

Onycho-Osteo-Cutaneous Defects of the Thumb Reconstructed by Partial Hallux Transfer

Francisco del Piñal, MD, PhD, Eduardo Moraleda, MD, Guillermo H. de Piero, MD,
Jaime S. Ruas, MD, Carlos Galindo, MD

Purpose To present our experience in distal thumb amputations reconstructed by partial toe to hand transfers with special emphasis on manual workers.

Methods Twenty-five patients who experienced amputation of the thumb distal to the interphalangeal joint, excluding pure soft tissue losses, were included in the study. All but 2 were manual workers. Twenty were reconstructed within 2 weeks after injury. The other 5 were referred late. In all patients, the ipsilateral hallux was used as donor, based on the proper digital artery (18 cases), the intermetatarsal artery (6 cases), and the dorsalis pedis artery (1 case).

Results All transferred flaps survived. At a minimum follow-up of 1 year (range, 1–14 y), active range of motion at the interphalangeal joint was more than 55° in 23 patients. Two had an interphalangeal joint arthrodesis, 1 of them before referral. Pinch and grip were similar to the contralateral side. Two-point discrimination was normal in the dorsal oblique amputations and 7 to 11 mm in the rest. Patient satisfaction was high from a functional and aesthetic standpoint (9.5 out of 10 on a visual analog scale for both outcomes). All patients returned to work 2 to 4.5 months after the operation. Delayed donor site healing was noticed in 4 cases.

Conclusions In contrast to classic teaching that recommends stump closure for cases of distal thumb amputation, we attained excellent results with partial toe transfer in manual workers. In our experience, the thumb can be restored to nearly normal with an acceptable donor site sequela. The best indication is for cases of dorsal oblique amputations, because thumb sensibility is unaffected, and for amputations where the germinal matrix is preserved, because nail regrowth occurs. Early transfer is strongly recommended. (*J Hand Surg Am.* 2014;39(1):29–36. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Therapeutic IV.

Key words Microsurgery, thumb amputation, toe-to-hand transfer, mutilated hand.

From the Instituto de Cirugía Plástica y de la Mano, Private Practice and Hospital Mutua Montañesa, Santander, Spain.

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Corresponding author: Francisco del Piñal, MD, PhD, Private Practice and Hospital Mutua Montañesa, Instituto de Cirugía Plástica y de la Mano, Paseo de Pereda 20-1, E-39004 Santander, Spain; e-mail: drpinal@drpinal.com or pacopinal@gmail.com.

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THE BENEFIT OF RECONSTRUCTING proximal thumb amputations with hallux transfer is undisputed.^{1–4} However, the operation may be unjustified if the amputation is distal to the interphalangeal (IP) joint.^{5–7} Adani et al⁸ reported 4 cases in which satisfactory results were obtained for amputations distal to the IP joint. Shibata et al⁹ presented their experience in vascularized toenail transfer. However, others¹⁰ consider this type of distal reconstruction appropriate only for musicians.

A salutary effect when reconstructing small finger defects with second toe transfer has been reported.¹¹ In this same line of reasoning, minimized impairment in laborers has also been noticed when reconstructing amputations distal to the proximal interphalangeal joint with toes.¹²

The aim of this study was to present the surgical details and outcomes in 25 patients (23 of whom were heavy manual workers) who experienced amputations of the thumb distal to the IP joint (Fig. 1) and who were reconstructed with custom-fashioned hallux transfer. With this approach, restitution is excellent and high satisfaction is to be expected.

MATERIALS AND METHODS

Of a consecutive experience of 348 toe-to-hand transfers performed by the first author, with 3 failures, 29 transfers were done for 29 patients with distal onycho-osteo-cutaneous defects of the thumbs. Of the latter, 25 consecutively reconstructed thumbs with a minimum follow-up of 1 year were included in this study. Excluded from this group were patients who had soft tissue defects only, even when reconstructed with portions of toes.

There were 22 men and 3 women. The average age was 31 years (range, 16–49 y). The dominant hand was involved in 16 cases. All were mechanical injuries. Two patients were students. The others had work-related injuries from heavy work (10 construction workers, 6 punch press operators, 4 carpenters, 1 farmer, 1 truck driver, and 1 stone carver). All workers were covered by workers' compensation, and the 2 students were involved in litigation because of the mechanism of injury (a road traffic accident and a horse-riding rope injury).

In all cases, a part of the nail, a segment of the distal phalanx, and a portion of the pulp were missing. The thumb germinal matrix was totally or partially preserved in 9 cases; in 2 of these, a lateral or medial segment of the sterile matrix was also present. The rest had complete nail loss except for eponychium remnants in some. The base of the distal phalanx was preserved in all: 3 were fractured. One patient was referred with a painful, failed fusion of the IP joint.

The injury in 23 patients was limited to the thumb, whereas the remaining 2 had different degrees of damage to the other fingers. Five patients came for assessment more than 2 weeks after the accident, with their stumps total or partially closed. Two of them had had previous failed treatment with local flaps.

At the latest follow-up visit (1–14 y after the injury), active range of motion, pinch and grip strength, Patient-Rated Wrist–Hand Evaluation score, and dexterity tests (Moberg pickup test and 9-hole peg test)¹³ were administered to the involved and healthy hand, which served as a control. Patients were asked to rate their satisfaction with the appearance of the thumb and the foot on a visual analog scale (0 = worst and 10 = best). To assess the impact on the foot, we also administered the American Orthopaedic Foot and Ankle Society questionnaire for hallux.

Our institution does not require institutional review board approval; however, all patients were aware of the treatment aims, understood the risks and possible benefits, and were aware of other reconstructive alternatives.

Surgical technique

The operation was scheduled as soon as feasible; in most cases (16 patients), it was within a week after injury. High priority was given to 2 patients who were seen emergently with intra-articular fractures of the base of the distal phalanx, and who were treated 3 days after the accident.

Except for donor site closure, the first author carried out all procedures. As a rule, the thumb defect was assessed first. Debridement and bony stabilization when an articular fracture existed were done first (1 screw in 2 patients and a tension band in the other). Thumb pulp skin was not resected. We also were conservative when debriding the nail matrix, but when the entire germinal matrix had been lost and only the eponychial fold remained, this was resected to accommodate the hallux nail fold and to avoid leaving thumb nail remnants.

In all cases, the ipsilateral hallux was the donor site. This permitted the dominant artery and nerve to be oriented along the medial side. The flap was designed to fit the defect. In all cases, dissection was started by isolating the veins. Vein harvest technique varied depending on the level of nail transferred. The inclusion of the whole nail greatly facilitated harvesting, because large dorsal veins forming proximal to the eponychial fold could be included (Fig. 2). Harvesting of a partial nail obliged us to dissect the tiny veins of the lateral aspect of the pulp that are minute, fragile, and easily torn (Fig. 3). In both cases, some blood in the vein greatly facilitated dissection; hence, we applied the tourniquet without applying an Esmarch bandage.

Regarding the arteries, except in the early cases where the dissection went proximally to the dorsalis



FIGURE 1: Exemplary case of the series: distal amputation to the IP joint in a construction worker. **A** Status before debridement. **B** Posteroanterior x-ray taken in the emergency department.



FIGURE 2: A multitude of veins were available and were easily harvested when the whole nail was to be included.

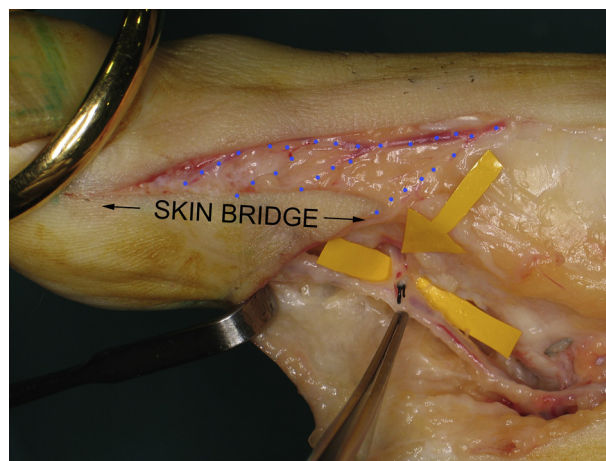


FIGURE 3: A portion of the pulp has to include a skin bridge to preserve the tiny and fragile veins in the skin bridge that drain into the larger dorsal veins (blue dots).

pedis artery (1 case), the donor was a segment of intermetatarsal artery (6 cases) or the lateral digital artery (18 cases). The digital artery was dissected from the proximal edge of the flap and traced proximally to its origin. This gave enough length for a comfortable anastomosis to the ulnar digital artery at the thumb. More recently, only a short segment of the toe's lateral digital artery was dissected, and the anastomosis was carried out at the edge of the amputation. Utmost care was taken to identify, isolate, and ligate a constant branch proximal to the

neck of the proximal phalanx. If it is missed or avulsed, the blood supply to the transfer may be endangered (Fig. 4).

A segment of the lateral digital nerve was always included, and depending on the size of the toe pulp harvested, a part of the medial digital nerve was also included. The pulp was reflected off the distal phalanx, and the bone was trimmed in the sagittal and coronal planes (Fig. 5).

Bony fixation was done with 2 or 3 Kirschner wires, and the vessels were passed under subcutaneous

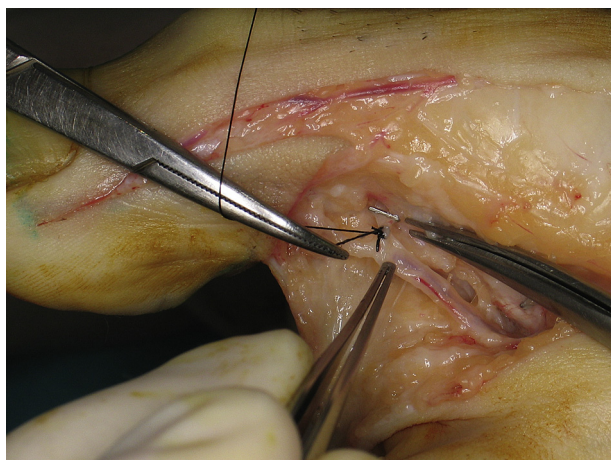


FIGURE 4: Isolation and ligation of the transverse digital artery arch before being divided just proximal to the neck of the toe proximal phalanx.

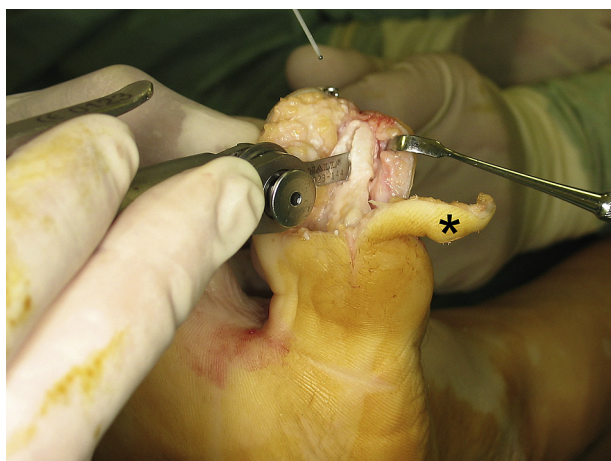


FIGURE 5: The medial third of the distal phalanx of the hallux is being excised. Trimming of the plantar surface of the bone is also needed to reproduce the shape of the thumb. Notice that this leaves a larger medial flap (asterisk) for later use as an advancement flap to close the toe defect (same patient as in Figs. 1, 6, and 9).

tunnels to minimize scarring. Revascularization was usually carried out by end-to-end anastomoses with 10-0 nylon on a 100- μ m needle. A single artery and a single vein were anastomosed in every case. Following our empiric protocol in toe transfer, patients were given a continuous perfusion with heparin 500 U/h for 2 days, reduced to half for another 2 days, and then given subcutaneous heparin for 2 weeks.

The donor site was closed by a V-Y advancement flap from the medial side. When the whole nail was elevated, we used the same type of flap to cover the bone plantarly and distally, and we found that a skin graft on top of the periosteum gave a naillike appearance (Fig. 6). In an early case, a cross-toe flap



FIGURE 6: A facsimile of a nail is provided for cases of total nail transfer by placing a skin graft on the periosteum of the distal phalanx (same patient as in Figs. 1 and 9).

was used. Ambulation was permitted immediately after the surgery, although foot elevation was advised until the toe was totally healed.

In the thumb, active range of motion of the IP joint was started at 3 to 4 weeks, when the Kirschner wires were removed. Assisted exercises were added once the union was solid (usually after 5–6 wk). Night splinting with aluminum splints to improve extension was prescribed for several months.

RESULTS

Arterial insufficiency was detected in 1 patient 48 hours after the operation. Release of a fascial band that was kinking the artery under a skin bridge resolved the problem. We noticed that closure of the medial aspect of the thumb frequently had to be released. This is because the skin of the worker's thumb was heavily keratinized and did not yield, and hence was unable to accept swelling. Thus, after 5 to 10 minutes of reestablishing the flow to the toe, as swelling increased, sluggish flow appeared in the toe. This problem was best prevented by inserting a small triangular skin graft for closure (Fig. 7).

All bones united without complications, except for a patient with an intra-articular fracture of the distal phalanx referred 19 days after the accident, who



FIGURE 7: Early vascular compromise caused by compression of the pedicle by the unyielding thumb skin can be prevented by a small triangular skin graft (white dots) taken from the instep. Letters correspond to the location of the neuroorrhaphy (n) and the arterial (a) and venous (v) anastomoses.

experienced septic arthritis. Debridement of the sequestra, minimal debridement of the hallux and head of the proximal phalanx, and installation of an external frame with compression achieved fusion.

Active motion of the IP joint averaged 62° (range, 55° to 95°), except in 2 patients who had an arthrodesis (1 after an infection and 1 referred with a painful failed fusion). Two of 3 with intra-articular fractures of the base of the distal phalanx achieved active motion of 85° and 65° , whereas the third mentioned previously ended in fusion. Key pinch was 96% of the contralateral side (80% to 115%), and grip strength averaged 97% of the contralateral hand, except in the patients with multi-digital injuries (80% and 88%). The Patient-Rated Wrist-Hand Evaluation score averaged 3.5 (range, 0–13). Patients who fared the worst were the 2 with multi-digital injuries (scores of 11 and 13). Two-point discrimination was tested when a major portion of toe pulp was transferred (22 cases) and ranged from 7 to 11 mm. Dexterity testing yielded similar results of 96% (range, 90% to 123% of the contralateral side). Patients with arthrodesis or with multi-digital injuries scored worst, although the numbers were insufficient to draw conclusions. Patients rated the cosmetic result on a visual analog scale as 9.5 (range, 8–10). One patient had a moderate nail deformity in our opinion, but he graded the result as a 10.

Delayed healing of the donor toe occurred in 4 cases owing to necrosis of the tip of the advancement flap. All healed by secondary intention by patient's self-care in less than 2.5 months. No patients in the series had problems with walking, nor did they

require special shoes or orthoses. Satisfaction was high regarding the foot donor site. The patients rated the appearance on a visual analog scale as 9.1 (range, 7–10) and an average score of 94 of 100 on the American Orthopedic Foot and Ankle Society score at last follow-up.

All patients resumed their previous work without limitations 2 to 4.5 months after the operation. Secondary pulp reduction was done in 2 patients.

DISCUSSION

Restitution of the thumb integrity has several salutary effects. Besides the fact that mutilation may have psychological implications, loss of the distal part of the thumb is a functional handicap. Indeed, although it is said that amputations distal to the IP joint are "compensated,"^{6,7} our experience is different. In an unpublished study in 6 patients with amputations of the thumb at or distal to the IP joint, we found that the Moberg pickup test and the 9-hole peg test¹³ were performed more than a third slower than with the contralateral side. Furthermore, patients on average rated the appearance of their hand to be 3.5 out of 10 on a visual analog scale (where 0 = extremely deformed and 10 = normal), and 5 of the 6 patients expressed worry when in public, and concealed their hand. Functionally, the lack of nail compromises any nail pinching and picking up small objects becomes difficult. Finally, the locking effect of the thumb distal phalanx (the so-called vice grip, as termed by Buncke and Valauri¹⁴) is also lost. Conversely, all of our patients had a nearly functional restoration, both objectively and subjectively. Despite being covered by workers' compensation insurance, all returned to their original jobs. The longest work absence was for the 2 patients who had multi-digital injury and for the 1 who had an arthrodesis resulting from infection.

Partial hallux transfer is a sophisticated operation that can provide a thumb replica, but it is not indicated for every amputated thumb. Although we do not make distinctions for age or smokers, the presence of a fringe of 2 to 3 mm of healthy sterile matrix is managed with a volar flap for the pulp and an eponychial flap to increase the nail plate exposure.^{15,16} When the sterile matrix is completely lost, however, the resulting nail plate will grow un-adhered. Minimal trauma will lift the nail plate off its bed, causing pain and hemorrhage. Primary nail bed excision and closure with or without a flap is recommended here.¹⁷ Contrarily, in this specific scenario, we have achieved excellent cosmetic and functional results with



FIGURE 8: Excellent appearance of the hand and foot can be achieved when part (or all) of the germinal matrix is preserved in the thumb stump. **A** Preoperative status. **B** Custom-fashioned flap. **C** Results at 2 years. **D** Foot appearance at 2 years.

minimal morbidity in the foot by partial hallux transfer. Indeed, preservation of the germinal matrix in the hallux provides some nail growth in toe, reducing the cosmetic price paid at the foot (Fig. 8).

Dorsal oblique amputations of the thumb with total nail loss and a minimal amount of pulp tissue loss are also ideally suited for partial hallux transfer. This group fared the best functionally, with the shortest



FIGURE 9: A direct transfer will look grotesque in distal reconstructions. Considerably bony work needs to be done to reduce the size of the hallux to obtain a closer thumb replica (same patient as in Figs. 1, 5, and 6).

discharge time (3 cases, 9 weeks on average). This is because once the bone was healed, they could be discharged without limitations, as most of the pulp will have normal sensibility. Technically speaking, the surgery for this group was the easiest because the complete nail was included in the transfer and dissection of the veins was uncomplicated. Conversely, the hallux nail was lost, and the donor site fared worse.

The procedure has been much simplified over the years. Elevation of a custom-fashioned hallux flap now takes between 30 and 40 minutes of tourniquet time, and the whole procedure takes around 3 hours. Several areas have been simplified. Our choice of artery is now always the proper digital artery close to its division in the web. This minimizes the amount of damage inflicted on the foot and, above all, dissection time. This length of vessel allows for an uncomplicated anastomosis at the base of the thumb, an area usually free of scar in these patients. When the ulnar digital artery is scarred, our policy is to isolate the proximal segment of the radial digital artery of the index and swing it to the base of the thumb at the metacarpophalangeal joint level, although this proved unnecessary in this group of patients. The length of the dissected vein is just a little bit longer than the artery. Usually, good veins for anastomosis are located in the distal aspect of the first web. The distal toe veins are extremely thin-walled, and they are more easily identified when they are partially filled

with blood. In any case, dissecting the veins is the trickiest part of the whole operation.

The cut in the toe phalanx is carried out no farther distally than the proximal edge of the sterile matrix. In previous experiences with pure wraparound hallux, we, like others,¹⁸ noticed that subperiosteal dissection of the sterile matrix carries the risk of abnormal nail growth. As a matter of fact, the only instance of dystrophic nail in our current series had that part of the sterile matrix transferred without bone.

We have always used the hallux as donor. In our view, the second toe has no role for distal reconstructions. It is too slender and the nail is too small to mimic the thumb. Conversely, the hallux is usually far too large. A direct transfer without modifications may be acceptable for proximal amputations,^{4,14} but it will look grotesque in distal reconstructions (Fig. 9). Reduction of the bone in the coronal and sagittal planes minimizes the need for coverage and allows preservation of a larger medial flap, thus facilitating closure in the foot. Resection of the medial portion of the distal phalanx gives the illusion of a narrower nail.¹⁹

We strongly recommend early treatment of distal amputation for the sake of preservation of exposed tissues,²⁰ but above all, for smooth and easy surgery. Our low complication rate does not reflect how difficult things become when the reconstructions are done late in toe transfer surgery: for example, scarring, unyielding tissue, and arteries that, despite

the good appearance, go into unremitting spasm. Conversely, early coverage allowed us to preserve motion in 2 cases of intra-articular fracture of the base of the distal phalanx and in several cases with exposed flexor pollicis longus insertions. Some of those cases could have been salvaged by temporary flaps, which at a minimum would have added more scarring.

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