Ischemic Toe Encountered During Harvesting: Report of 6 Cases

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Local vessel disease causing lack of arterial inflow at the time of toe harvesting represents a surgical emergency. In a personal experience of 194 toe transfers to the hand, 6 cases (in 4 patients) were found to have diseased vessels at the first web to the point that acute ischemia of the toe occurred when the tourniquet was released at the lower limb. We report our experience in these 6 cases. *(J Hand Surg 2008;33A:1820–1825. Copyright © 2008 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Arterial damage, microvascular surgery, mutilating hand injuries, thrombosis, toe to hand.

Toes can be transferred to the hand in busy microsurgical centers with a minimal risk of failure. Currently, 96% to 99% success rate is the norm.[1–4] Most failures in the early days were due to faulty technique and/or lack of understanding of the variable local anatomy.[1,5–7] Nowadays, systemic conditions, such as hypercoagulability, or unremitting spasm are the main causes when a microvascular case fails.[1,8–11]

It is frequent that the toe, once fully dissected and pedicled on the vessels, takes few minutes to reperfuse after the tourniquet is released at the lower limb. However, the issue of the toe that does not show any capillary refill or only a sluggish circulation while still pedicled on the donor vessels is rare. We report our experience with ischemia of the harvested toe in 6 cases.

CASE REPORTS

From February 1995 to February 2008, the first author has carried out 194 toe-to-hand transfers with a success rate of 99%. All transfers were performed after amputations, mainly after work-related injuries. Patient age ranged from 6 to 66 years. Six toes (in 4 patients) were found to have local arterial disease to the extent that the first web vessels did not provide arterial inflow to the toe. This group constitutes the body of this study (Table 1). Two additional toes from 2 of the patients had adequate arterial inflow to the harvested toe when transferred at subsequent operations.

All 4 patients were manual workers and injured at work. They all suffered severe injuries: one an acute metacarpal hand, another 4 finger amputations, the only woman a massive burn injury with an avulsing component, and finally one patient, referred secondarily for reconstruction, who sustained bilateral mutilating injuries. Three of the patient, treated acutely by our team, had the reconstruction early.

Patients were cleared by anesthesia and rated as minimal or no anesthetic risk. Average age was 53 years (range, 47 to 59 years). Two of the patients, however, had, apart from age,[12] comorbidities known to affect the blood vessels: both were former heavy smokers and one of these patients was obese with unknown arterial hypertension. All operations were carried out under continuous axillary and epidural blocks and proceeded uneventfully from an anesthesiology standpoint.

Our 6 cases can be divided into 2 groups depending on whether they had or had not preserved a secondary arterial inflow pathway during the toe dissection (ie, whether they had another artery dissected as a backup).

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Received for publication March 13, 2008; accepted in revised form June 17, 2008.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/08/33A10-0021$34.00/0
doi:10.1016/j.jhsa.2008.06.016

Group 1 had no alternative pathway available, whereas group 2 had a backup vessel connected but clamped at the foot. In our first group, with 3 cases (cases 1–3), sluggish or no flow at the toe was noticed when the tourniquet was released at the lower extremity. This status did not improve after local warming, topical vasodilator (verapamil), systematic search of untied side branches, and after sufficient time had elapsed to relieve any vasospasm. As no cause was apparent, and to avoid any further prolongation of warm ischemia time, the toe was transferred to the hand and attempts were made to revascularize it there. In cases 1 and 2, after releasing the clamps at the hand, the toe did not reperfuse appropriately. Both patients (patients 1 and 2) had atherosclerotic changes at the first web vessels: hardened vessels, fatty streaks, and plaques. Compromised donor vessels were immediately evident. Our first patient had had a combined hallux hemipulp–second toe transfer a week before and no reperfusion problems were noticed at the time (although the vessels were similarly affected). In this second operation, as the anastomosis seemed patent but no capillary refill was noticed at the toe, the adventitia was dissected off the first plantar metatarsal artery all the way to the tibial digital artery. A clear stop was found at the tibial digital artery level (Fig. 1). The digital artery was opened and a hard gritty whitish substance was found inside the lumen. A 5-mm segment of digital artery was resected, and an end-to-end anastomosis restored the flow to the toe without further complications.

Case 2 had a plantar dominant system, and a vein graft had been planned to reach the radial artery. The anastomosis was difficult because the donor artery was hard and the intima separated from the media collapsing into the lumen. Despite flow through the graft, the distal anastomosis was not patent. Resection of the first plantar metatarsal artery was progressively done until a "healthy" segment was found to carry out the anastomosis, this time without any event. Three months later this patient (patient 2) had a complex reconstruction of his contralateral hand by a tandem second and third toe transfer combined with a free perforator flap in 1 stage. For this transfer, a triple arterial inflow was harvested, immediate capillary refill was noticed, and the transfer proceeded uneventfully.

In case 3, an alternative artery had also been dissected at the toe (a short stump of second plantar metatarsal) but clipped during elevation, so it could not be used during reperfusion at the foot. When transplanted at the hand, both arteries were anastomosed: the tibial digital artery was friable and no lumen could be seen and proved extremely difficult to anastomose. No flow was seen passing through; however, the operation was terminated as the other artery seemed sufficient.

The second group, also composed of 3 cases (cases 4 and 5, including 1 second toe belonging to a patient of the former group [case 4, patient 3]), was suspected to have unusable vessels during the dissection (Fig. 2). At the time of dissection in the first web space, the tibial digital artery was unidentifiable and replaced by a kind of scarred tissue, whereas the nerve was clearly identified. These findings were common to all cases of this group. An alternative inflow pathway was then searched and preserved during harvesting: a contralateral second plantar metatarsal artery (Fig. 3), a second dorsal metatarsal artery, and a tiny dorsal digital artery in 1 case each. These were clamped at the time of tourniquet release, and after sufficient time elapsed to prove that the main vessels had no flow, the clamps were released. Immediate flow was noticed in all toes when this alternative pathway was unclamped.

Both patients of this group (patients 3 and 4) were nonsmokers, and apart from age[12] they had no comorbidity affecting blood vessels. They both received 2 second-toes each (one of them a hemipulp flap), and in every case the local findings were similar. At the tibial digital artery, the vessel was unidentifiable (see Fig. 2). The pathology report of 1 case was media hyperplasia (Fig. 4). In our first experience with this entity (case 3), this problem was not sufficiently understood, and the second web vessels although dissected were clipped. The toe remained ischemic at the foot, and at the hand the second web vessels proved to be the good ones.

In the second group of 3 toe transfers, where the digital artery at the level of the branching from the metatarsal arteries were hardly discernible, alternatives routes of arterial inflow were sought and not clipped. In 2 cases, the fibular digital artery extended proximally by the second plantar or dorsal metatarsal artery or a tiny dorsal digital artery (1 case) were used as arterial inflow.

At the time of clamp release, all patients received a bolus of 1500 U heparin and for the first 48 hours received heparin at a rate of 750 U/ hour. The perfusion with heparin was reduced progressively over the ensuing 48 hours. All toes survived without complications or reoperations.

DISCUSSION

Currently, we harvest our toes by using as donor the digital artery proper or a short stump of the dominant first metatarsal artery. We initially locate the digital artery at the proximal part of the toe and track it back as required. We do so as this speeds up dissection time, and we have also found less spasm after release of the

TABLE 1. Demographics and Surgical Details

Case No.	Patient No.	Age (y)	Comorbidities	Injury	Transfer	Timing
1	1	47	Former smoker	Metacarpal hand	Second-toe fasciosubcutaneous	10 d
2	2	47	Former smoker/ hypertension/ obesity	Bilateral multilating injuries	First-trimmed toe	5 mo
3	3	58	—	Four-finger amputation at PIP joint	Second toe	7 d
4					Second toe	14 d
5	4	59	—	Severe burn + avulsion	Second toe hemipulp	1 d
6					Second toe wrap-around	6 d

PIP, proximal interphalangeal; FPMA, first plantar metatarsal artery; SPMA, second plantar metatarsal artery; SDMA, second dorsal metatarsal artery; RA, radial artery; VG, vein graft; PCDA, common palmar digital artery. In parentheses, the type of anastomoses; E-E, end-to-end; E-S, end-to-side; dig, digital.

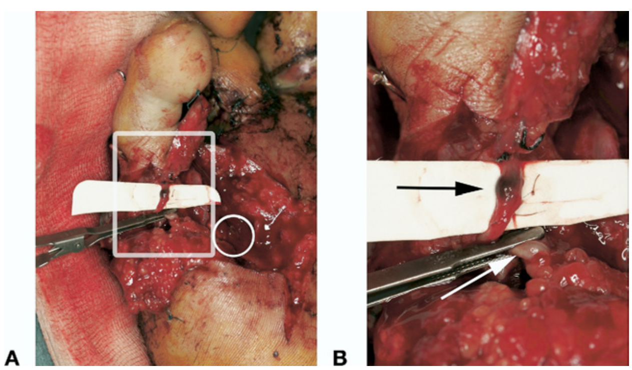

FIGURE 1: A The white circle highlights the anastomosis at the palm. **B** An embolus can be seen lodged in the tibial digital artery (black arrow). Atherosclerotic changes (fatty streaks and plaque) can be seen in the first plantar metatarsal artery (white arrow). The clamp is located just distal in a "healthy" area.

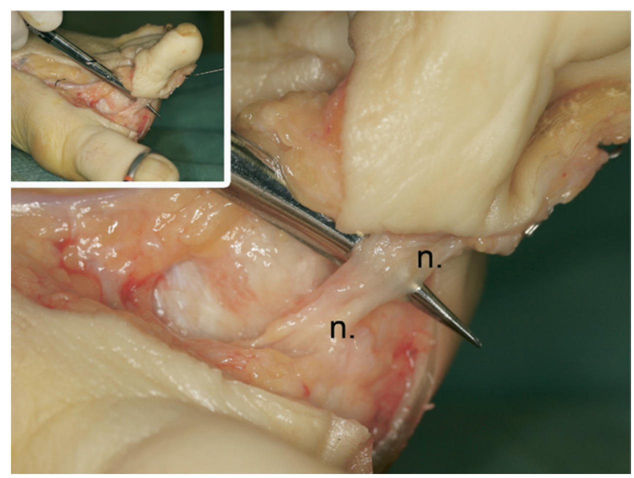

FIGURE 2: Patient 4: Although the digital nerve is clearly seen (n.), the digital artery is barely discernible at this level and proved to carry no flow to the toe when the tourniquet was released. (Inset, corresponding panoramic view.)

tourniquet when the dissection is limited. Additionally, except under rare circumstances (avulsions-crush), recipient vessels are available very close at the stump in the hand so there is no need for a long pedicle. The vessels are rather small, and as a safety measure we usually dissect a short stump of the contralateral digital artery that is clipped and cut. This backup vessel can be used later as double inflow if local vessels are available or just discarded. Even if we have to resort to this second anastomosis, the total operating time can be kept to around 3 hours, most of the time being spent on the bone and tendon work.

If one begins the arterial dissection distally, at the take-off of the digital artery in the first web, the problematic cases will become immediately evident. Sometimes the vessel will not be discernible out of the fibrosis (Fig. 2) and in others the atherosclerotic changes will be noticed (Fig. 1). To avoid the critical situation of an "ischemic toe at the foot" that we had in our earlier experience, we have modified our dissecting protocol. When a potentially problematic patient is scheduled for a toe transfer, we recommend (Fig. 5):

- Dissect alternative inflow pathways. For example, in the case of the second toe, we usually use the first web vessels but the peroneal digital artery and/or its parent vessels (second plantar or dorsal metatarsal arteries).

TABLE 1. Demographics and Surgical Details (Continued)

Dissected Vessels	Reperfusion at the Foot	Artery Donor ⇒ Recipient	Reperfusion at the Hand	Finding	Management
FPMA ⇒	Sluggish to none	FPMA ⇒ Fourth PCDA (E-E)	None	Distal emboli	Extraction + end to end
FPMA ⇒	None	FPMA ⇒ VG ⇒ RA (E-S)	None	Plaque in FPMA	Resection + reanastomosis
Tibial dig ⇒	None	SPMA ⇒ Digital a (E-E)	Immediate	—	None
Tibial dig ⇒ SPMA ⇒	None Immediate	SPMA ⇒ Digital a (E-E)	Immediate	—	None
Tibial dig ⇒ Dorsal dig ⇒	None Immediate	Dorsal dig ⇒ Digital (E-E)	Immediate	—	None
Tibial dig ⇒ SDMA ⇒	None Immediate	SDMA ⇒ Digital a (E-E)	Slow	Spasm in recipient	Topical verapamil

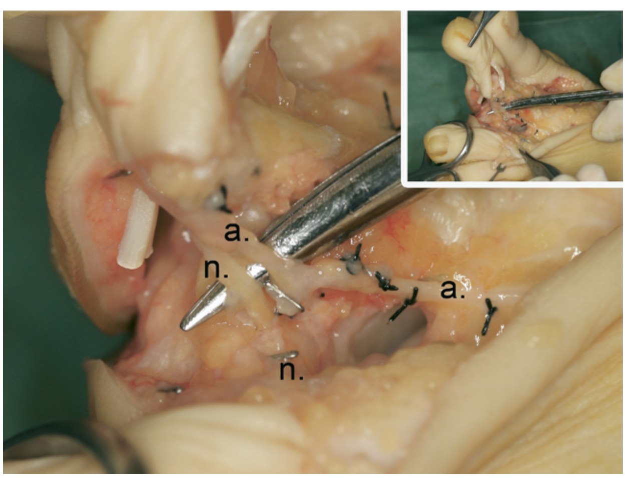

FIGURE 3: On the second web space, healthy vessels can be seen (same case as that of Fig. 2). Under the tip of the scissors, the fibular digital artery extended proximally by the second dorsal metatarsal artery can be seen (a) and also the digital nerve (n). (Inset, corresponding panoramic view.)

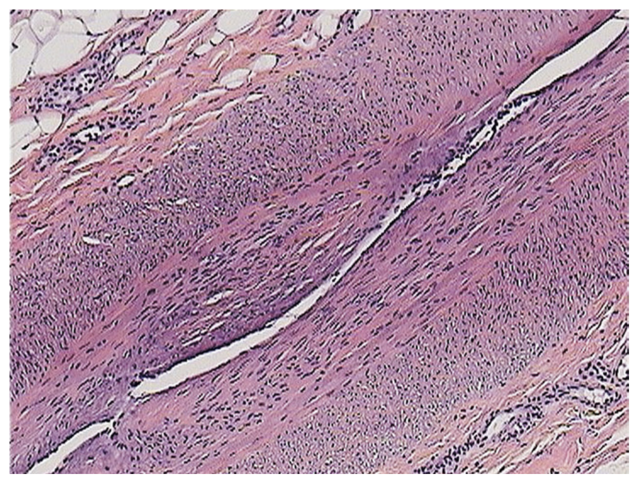

FIGURE 4: Pathology specimen corresponding with the tibial digital artery of patient 4. Notice the medial hyperplasia and the reduction of the lumen diameter in this longitudinal section of the artery (macroscopic view in Fig. 1). (Hematoxylin-eosin stain, magnification ×20.)

- Even if it is cumbersome during the dissection, keep the toe connected by the alternative vessels until after the tourniquet has been released and the main vessels have proved to be competent. In this way, the alternative vessels can serve as a lifeboat.
- Leave the stumps of the important arteries 3 to 5 mm long, as they may be used for inflow if the selected artery does not work. For example, if the hallux is being harvested with the first dorsal metatarsal artery as its pedicle, tag the stump of the plantar metatarsal vessels and the tibial digital artery of the second toe. These stumps may be needed later for inflow. (We have had to resort to these alternative vessels more than once, although not in this group of patients.)

If for whatever the reason one is faced with an "ischemic toe at the foot," we recommend exploration for local problems such as untied branches and trying to relieve spasm with toe warming, topical verapamil (a vasodilator), and if this fails adventitia stripping. If all these measures fall short, we advise proceeding immediately to toe transfer to the hand to shorten the already long ischemia time. As explained previously, anasto-

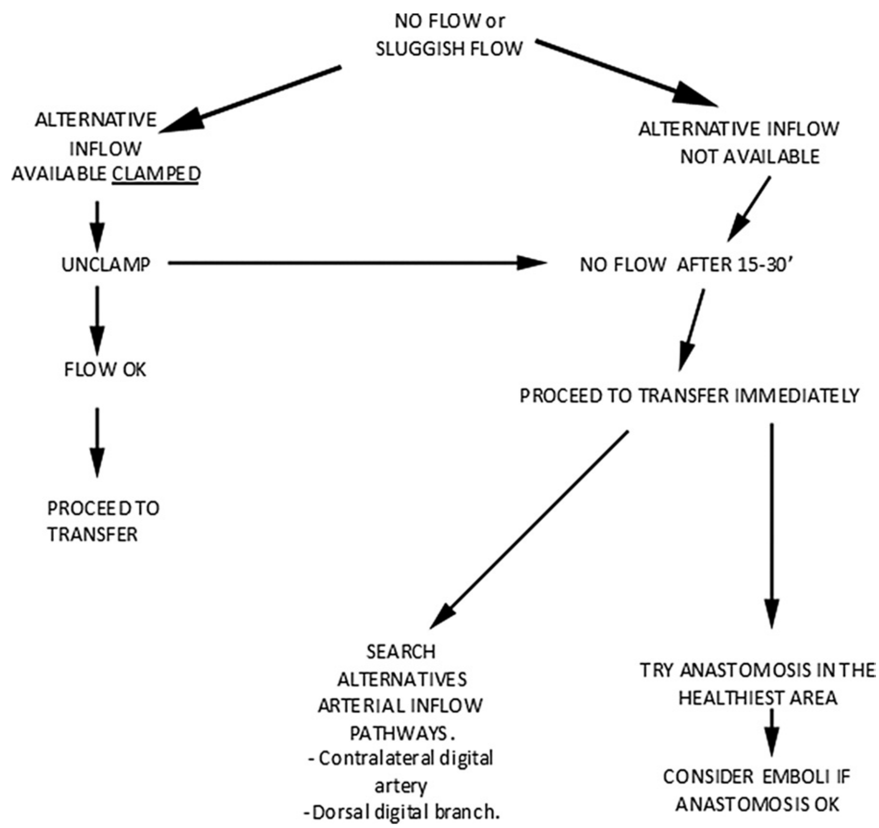

FIGURE 5: Management of the ischemic toe at the foot with and without alternative arterial inflow available.

mosis to the healthiest part of the vessel, a search for alternative pathways, and dismissal of rare causes such as an embolus are carried out. Vein grafts should be used as required.

Microvascular management of damaged vessels has been discussed in the literature, as dealing with atherosclerotic vessels at the lower limb[13–16] or radiated vessels at the neck[17] is not infrequent. When atherosclerosis is found, it is best to repair the vessel where no plaques are present.[18,19] Even if an artery is found without atheromata, detachment of the intima as in radiotherapy is quite common. The lumen is full of a mushy tissue that corresponds with the intima floating inside. This in itself is not a contraindication to use that vessel but may create confusion as a pseudolumen can be formed between the intimal flap and the media. To ensure that the intima is picked up and intimal separation is not aggravated during suturing, the stitch should pass inside out (i.e., the needle should go from outside of the healthier vessel and then from the inside to the outside of the damaged vessel). If the stitch has to come the other way, then we place the vessel dilator inside the artery acting as a counterforce holding the intima in place. Because the “healthier vessel” is rarely so, one should avoid vessel dilation and only use the softest clamps placed in apparently healthy segments (or better, carry out the anastomosis without clamps). Obviously, “the patency or milking test” or any rough handling of the arteries can cause an atheromatous plaque to detach acting as embolus and are to be avoided. It is unclear what was the cause of the embolus in our case 1, as the toe was still pedicled on the foot. In any event, this confirms that any handling can cause plaque detachment. Small embolus such as this in a large flap bed can be circumvented by collateral circulation but may prove fatidic when one deals with small vessels only.

Iatrogenic “ischemic toe at the foot” is also a possibility. Rough maneuvers at the time of toe harvesting, such as spreading with scissors or traction from the pedicle, may cause avulsion of side branches. These may irreversibly damage the tiny digital artery. Surgeon’s fault can reasonably be ruled out in this study, as our first case occurred in toe transfer number 122 of the consecutive series of the first author.

Toe transfer in patients where vascular disease may be an issue (older than 40 years,[12] long history of smoking,s diabetes, hypertension) add some risk to the procedure. Rejecting surgery on these grounds may not be justified as the benefits may far outweigh the risk incurred by the patient and surgeon (Fig. 6). By search-

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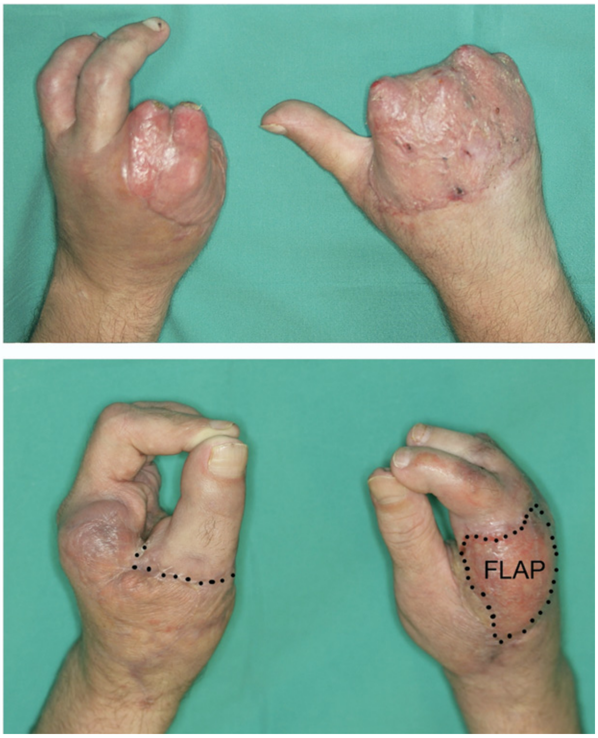

B

FIGURE 6: A Preoperative view of patient 2. **B** Five months after the reconstruction with a trimmed toe on the left and 10 weeks after a tandem transfer plus a free perforator flap in a single stage in the right hand.

ing for alternative inflow pathways, minimizing vessel dissection, avoiding the use of clamps on damaged vessels, and following the rules that had been given for anastomosis of atherosclerotic and radiated vessels, the surgeon may transform this otherwise risky operation into a safe one. A high survival rate can be expected as long as one is prepared to deal with small and fragile vessels.

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