postoperative follow-up.

one of the key points in repairing back wounds is to minimize tension for successful healing. The keystone flap is known to be versatile because of its simplicity, good vascularity, tension-reducing effect,⁸ potential for “like-with-like” replacement, and no need for microsurgery. Other alternative local flaps such as the trapezius flap or latissimus dorsi flap² were withdrawn in this case due to surgical complexity and prolonged operation time. In addition, possible increased donor site morbidity could be anticipated. The basis of the keystone flap is a curvilinear-shaped trapezoidal design directed toward the defect, and closure of the lateral angles of the donor site in a V-Y manner. The resulting keystone flap design develops a flap-to-defect-width ratio ranging from 1:1 to 5:1. If the advancement and coverage are inadequate, then an additional flap or double-opposite, type III, keystone flaps may be more suitable.^{9,10} Supplemental Digital Content 2 showed the traditional keystone design perforator island flap classified by Behan.⁶ (See table, Supplemental Digital Content 2, which displays a Behan’s classification of keystone design perforator island flap. <http://links.lww.com/PRSGO/B901>.) A systemic review of the keystone flap on the trunk mentions that the flap may be useful, but local tissue laxity is still crucial. This may consequently lead to a higher complication rate on the trunk than on the extremities, which includes infection (11.6%), wound dehiscence (7.4%), and delayed wound healing (7.4%).¹² A recent case series described 20 keystone flap reconstructions (17 patients) for oncological

back defects. Although high success rates were reported, there were still four patients requiring skin grafting owing to a large upper- to mid-back defect.⁵

To overcome the insufficient local tissue and tense laxity, the vessel loop shoelace technique described by Cohn et al¹³ is applied for external tissue expansion in this case. This technique not only has the advantage of being less aggressive, but also can be easily implemented on wound closure, which decreases tissue gap effectively. By using this method, elastic loops create a constant traction on the wound edges that can be gradually tightened on both ends until primary wound closure is achieved.¹⁴ We stopped increasing tension after 10 days due to tightening deemed ineffective once 4 cm width was reached. The edges became hard to advance, and the patient also experienced greatest tolerable tension. Previously, the shoelace technique was commonly used to treat fasciotomy wounds at the extremities for compartment syndrome, with a significant reduction in the time to closure and with low complication rates¹⁴; however, the management of larger defects with skin and soft tissue loss through this technique has rarely been discussed. Another modality that has been reported in the literature as a delayed primary closure technique is negative pressure wound therapy,¹⁵ but this method was not applied in this case, because of its contraindication related to malignancies¹⁶; furthermore, the tumor margin still needed assessment.

In this case, we combined two well-established methods. To minimize the wound size and improve local skin laxity, continuous traction was provided by the elasticity of the vessel loop during the interval between the two operations (tumor wide excision and keystone flap reconstruction). To prevent elastic recoil after applying tension to the temporary elastic threads, we created a new knot to be fixed at the longitudinal staple, which served as a new anchoring point. It allowed us to close the wound with only one keystone flap instead of two. Moreover, instead of microsurgery, such a large mid-back defect may also be reconstructed with pedicled or other perforator flaps¹; Nevertheless, the keystone flap is superior owing to its simplicity, defect-adaptive design, easy reproducibility, tension-reducing effect, and straightforward elevation. Skin grafting may not be ideal because of the probability of using adjuvant radiotherapy and the risk of scar formation.

CONCLUSIONS

Using the shoelace technique for external tissue expansion, followed by a keystone flap, may be effective in the reconstruction of large defects on the back. Owing to the advantages of both techniques, this combined method shows its applicability, feasibility, and reliability, with an optimal aesthetic outcome.

Ching-En Chen, MD

Division of Plastic and Reconstructive Surgery
Taipei Veterans General Hospital
19F, No 201, Sec. 2, Shi-Pei Street
Beitou Dist, Taipei 112
Taiwan
E-mail: cechen2292@gmail.com

REFERENCES

1. Komagoe S, Watanabe T, Komatsu S, et al. Pedicled flaps versus free flaps for back reconstruction. *Ann Plast Surg.* 2018;81:702–707.
2. Ndayishimiye JM, Husson JL, Watier E. Reconstruction of extensive posterior mid-thoracic soft-tissue defects after spinal surgery on irradiated skin. *Orthop Traumatol Surg Res.* 2009;95(4 Suppl 1):S35–S40.
3. Pelissier P, Santoul M, Pinsolle V, et al. The keystone design perforator island flap. Part I: anatomic study. *J Plast Reconstr Aesthet Surg.* 2007;60:883–887.
4. Lanni MA, Van Kouwenberg E, Yan A, et al. 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;79:60–67.
5. Yan M, Rose PS, Houdek MT, et al. Outcomes of the keystone perforator island flap for oncologic reconstruction of the back. *J Surg Oncol.* 2021;124:1002–1007.
6. Behan FC. The keystone design perforator island flap in reconstructive surgery. *ANZ J Surg.* 2003;73:112–120.
7. Khouri JS, Egeland BM, Daily SD, et al. The keystone island flap: use in large defects of the trunk and extremities in soft-tissue reconstruction. *Plast Reconstr Surg.* 2011;127:1212–1221.
8. Yoon CS, Kong YT, Lim SY, et al. A comparative study for tension-reducing effect of Type I and Type II keystone perforator island flap in the human back. *Sci Rep.* 2021;11:16699.
9. Sinha S, Yip MJ, Gill S, et al. A giant fungating metastatic basal cell carcinoma of the back and novel reconstruction using two large keystone design island perforator flaps. *J Plast Reconstr Aesthet Surg.* 2013;66:1015–1018.
10. Nedu ME, Matei IR, Georgescu AV. Giant keystone type III perforator flaps for dermatofibrosarcoma protuberans defect reconstruction. *Injury.* 2019;50 (Suppl 5):S21–S24.
11. Endo M, Lin PP. Surgical margins in the management of extremity soft tissue sarcoma. *Chin Clin Oncol.* 2018;7:37.
12. Rini IS, Gunardi AJ, Marsaulina RP, et al. A systematic review of the keystone design perforator island flap in the reconstruction of trunk defects. *Arch Plast Surg.* 2020;47:535–541.
13. Cohn BT, Shall J, Berkowitz M. Forearm fasciotomy for acute compartment syndrome: a new technique for delayed primary closure. *Orthopedics.* 1986;9:1243–1246.
14. Zorrilla P, Marín A, Gómez LA, et al. Shoelace technique for gradual closure of fasciotomy wounds. *J Trauma.* 2005;59:1515–1517.
15. Lee JY, Jung H, Kwon H, et al. Extended negative pressure wound therapy-assisted dermatotraction for the closure of large open fasciotomy wounds in necrotizing fasciitis patients. *World J Emerg Surg.* 2014;9:29.
16. Pflibsen LR, Lettieri SC, Kruger EA, et al. Negative pressure wound therapy in malignancy: always an absolute contraindication? *Plast Reconstr Surg Glob Open.* 2020;8:e3007.