

TECHNIQUE ARTICLE

A Technique to Improve Foot Appearance After Trimmed Toe or Hallux Harvesting

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We describe a technique to improve the appearance of the donor site after hallux harvesting. The surgery has been used in 6 consecutive patients having a trimmed-toe-type transfer. Instead of the classic stump closure advised by Wei, the following steps were performed on the donor site: (1) removal *en bloc* of the second metatarsal and transposition of the second toe on top of the proximal phalanx of the hallux, (2) interposition of a tibial (medial) glabrous flap from the tibial aspect of the hallux onto the tibial side of the second toe to increase its size, and (3) eponychial flap to increase the nail show on the second toe. Fixation of the toe was achieved with K-wires and cerclage wire. Crossed K-wires stabilized the first to the third metatarsals for 4 to 6 weeks. Ambulation with a stiff sole was allowed a few days after surgery. The main advantage of this technique is the improved donor site appearance. As a bonus, the amount of skin that can be harvested with the trimmed toe is slightly increased. The main drawback is that the number of toes is reduced to 4. (J Hand Surg 2007;32A: 409–413. Copyright © 2007 by the American Society for Surgery of the Hand.)

Key words: Toe-to-hand transfer, thumb reconstruction, trimmed toe transfer, hallux harvesting, hallux donor site, microsurgery.

Since its introduction as a suitable alternative for thumb reconstruction,^{1,2} great toe transfer has been considered the best way of reconstructing an amputated thumb, especially after mutilating hand injuries.^{3–6}

In the early days of great toe harvesting, when the metatarsal was included with the transferred toe, alterations in gait and/or foot pain were frequent.^{7,8} Several researchers have shown, however, that if a 1-cm stump of proximal phalanx, or at a minimum the whole first metatarsal, is left in place, minimal interference with foot function will occur.^{7–10} Having overcome the functional aspect, the donor site was a drawback, which detracted from a wider usage.

Several alternatives that minimize the donor site morbidity, such as use of the second toe¹¹ or the so-called wrap-around,¹² were also available, but neither was ideal. The second toe produces too small a thumb replica, and the wrap-around has among other limitations the fact that no motion exists at the interphalangeal (IP) joint.

Foucher et al^{13–15} devised the twisted-two-toes technique, in which some motion at the IP joint is obtained by wrapping the skin of the hallux around the proximal interphalangeal joint of the second toe. The foot donor site is closed by filleting the skin of the second toe, which is wrapped around the bony framework of the great toe. The twisted-two-toes technique is technically difficult and has not become popular; only a few articles about it have been published.^{16–19} The main collateral advantage of the technique, however—the way the donor site was closed—went unappreciated.

Bearing in mind this principle, we have developed a technique to improve the donor site after trimmed toe²⁰ or hallux harvesting to avoid the classic stump closure. Three surgical maneuvers are performed: (1) transposition of the second toe on top of the proximal phalanx of the hallux, (2) enlargement of the second toe by interposing a flap on its tibial (medial) aspect, and (3) an eponychial flap to increase the nail show.^{21,22}

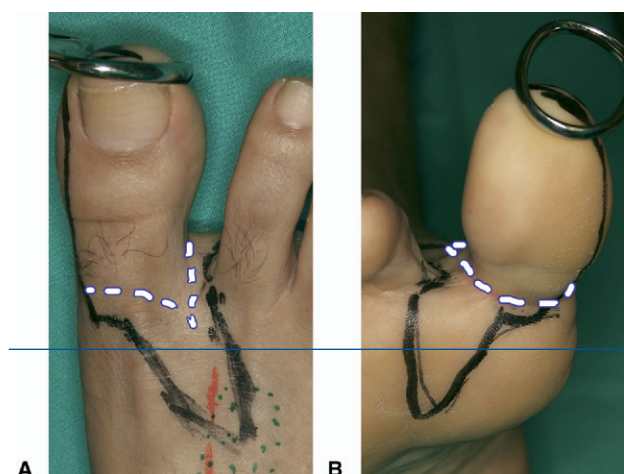


Figure 1. Modifications on the flap's design for trimmed toe harvesting. Classic skin incisions have been marked with a broken white line. The modified harvesting with proximal V flap extensions in black (A) Dorsal (B) Plantar views.

Our purpose is to present the surgical technique and results in 6 patients who had this procedure.

Surgical Technique

The skin markings on the foot are similar to the classic trimmed toe on the medial side, but proximal palmar and dorsal V flaps extension are also included in the lateral side to allow easy transposition of the second toe later in the surgery (Fig. 1). The trimmed toe is elevated as recommended by Wei et al,²⁰ with care taken to maintain the blood supply of the tibial (medial) flap that will be used in step 2. The toe is transferred to the hand after 15 to 20 minutes of reperfusion. To shorten the operative time, usually while the first team of surgeons operates on the hand a second team proceeds on the foot.

Step 1: Second Toe Transposition

The second metatarsal is exposed subperiostally, and an osteotomy is performed on its proximal fourth. It is then elevated distally, detaching all muscular insertions and dividing the intermetatarsal ligaments. On the fibular side care is taken to avoid damaging the second plantar intermetatarsal artery that at times is closely adhered to the plantar aspect of the metatarsophalangeal joint.²³ The base of the proximal phalanx is then exposed subperiostally, and an osteotomy is performed. This allows us to remove *en bloc* the metatarsal-metatarsophalangeal joint with a small segment of neighboring proximal phalanx.

A 3/0 nylon stitch is preplaced for later reconstructing the intermetatarsal ligament. The second toe, now pedicled on the intact second plantar meta-

tarsal-fibular digital vessels, is transposed on top of the proximal phalanx of the great toe. With bone clamps the first metatarsal is approximated to the third. Two crossed K-wires (1.4 mm) are inserted from the medial aspect of the foot, skewering the third metatarsal. Toe fixation is achieved with cross K-wires or Lister's wiring plus an oblique K-wire. The preplaced stitch in the intermetatarsal ligament is then tightened (Fig. 2).

Step 2: Second Toe Enlargement

A midline incision is made on the tibial side of the second toe. The flaps are elevated in the suprapariosteal level up to the dorsal and plantar midline. Great care is taken in the plantar flap to keep the digital nerve intact (Fig. 3A).

The tibial flap that was elevated from the great toe's medial aspect to reduce its size is now interposed in the medial aspect of the second toe, achieving a Y-V enlargement effect (Fig. 3B). Because this flap might have a marginal blood supply if too thinned during toe harvesting, care should be taken to protect it during trimmed toe elevation. During the time the tourniquet is released for toe reperfusion, the blood supply to this flap is carefully assessed. Obviously, if this flap blood supply is doubtful, this second step should be omitted.

Step 3: Eponychial Flap

Adani et al. and Bakhach et al.^{21,22} published a technique to increase the nail show in cases where the fingers have lost a major portion of the nail. We incorporated this technique in the last 4 patients.

Two longitudinal incisions are made following the

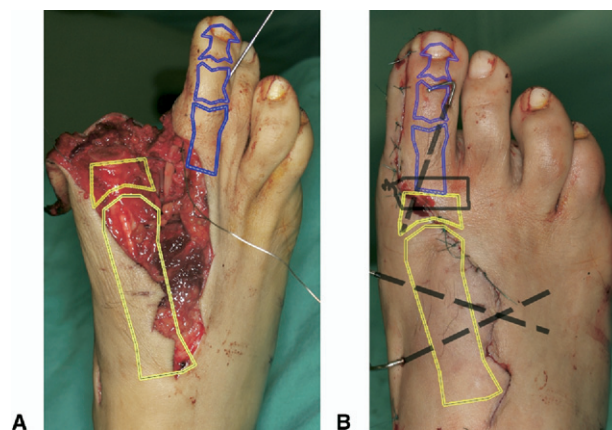


Figure 2. Step 1: second toe transposition. (A) The second metatarsal has already been resected, exposing the flexor tendon to be sutured to the flexor hallucis longus. (B) Immediate postoperative view. The bony framework of the neo-hallux and the fixation hardware are highlighted.

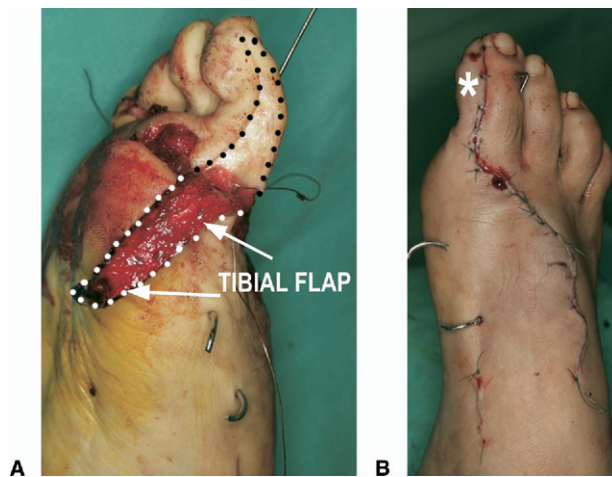


Figure 3. Step 2: Enlargement of the second toe. (A) A mid-line incision has been made on the tibial aspect of the second toe, and the flaps have been partially elevated from the periosteum in preparation for interposing the tibial flap (reflected proximally and highlighted by dots). (B) Immediate postoperative view. (The eponychial flap is pending). (Same patient as in Figs. 1, 2).

line of the paronychial fold deep to the nail plate and then to the bone up to the distal interphalangeal joint (Fig. 4A). Three to 4 mm proximal to the eponychial fold a rectangle of skin is de-epithelialized (Fig. 4B). The eponychial fold is then elevated from the nail plate and mobilized proximally, closing the de-epithelialized area (Fig. 4C).

Additional Procedures

In the cases where the long stumps of the tendons of the great toe (flexor and extensor hallucis longus) were not needed at the hand for carrying the suturing proximal to the wrist, then the corresponding flexor and extensor longus tendons of the second toe were divided and motorized by the great toe tendons. Standard locking stitches were used.

Postoperative Care

Ambulation was permitted on the heel after the second to third day. Unprotected walking was permitted at 4 to 6 weeks, at the time of the K-wire removal. Low-dose heparin was maintained until then.

Results

Six consecutive patients (age range, 29–61 y) had the initial surgery of transferring a trimmed toe to the thumb. All toes survived, although one required an early take-back for arterial insufficiency.

The procedure was modified by including the eponychial flap after patient 2. In 3 patients long flexor and extensor hallucis longus tendons were needed to

perform the repair proximal to the wrist crease in the hand. In the other 3 patients the long flexor and extensor tendons were sutured to the corresponding tendons of the hallux in an attempt to improve the thrust.⁸ No differences were found, although the sample is small and no gait analyses were performed.

Slight valgization was present in all patients at the latest follow-up visit (Figs. 5, 6). We interpreted this as a consequence of separation of the metatarsals, because they retook their original position once the crossed K-wires were removed. One patient developed an early valgization of the second toe. This occurred early after surgery, largely because of an incorrect alignment of the proximal phalanges of the first and second toes during surgery. The deformity had not progressed at the 2-year follow-up visit. The patient rejected a new x-ray at this visit, claiming he had neither pain nor limitation. This patient is an active sportsman and is involved in amateur jogging at the same level as before the surgery.

All patients wear their regular shoes without any special inlays. One patient developed a keloid on the scar in the dorsum of the foot. This was treated by steroid injections with partial improvement.

No limitations on walking or at work were reported (2 patients retired because of the severity of their concomitant hand injuries). Patients were very satisfied with the cosmetic aspect of their feet, and all much preferred this modification to the classic stump closure (Fig. 5).

Discussion

Reducing donor site morbidity is a must in any reconstructive surgery. It is agreed that the great toe gives the best overall results for thumb reconstruction, particularly in multidigital amputations.^{3–6}

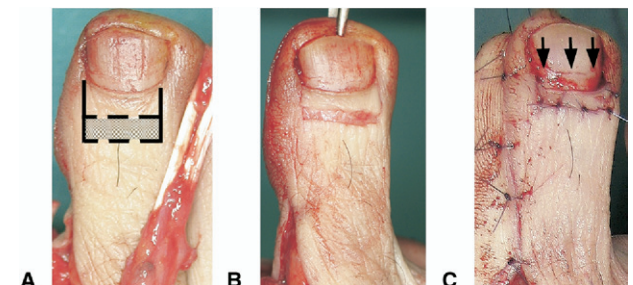


Figure 4. Step 3: The eponychial flap (different patient). (A) The flap design on the dorsum of the second toe. The area to be de-epithelialized is stippled. (B) After de-epithelialization of the flap, the eponychium is prepared for proximal mobilization. (C) The eponychial flap has been sutured proximally. Notice the increase in nail show (previous eponychial level has been marked with arrows).



Figure 5. (A) The result at 1 year of a patient who had the classic technique compared with (B) the result of the patient shown in Figures 1, 2 and 3.

Rather than functional issues, cosmetic morbidity is the major deterrent for its widespread use.

In 1980 Foucher et al¹³ introduced the concept of twisted-two-toes, in which the bony framework of the hallux is preserved *in situ* and the skin of the second toe is wrapped around it. In this way the hallux was preserved in the foot, and some motion was obtained at the IP joint on the transferred toe.^{13–15} Tsai and Aziz¹⁶ proposed a slight modification of Foucher's surgery that allows preservation of all 5 toes. Unfortunately all of these techniques are difficult, involving dissection of 2 free flaps (hallux, proximal interphalangeal joint), and have not gained popularity: only a few cases^{17–19} have been reported.

The second toe has a minimal functional donor site morbidity and nearly no cosmetic defect when the metatarsal is also removed.^{7,8} Unfortunately, it provides the weakest and least cosmetically appealing result when used as a thumb.^{10,15,20,24}

In an attempt to minimize donor site morbidity, Morrison et al¹² introduced the wrap-around technique, which allows preservation of all 5 toes. Problems at the recipient site (eg, bone resorption, fractures, nail instabilities) and at the donor site (eg, ulcerations, hyperkeratosis, pain) have been reported.^{10,15,24,25}

Some motion at the IP joint was thought to be crucial when reconstructing the thumb for restoring the vise grip and also for pinching activities.⁶ This was the basis of the trimmed toe modification introduced by Wei et al²⁰: the hallux is reduced by means of a tibial flap (as in the wrap-around technique),¹² and the tibial aspects of the distal and proximal phalanges are also reduced. This modification achieved a closer-to-normal neothumb with some motion at the IP joint in a much less complicated way than the surgery of Foucher et

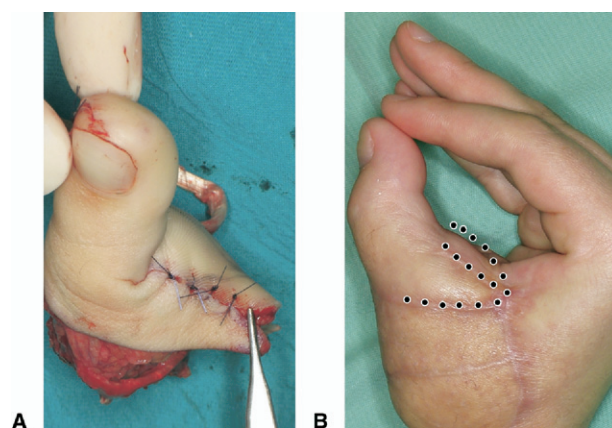


Figure 6. (A) Dorsal and (B) plantar V flaps can be advantageously used to restore the web space.

al^{13–15}; however, the cosmetic appearance at the foot was rather similar to that achieved with the classic hallux transfer (Fig. 5A).

Our modification includes 3 surgical maneuvers. Transposition of the second toe compensates for the hole left after hallux harvesting. The second toe is nevertheless rather small, and by using the tibial flap it is enlarged somewhat. Finally the eponychial flap adds a further cosmetic refinement, achieving a slightly larger nail. More important, the basic principle of not altering the first metatarsophalangeal joint is accomplished, and the second toe ray amputation is reported to have minimal functional consequences.^{7,8} One bonus of our modification is that during toe harvesting a surplus of skin from the foot is included, thus enabling the second toe transposition. These 2 triangular flaps can be used for web reconstruction (Fig. 6).

The procedure has the obvious drawback that a toe



Figure 7. Result at 3 years (no eponychial flap was performed in this very first case).

needs to be amputated, adding further complexity to an already complex surgery. Moreover, compared with our present toe harvesting, in which we use the digital artery or the first metatarsal artery as the donor, a much longer proximal incision is needed to accomplish the proximal metatarsal osteotomy. One patient developed a keloid on the proximal foot scar. Some minor degrees of valguation of the second toe were noted in all, but no alteration of the morphology of the metatarsophalangeal joint was detected by plain radiograms. Although no complaints from the donor site have been reported, neither gait nor functional analysis were performed in our study.

If the hallux is smaller than customary and hence does not require reduction by elevating the tibial flap, or if the tibial flap has a doubtful blood supply after harvesting, the benefit of using the medial flap to enlarge the second toe would not exist. All other maneuvers (toe transposition and eponychial flap) would help the donor foot equally.

This modification may give a wider application to the trimmed toe transfer, the hallux itself, or other variants²⁶ when the great toe needs to be amputated. Such an irrationality for a hand surgeon, such as the inability to wear thong sandals again,⁹ may be sufficient for a patient to reject the hallux as a reconstructive option in an environment such as ours where foot exposure is the norm in summertime, particularly for girls and women (Fig. 7). The functional donor site limitations to date are inconsequential.

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References

- Buncke HJ Jr, Buncke CM, Schulz WP. Immediate Nicolaoni procedure in the Rhesus monkey, or hallux-to-hand transplantation, utilising microminiature vascular anastomoses. *Br J Plast Surg* 1966;19:332-337.
- Cobbett JR. Free digital transfer. Report of a case of transfer of a great toe to replace an amputated thumb. *J Bone Joint Surg* 1969;51B:677-679.
- May JW Jr. Aesthetic and functional thumb reconstruction: great toe to hand transfer. *Clin Plast Surg* 1981;8:357-362.
- Lister GD, Kalisman M, Tsai TM. Reconstruction of the hand with free microvascular toe-to-hand transfer: experience with 54 toe transfers. *Plast Reconstr Surg* 1983;71:372-386.
- Michon J, Merle M, Bouchon Y, Foucher G. Thumb reconstruction pollicisation or toe-to-hand transfers. A comparative study of functional results. *Ann Chir Main* 1985;4:98-110.
- Buncke HJ. Discussion of "reconstruction of the thumb with a trimmed-toe transfer technique". *Plast Reconstr Surg* 1988;82:514-515.
- Frykman GK, O'Brien BM, Morrison WA, MacLeod AM. Functional evaluation of the hand and foot after one-stage toe-to-hand transfer. *J Hand Surg* 1986;11A:9-17.
- Barca F, Santi A, Tartoni PL, Landi A. Gait analysis of the donor foot in microsurgical reconstruction of the thumb. *Foot Ankle Int* 1995;16:201-206.
- Lipton HA, May JW Jr, Simon SR. Preoperative and postoperative gait analyses of patients undergoing great toe-to-thumb transfer. *J Hand Surg* 1987;12A:66-69.
- Wei F-C. Toe-to-hand transplantation. In: Green DP, Pederson WC, Hotchkiss RN, Wolfe SW, eds. *Green's operative hand surgery*. Philadelphia: Elsevier, 2005:1835-1863.
- Gu YD, Zhang GM, Cheng DS, Yan JG, Chen XM. Free toe transfer for thumb and finger reconstruction in 300 cases. *Plast Reconstr Surg* 1993;91:693-700.
- Morrison WA, O'Brien BM, MacLeod AM. Thumb reconstruction with a free neurovascular wrap-around flap from the big toe. *J Hand Surg* 1980;5:575-583.
- Foucher G, Merle M, Maneaud M, Michon J. Microsurgical free partial toe transfer in hand reconstruction: a report of 12 cases. *Plast Reconstr Surg* 1980;65:616-627.
- Foucher G. Twisted two toes technique in thumb reconstruction. In: Landi A, ed. *Reconstruction of the thumb*. London: Chapman, 1989:275-279.
- Foucher G, Binhammer P. Plea to save the great toe in total thumb reconstruction. *Microsurgery* 1995;16:373-376.
- Tsai TM, Aziz W. Toe-to-thumb transfer: a new technique. *Plast Reconstr Surg* 1991;88:149-153.
- Yu Z-J. thumb reconstruction. In: Yu ZY, ed. *Microvascular surgery of the extremities*. Berlin: Springer-Verlag, 1993:85-174.
- Iglesias M, Butron P, Serrano A. Thumb reconstruction with extended twisted toe flap. *J Hand Surg* 1995;20A:731-736.
- Koshima I, Kawada S, Etoh H, Saisho H, Moriguchi T. Free combined thin wrap-around flap with a second toe proximal interphalangeal joint transfer for reconstruction of the thumb. *Plast Reconstr Surg* 1995;96:1205-1210.
- Wei FC, Chen HC, Chuang CC, Noordhoff MS. Reconstruction of the thumb with a trimmed-toe transfer technique. *Plast Reconstr Surg* 1988;82:506-515.
- Adani R, Marcoccio I, Tarallo L. Nail lengthening and fingertip amputations. *Plast Reconstr Surg* 2003;112:1287-1294.
- Bakhach J, Demiri E, Guimbeteau JC. Use of the eponychial flap to restore the length of a short nail: a review of 30 cases. *Plast Reconstr Surg* 2005;116:478-483.
- Foucher G, Norris RW. The dorsal approach in harvesting the second toe. *J Reconstr Microsurg* 1988;4:185-187.
- Wei FC, Chen HC, Chuang CC, Chen SH. Microsurgical thumb reconstruction with toe transfer: selection of various techniques. *Plast Reconstr Surg* 1994;93:345-351.
- Doi K, Hattori Y, Dhawan V. The wrap-around flap in thumb reconstruction. *Tech Hand Up Extrem Surg* 2002;6:124-132.
- Upton J, Mutimer K. A modification of the great-toe transfer for thumb reconstruction. *Plast Reconstr Surg* 1988;82:535-8.