The Modified 3-square Flap Method for Reconstruction of Toe Syndactyly

Naoshige Iida, MD, PhD
Ayako Watanabe, MD

Bandoh reported the 3-square-flap method as a procedure for interdigital space reconstruction in patients with minor syndactyly. We recently modified this flap design so that it could be used in the treatment of toe syndactyly involving fusion of the areas distal to the proximal interphalangeal joint. With our method, the reconstructed interdigital space consists of 4 oblong flaps (A through D). Flaps A and D are designed on the dorsal side, flap B is designed on the frontal plane of the interdigital space, and flap C is designed on the plantar side. Flaps A, B, and C are raised immediately below the dermis in a manner that allowed slight fat tissue to adhere to each flap. Flap D is freed to a degree minimally needed for dislocation, while leaving a thick subcutaneous pedicle. Flaps A, B, and C are each folded in 90 degrees; flap D is dislocated to the proximal plane of the reconstructed digit, followed by skin suturing. In this process, suturing is avoided between flaps A and C, between flaps A and D, and between flaps B and D. During the period of 2011 to 2015, we treated 8 patients of toe syndactyly involving fusion distal to the proximal interphalangeal joint. Cases of congenital syndactyly received surgery between the ages of 8 and 11 months. Using this technique, flap ischemia/necrosis was not observed. During the postoperative follow-up period, the interdigital space retained sufficient depth without developing any scar contracture. No case required additional surgery. (Plast Reconstr Surg Glob Open 2016;4:e793; doi: 10.1097/GOX.0000000000000735; Published online 11 July 2016.)

Surgical Methods

The 3-square-flap method involves designing 3 square flaps of the same size (Fig. 1). Each flap is folded in 90 degrees and sutured to create interdigital space. This method is applicable only to minor syndactyly involving fusion confined to the area proximal to the PIP joint. With the modified 3-square-flap method, the interdigital space of the area affected by syndactyly involving fusion distal to the PIP joint was designed in a rectangular form. The reconstructed

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.
The interdigital space consists of 4 oblong flaps (A through D). Flap D is raised as a subcutaneous pedicle flap and is dislocated to the proximal plane of the reconstructed digit. Flaps A and D are designed on the dorsal side of the interdigital space, flap B is designed on the frontal plane of the interdigital space, and flap C is designed on the plantar side. Flap D is designed as large as possible to obtain adequate vascular supply from the subcutaneous tissue. If there is laterality difference between medial and lateral sides in the length of the fused digits, the base of flap B is allocated for the shorter digit and the greater length of the flap is taken from the lateral side of the longer digit. By this design, the lateral aspect of the reconstructed digit can be closed with sufficient margin by flaps B and D at the time of skin suturing. Flaps A, B, and C were each folded in 90 degrees; flap D was dislocated to the proximal plane of the reconstructed digit, followed by skin suturing. In this process, suturing was avoided between flaps A and C, between flaps A and D, and between flaps B and D.

RESULTS
During the period of 2011 to 2015, we treated 8 patients of toe syndactyly involving fusion distal to the PIP joint (Table 1). Cases of congenital syndactyly received surgery between the ages of 8 and 11 months. In cases of bilateral syndactyly, operation was performed on both sides at a time. Postoperatively, all cases remained free of disturbed blood flow through the flaps, with flaps surviving successfully in all cases. During the postoperative follow-up period, the interdigital space retained sufficient depth without developing any scar contracture. No case required additional surgery.

CASE REPORT
Case 1
An 11-year-old girl with right first web toe syndactyly resulting from burn injury underwent interdigital space reconstruction with this method (Fig. 2A and B). The flaps survived successfully without any postoperative complication. Currently, 2 years postoperatively, the interdigital space retains sufficient depth, showing no sign of scar contracture (Fig. 2C).

DISCUSSION
Toe syndactyly is a congenital anomaly with a relatively high incidence. In Japan, many people remain barefoot throughout their daily routine; therefore, patients often desire surgery for children with toe anomalies for aesthetic reason.²
Although syndactyly is usually treated surgically with a combination of skin graft and local flap, this approach has shortcomings of inconsistency in color and texture between the skin grafted area and the surrounding skin. In addition, there is likelihood for postoperative scar contracture due to shrinkage of the grafted area.

Several investigators have reported surgical techniques for syndactyly without the need for skin grafting. However, all of these techniques are only applicable to minor syndactyly. For cases of severe syndactyly involving fusion up to the distal interphalangeal joint, an operative procedure using an expander has been reported. However, such a procedure needs to be applied multiple times and requires a long period of treatment, thus limiting its indications.

The 3-square-flap method was reported in 1996 by Bandoh et al as an operative procedure for minor syndactyly. Hayashi et al applied surgery with a combination of this method and a subcutaneous pedicle flap to 10 patients of toe polysyndactyly, resulting in partial necrosis of the subcutaneous flap in 3 cases. Hayashi et al regarded that such results occurred because the subcutaneous flap was delicate and hence prone to necrosis.

To resolve such problems, we modified the 3-square-flap method in the following aspects: (1) designing flaps A, B, C, and D in oblong form, (2) designing a large subcutaneous pedicle flap to reduce the distance needed for dislocation to the defective area, (3) freeing the subcutaneous pedicle flap to a minimum necessary extent, while leaving a thick pedicle, (4) designing flap B longer, and (5) avoiding suturing between flaps A and C, between flaps A and D, and between flaps B and D. Using this technique, flap ischemia/necrosis was not observed. Furthermore, the reconstructed interdigital space retained sufficient depth for a long period of time, requiring no additional surgery.

**CONCLUSION**

We devised the modified 3-square-flap method for syndactyly involving fusion distal to the PIP joint. This modified method was applied to 8 patients with severe toe syndactyly, resulting in favorable outcomes in all cases.

Naoshige Iida, MD
Department of Plastic and Reconstructive Surgery
Japanese Red Cross Akita Hospital
222-1, Naeshirozawa, Saruta
Kamikitake, Akita City, 010-1406, Japan
E-mail: naoshige@archosp-1998.com

**PATIENT CONSENT**

The patient provided written consent for the use of the images.
REFERENCES
1. Bandoh Y, Yanai A, Seno H. The three-square-flap method for reconstruction of minor syndactyly. *J Hand Surg Am*. 1997;22:680–684.
2. Iida N, Kotake A. A new surgical procedure for little toe polysyndactyly without skin graft. *Ann Plast Surg*. 2011;67:167–169.
3. Woolf RM, Broadbent TR. The four-flap Z-plasty. *Plast Reconstr Surg*. 1972;49:48–51.
4. Shaw DT, Li CS, Richey DG, et al. Interdigital butterfly flap in the hand (the double-opposing Z-plasty). *J Bone Joint Surg Am*. 1973;55:1677–1679.
5. Hirshowitz B, Karev A, Rousso M. Combined double Z-plasty and Y-V advancement for thumb web contracture. *Hand*. 1975;7:291–293.
6. Chapman P, Banerjee A, Campbell RC. Extended use of the Mustardé dancing man procedure. *Br J Plast Surg*. 1987;40:432–435.
7. Ostrowski DM, Feagin CA, Gould JS. A three-flap web-plasty for release of short congenital syndactyly and dorsal adduction contracture. *J Hand Surg Am*. 1991;16:634–641.
8. Ogawa Y, Kasai K, Doi H, et al. The preoperative use of extra-tissue expander for syndactyly. *Ann Plast Surg*. 1989;23:552–559.
9. Hayashi A, Yanai A, Komuro Y, et al. A new surgical technique for polysyndactyly of the toes without skin graft. *Plast Reconstr Surg*. 2004;114:433–438.