

Invited personal view article

THE INDICATIONS FOR TOE TRANSFER AFTER “MINOR” FINGER INJURIES

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Toe-to-hand transfer is widely considered to be unjustified for “minor” finger injuries. In this invited personal view article the indications for toe-to-hand transfer for finger amputation and neurocutaneous and major pulp defects are discussed, and a classification of multidigital injury that has both prognostic and decision-making value is presented. In the author’s opinion a toe transfer should always be considered as an option when reconstructing “minor” finger injuries, as it can reproduce significant long-term benefit to the hand and the patient’s sense of well being. The procedure should be carried out in the acute period, not only because it is technically easier and better for hand function, but above all because the surgeon can save structures that will be lost if the transfer is delayed.

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Since the hand is always naked and exposed, even if only the fingertip is lost, it presents a very large handicap for the patient. (Hirasé et al., 1997)

There was a time when only loss of the thumb was considered an acceptable indication for toe-to-hand transfer (Buncke et al., 1973; Cobbett, 1969). However, in the early 1980s, and under the leadership of Fu-Chan Wei and Tsu-min Tsai, lesser toes were used to replace fingers and restore pinch and grasp to severely injured hands, goals that were unattainable by other methods (Tsai, 1979; Tsai et al., 1981; Vitkus, 1988; Wei et al., 1989; Wei et al., 1997). In the 1990s, protocols were designed even for reconstruction of bilateral metacarpal hands (Tan et al., 1999; Wei et al., 1999; Yu and Huang, 2000). It is thus well accepted by the Hand Community that “major” hand injuries deserve a major effort of reconstruction, even though the price for the donor foot may be high. Fortunately these types of injuries are rare in a developed country.

On the other hand, we all see everyday “minor” finger injuries that are not so bad as to label as incapacitating, but are sufficient to interfere with the patients’ work or leisure activities and sense of well being. These injuries can be restored nearly “ad integrum” with a toe transfer, and the price to pay (at the donor site) may be minimal (the second toe or a portion thereof). However, there are only a limited (and timid) number of papers which openly address this subject, particularly in adults (Demirkan et al., 1999; Koshima et al., 2000). As toe transfer survival rates are now over 95% and complications are minimal in a busy microsurgical unit, the time has come to reassess the indications for finger

reconstruction. In this personal view article only the most “typical” indications will be discussed. The metacarpal hand (Tan et al., 1999; Wei et al., 1997, 1999; Yu and Huang, 2000), congenital reconstruction (Kay and Wiberg, 1996; Shibata et al., 1998; Van Holder et al., 1999), joint transfer (Dautel and Merle 1997; Foucher et al., 1994; Kimori et al., 2001; Tsubokawa et al., 2003) and other well-established indications will not be discussed.

TOE-TO-HAND FOR FINGER LOSSES

Although it may be tempting to reconstruct every amputated finger using a toe transfer, not all can, or should, be reconstructed if one wants to avoid “surgerying”. The decision to proceed is not easy, and I consider four factors when faced with digital amputations: the number of fingers amputated; the level of amputation; toe limitations; and a harmonious digital arcade.

Number: A hand with less than three fingers is functionally handicapped and very distracting aesthetically. The surgeon should expend major efforts to obtain a three fingered hand (plus a thumb) because, in spite of the fact that it lacks one finger, this type of hand is socially and functionally acceptable.

Level: Toes placed on top of the proximal phalanx are a nuisance if the rest of the hand is functional (Buncke et al., 1992; Foucher and Moss, 1991; Wei et al., 1989) and ray amputation is my recommendation for single finger amputations proximal to the proximal

interphalangeal joint. On the other hand, as in replantation (May et al., 1982), the results of second toe transfer for amputations distal to the proximal interphalangeal joint are excellent. This latter indication for a toe transfer is usually restricted to patients with special professions (musicians), children or women for cosmesis (Dautel et al., 1998; Spokevicius and Vitkus, 1991; Vitkus, 1988). This is a shame because I think that the people who benefit most from toe transfer for an amputation distal to the proximal interphalangeal joint are manual workers (Piñal et al., 2003). In our environment (work related injuries in Spain) only rarely does a worker return to work if he has amputations of two fingers near the proximal interphalangeal joint and never if the hand was dominant and/or the injury occurred at work.

Toe inherent limitations: Disregarding minor cosmetic issues such as the facts that toes are bulbous and have noticeably smaller nails, toes have the major limitation of being much shorter than fingers. Furthermore, in my experience, their interphalangeal joints move poorly once transferred. In general, the full length of the middle and the distal phalanx of a toe is equivalent to distal third of the middle and the distal phalanx of a finger. Because considerable variation exists, I always take X-rays of the toes and the damaged and normal hand and, with the help of tracing paper, transfer the toe length to the hand to give me a rough idea of the likely result and to compare it to the normal side. At times I have used an interposition bone graft to lengthen a reconstruction if this produces a balanced hand.

Balanced hand: The finger tips describe a smooth arcade whose peak is at the middle finger. Any alteration to this curve is appreciated as abnormal by the patient and others, and is a source of dissatisfaction.

These concepts are the basis of a classification that has prognostic, as well as decision-making value (Piñal et al., 2003). Presently, we recognize six possible situations: *normal*, *acceptable*, *unbalanced*, *crippled*, *mutilated* and *metacarpal hands* (Fig 1). A (near) *normal*

hand has four fingers with (near) normal length and sensation and a normal thumb. An *acceptable hand* is the minimum goal the surgeon should strive for. It should have at least three fingers with normal motion at the proximal interphalangeal joints, at least protective sensation, as much length as possible distal to the proximal interphalangeal joint and most importantly harmonious finger lengths. The proportional length of the fingers should not be disregarded as even minimal shortening in one finger draws attention to the others and gives a disfigured aspect: the *unbalanced hand*. *Crippled* and *mutilated hands* both have amputations of at least two fingers, the difference being that in the former the amputations are distal to proximal interphalangeal joint while in the latter they are proximal. As mentioned above this issue is crucial, as the surgeon is unable to normalize a finger amputated proximal to this joint. A *metacarpal hand* lacks prehension ability and has been classified further by Wei into types I and II, according to whether the thumb is present or not (Wei et al., 1997). Following this subdivision, we have also segregated mutilated and crippled hand into types I (thumb present) and II (thumb absent).

The aim is to convert injured hands into normal or acceptable ones (Fig 2), and the surgeon has to use the surgical armamentarium freely to do so. This includes not only toe transfer, but also flaps, ray resection and lengthening procedures as required to meet the goal. The surgeon should also let the patient know that, although a mutilated hand can be upgraded, he is unable to attain a normal or acceptable hand...an informed and understanding patient is the key to avoiding disappointment (Figs 3 and 4).

Once an acceptable hand has been achieved (with one or two toe transfers), how does one decide when to proceed with further reconstruction? i.e. when do we decide to pursue a four-fingered hand? In the case of two finger amputations we favour reconstruction of both in central hand (middle and ring) defects, as even single finger losses, when centrally located, are very obvious

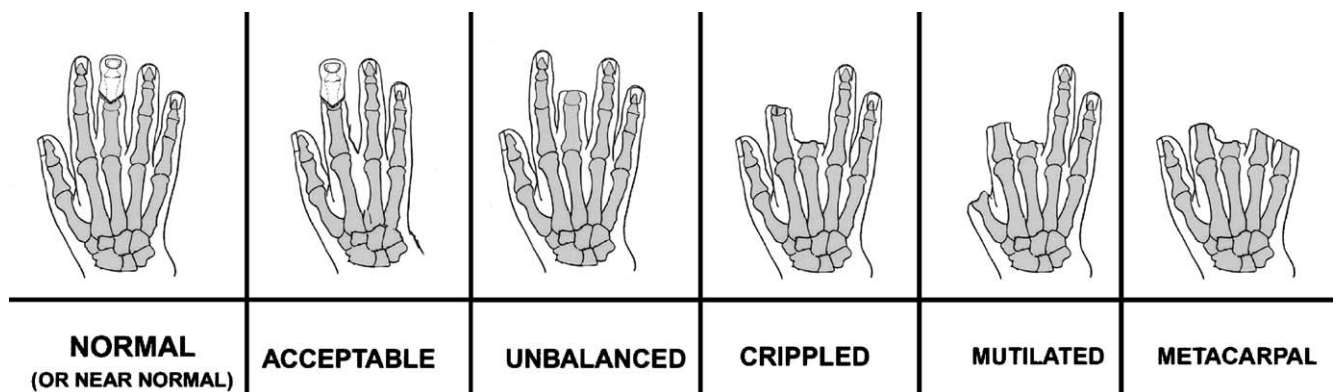


Fig 1 Classification of finger injuries (see text for details). In this sketch the normal hand corresponds to an unbalanced hand upgraded by a second toe transfer, and the acceptable hand is a crippled hand upgraded by a toe transfer for the index finger and amputation of the middle ray (modified from Piñal et al., 2003).

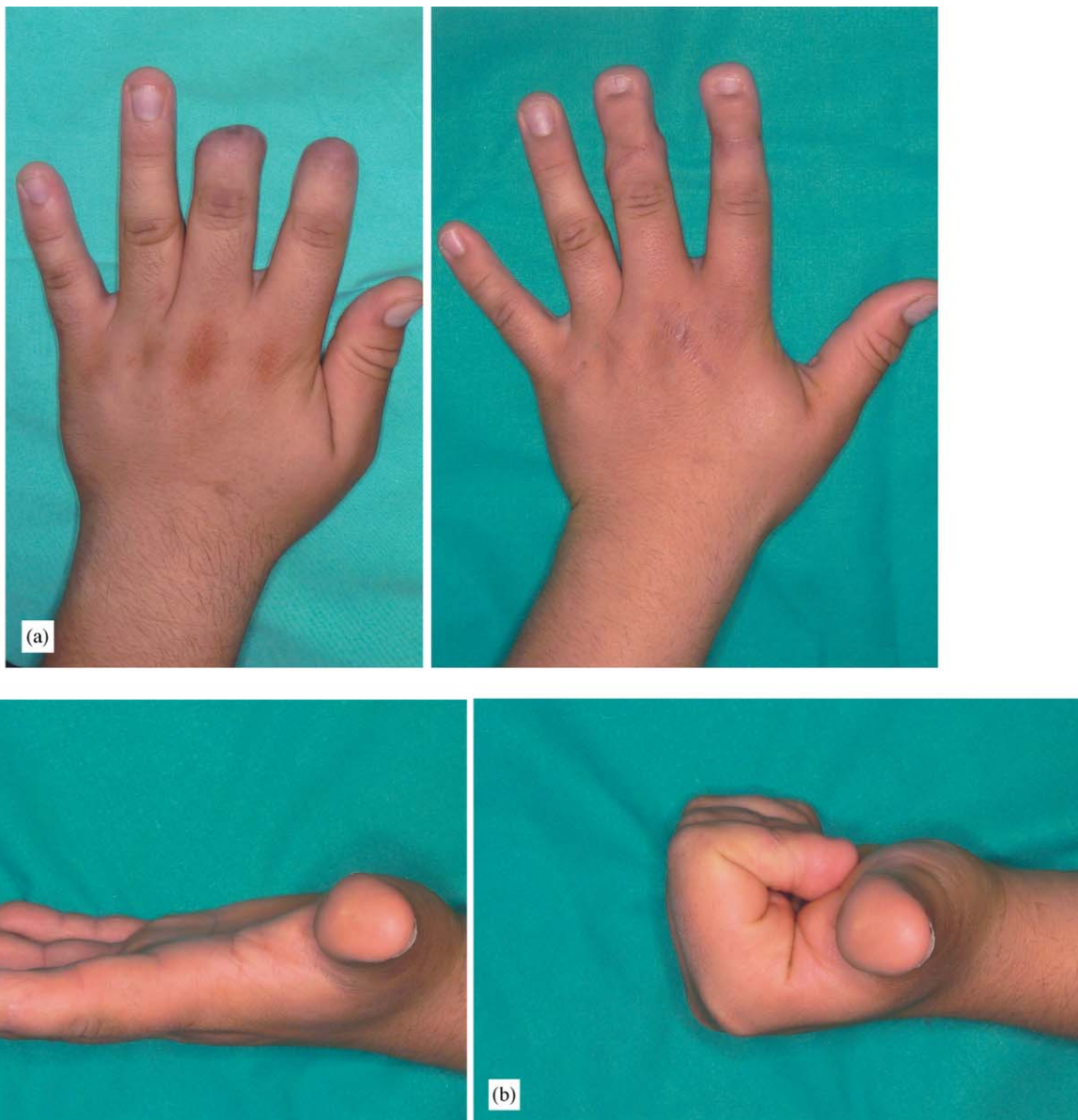


Fig 2 (a) This 19-year-old construction worker was referred 8 months after suffering minor amputations of the index and middle fingers of his non-dominant hand. He had been on sick leave since the injury with depression, self-image derangement and post traumatic anxiety. I advised a single digit (the middle finger) reconstruction, but once this transfer had been completed he insisted upon a second transfer to the index which was done 1 week later. The patient stopped taking his psychiatric medication 2 weeks after completion of the surgery (claiming he was not crazy!) and returned to work 5 months later. Two years later he continues to be very satisfied. (b) Note that the range of motion at the transplanted distal interphalangeal joints is minimal.

(unbalanced hand). However, the lack of a border finger is more easily disguisable (particularly the little) and, when dealing with border two digit defects (index and middle or ring and little) we usually only try to reconstruct the more central finger (the middle or the ring), although we are sensitive to patient wishes. In the past, we were reluctant to transfer three toes (the second from one foot and the second and a third from the other (Wei and Yim, 1995)) because of the major aesthetic

sequela in the foot. We accepted less perfect results provided a harmonious hand was achieved (Piñal et al., 2003). However, now I do not hesitate to transfer more than one toe from each foot to upgrade the hand, as in my experience the foot sequelae, even when the second and third toe are combined, are not too dreadful.

Koshima et al. (2000) presented a series of over 60 very distal finger defect reconstructions using a toe. Good results were achieved and the main indication was

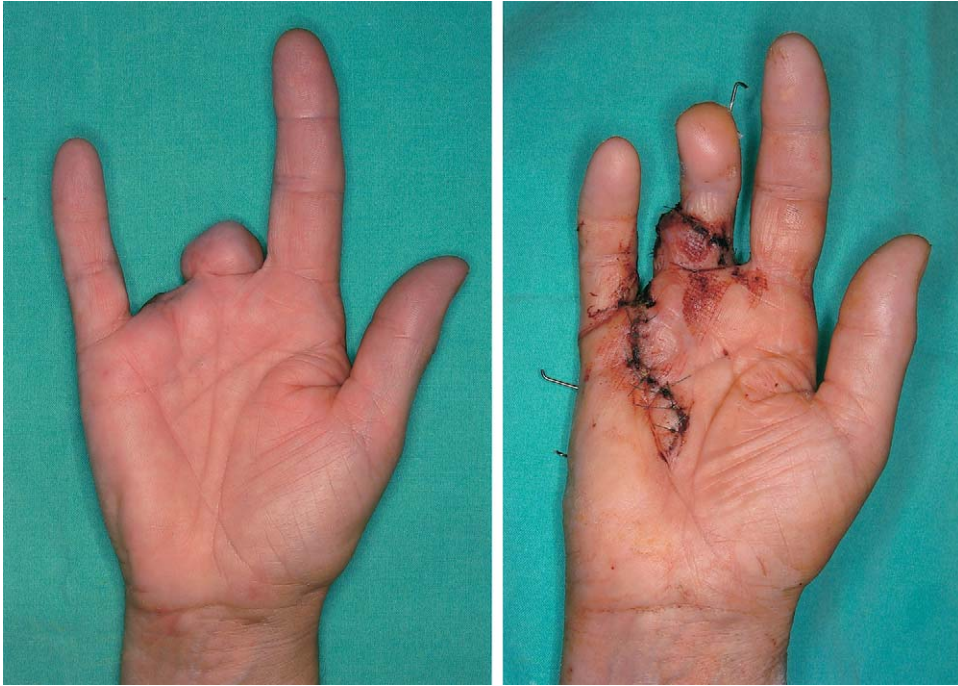


Fig 3 This 66-year-old (otherwise fit) woman came for a second opinion 5 months after suffering a mutilating type I injury to her dominant hand. In a single stage the ring finger was resected and a second toe was transferred to the top of the remnants of the middle finger proximal phalanx. An interpositional slice bone graft taken from the ring finger was not considered appropriate for this elderly lady and the negative effect on the digital arcade can be seen. Although we knew preoperatively that we would not be able to achieve an acceptable hand, the improvement is evident at 2 weeks.

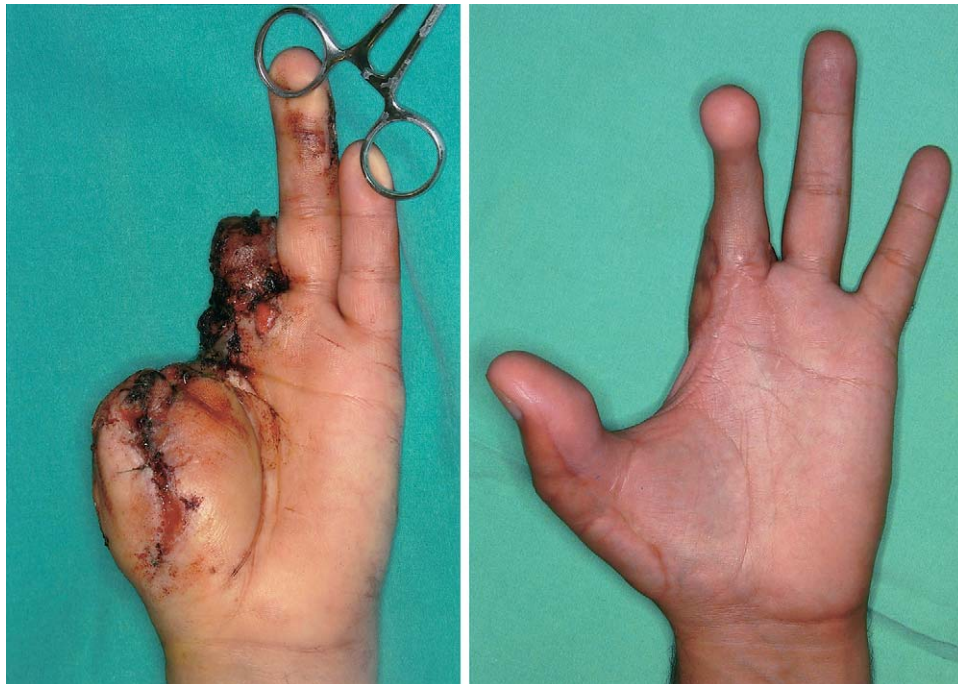


Fig 4 The hand of a 25-year-old punch press operator 5 days after a massive crush (mutilating type II) injury. The first ray was reconstructed with a trimmed-great-toe transfer (Wei et al., 1988). In the second stage, 1 week later, a modified second toe was placed on top of the proximal phalanx of the middle finger. No other surgery has been done. Although pinch and a harmonious digital arcade have been restored, absence of motion at the proximal interphalangeal joint precluded the acceptable hand level being reached. The patient retired from his previous work and is now working as a gardener.

cosmesis, as was the case in [Shibata et al.'s \(1991\)](#) series in which the finger nail was reconstructed. In labourers we only perform a toe transfer for a single finger amputation if the man is a non-smoker, less than 40 years old, and wishes to achieve a normal hand: again this transfer is more indicated for a central, rather than a lateral, defect. In any case the surgeon should ensure that the benefits of the transfer do not outweigh the sequelae for the foot. Most of the time the toe for transfer is disarticulated at the metatarsophalangeal joint but, for very distal amputations, attempts have been made to avoid loss of the second toe or a portion thereof, by instead transplanting a thin osteo-onychocutaneous flap from the big toe ([Koshima et al., 1992](#); [Hirasé et al., 1997](#)). Unfortunately, the cosmetic appearance of this transfer is poor, and several authors have reverted to using a trimmed second toe despite the fact that it entails partial or total amputation of the donor toe ([Dautel et al., 1998](#); [Koshima et al., 2000](#)).

Although several authors ([O'Farrell et al., 1996](#); [Pillet, 1997](#); [Pillet and Didierjean-Pillet, 2001](#)) have reported high satisfaction rates from a cosmetic standpoint with finger prostheses, I have a different experience. In my view drawbacks such as colour match, wear and price only make prostheses a good option for cases with major finger mutilations and for patients who do not want to invest any effort in surgery. My patients tend to prefer the option of chubby fingers that have sensation and are warm, rather than beautiful, but unstable and insensate, prostheses.

We have performed 24 second toe transfers for finger reconstruction with a 100% survival rate. Nineteen cases in 13 labourers with a follow-up of more than 1 year were transfers for amputations distal to the proximal interphalangeal joint, and in these patient satisfaction was high and 12 of the 13 returned to work. From my experience I conclude that manual workers benefit enormously from toe-to-hand transfer for amputations distal to the proximal interphalangeal joint, and I think that the transfer should be done as early as possible in order to maximize functional recovery and preserve vital structures that will be lost if surgery is delayed ([Piñal et al., 2003](#)). [Demirkan et al. \(1999\)](#) warn that early reconstruction, although safe, does not allow an intervening mourning period, and may create unrealistic expectations. The benefits of early surgery far outweigh the potential risk of a more demanding patient and in our opinion is highly recommended.

NEURO CUTANEOUS SOFT-TISSUE RECONSTRUCTION

Occasionally the surgeon has to deal with fingers with a combined loss of palmar soft tissues and a digital nerve. The "classic" and "straightforward" way of dealing with this type of injury is a two-stage procedure: a local

flap (that becomes a parasite in the bed) and a secondary interpositional nerve graft (taken from the medial forearm or the distal posterior interosseus nerve). I am very dissatisfied with this classic method. Firstly it is not straightforward and takes 2 or 3 months to complete, and secondly as my results have been disappointing, with complaints regarding the donor site and poor recovery of sensation. The latter is not surprising as a nerve graft obtains its nutrients and revascularizes from the recipient bed ([Prpa et al., 2002](#)) which in this case will be scarred. [Koshima and Harii \(1985\)](#) achieved better results when vascularized nerve grafts were used in scarred beds, and [Rose \(Rose and Kowalski, 1985; Rose et al., 1989\)](#) obtained good results when vascularized nerve grafts from the deep peroneal nerve were used to bridge digital nerve defects. [Koshima et al. \(1991\)](#) achieved a good result with reconstruction of a compound digital defect using a combined neurocutaneous flap consisting of a toe web space and the deep peroneal nerve. To avoid the problems of a web space donor site ([Willemart et al., 1999](#)), and to utilize a more consistent nerve than the deep peroneal nerve, I use a tibial neurocutaneous second toe flap ([Fig 5a](#)). I harvest the flap from the tibial side of the second toe and include the digital nerve, and sometimes also the corresponding branch of the deep peroneal nerve. My present experience is limited to five cases ([Fig 5b](#)), but I am pleased and have not had any complaints regarding the donor site. The recovery of sensibility in the recipient pulp has been 11 mm on average, although we expect this to improve with longer follow-up. Raising the flap is truly straightforward and takes around 1 hour, so that the procedure can be completed in 4 hours using combined axillary and epidural blocks. To avoid the criticism of sacrificing a major artery for a "minor" endeavour, I have always used the first dorsal or plantar metatarsal artery, or even a digital artery as the donor and perform an end-to-side anastomosis to a common digital artery or an end-to-end one to a digital artery.

I recommend this procedure for young patients (less than 50) when there is a combined nerve and soft-tissue defect in the radial part of the index or the ulnar part of the little finger. I also use this transfer in Dupuytren's patients with severely flexed fingers and a nerve defect from previous surgery. For the latter indication my longest follow-up is 2 years with no recurrence and good recovery of sensibility.

MASSIVE PULP LOSS

Hemipulp great toe transfer ([Buncke and Rose, 1979; May et al., 1977](#)) is an accepted method for reconstruction of a thumb pulp. Its main aims are to improve sensory recovery and provide a shear-resistant surface for pinching ([Kato et al., 1989; Kimata et al., 1998; Logan et al., 1985; Ratcliffe and McGruther, 1991](#)).

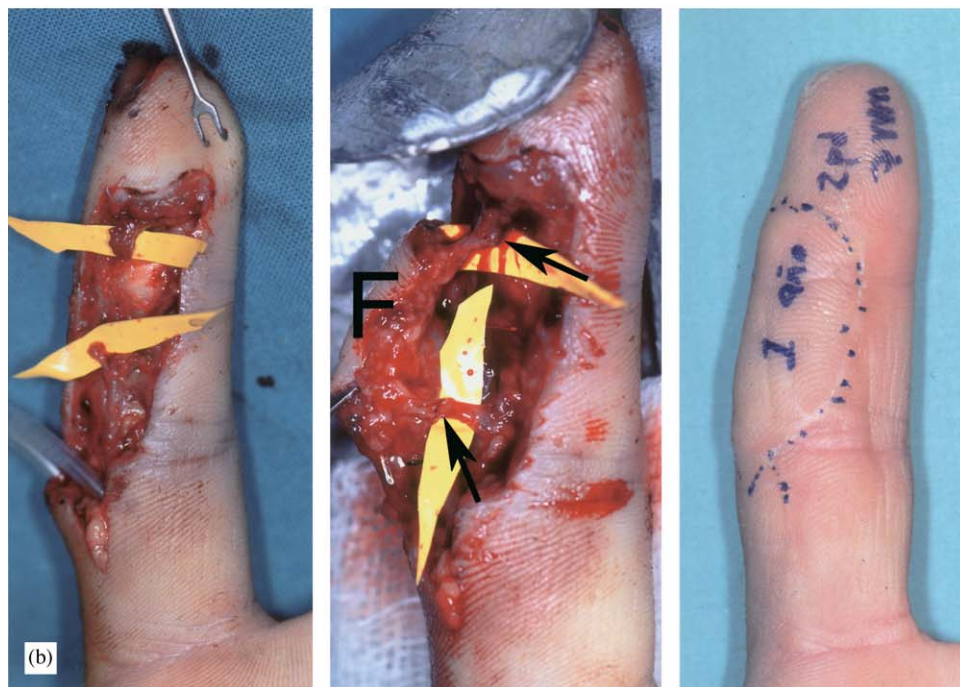
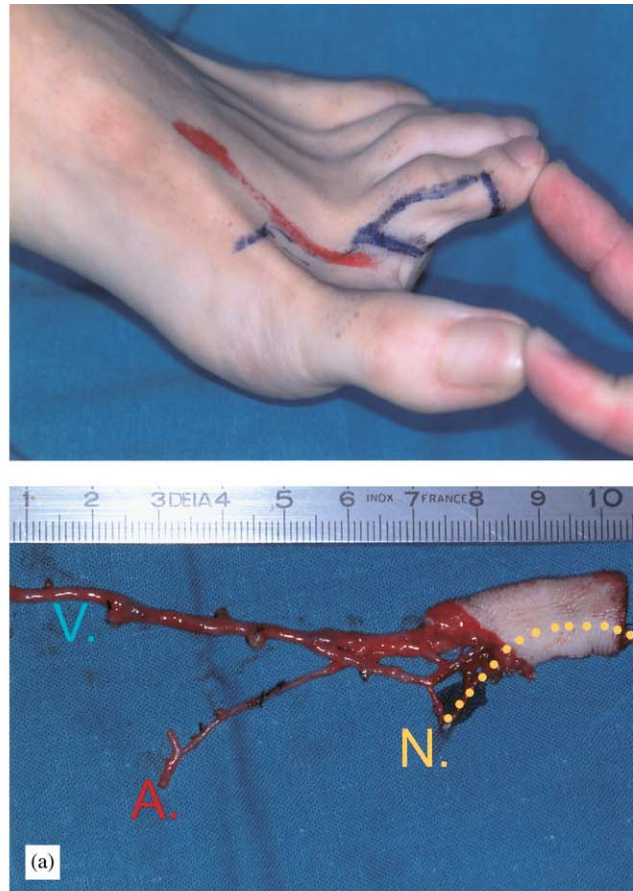


Fig 5 (a) The tibial neurocutaneous second toe flap. (b) This 24-year-old carpenter was seen acutely with a 2.5 cm compound neurovascular defect on the radial side of the index finger. Three days later a neurocutaneous tibial second toe flap was transferred. The 1-year result is shown (two point discrimination = 7 mm). (N = tibial digital nerve (marked by dots); A = first dorsal metatarsal artery; V = subcutaneous vein; F = flap; arrows point to the nerve sutures)

The index pulp has not received any attention, except for a few case reports (Logan et al., 1985) including one in the pioneering paper of Foucher et al. (1980). To me it does not make any sense to expend major reconstructive

efforts on the thumb in order to provide a sensate pinch, but then not to do so for the index finger (the opposite part of the pinch). Several years ago we started to reconstruct major defects of the index finger with a

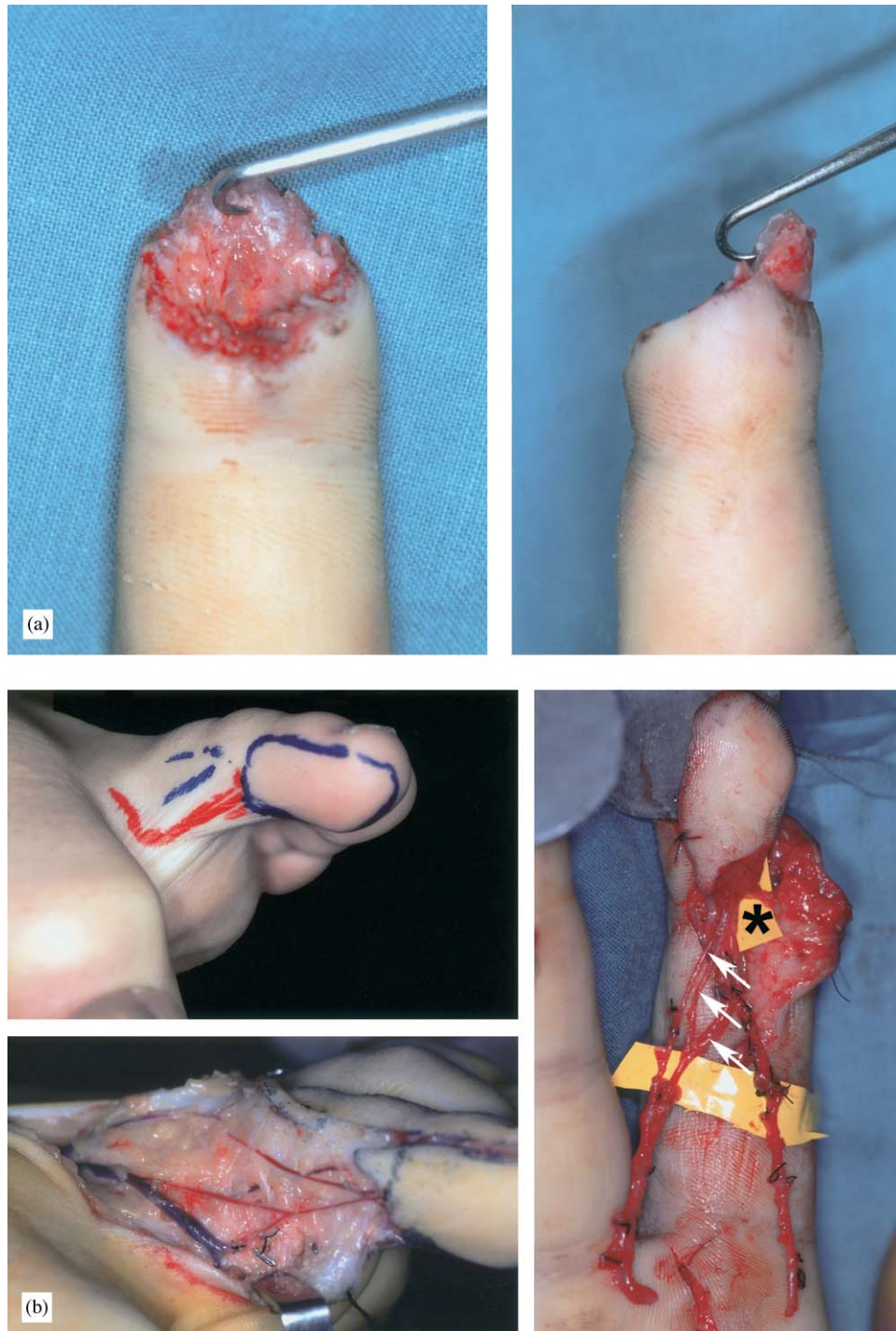


Fig 6 (a) A massive soft-tissue defect in the index finger pulp of a young patient was reconstructed 2 days later with a second toe hemipulp. (b) The radial digital nerve of the index finger was sutured to the tibial digital nerve (asterisk). The three white arrows show the skeletonized veins. (c) The final result. Two point discrimination was 5mm.

second toe hemipulp transfer. Our experience is limited (four cases of which three have been followed up for longer than 1 year (Fig 6)), because our indications for this surgery are a young patient with major pulp defect. Under other conditions the defect is covered with any of

the available local flaps (V-Y, homodigital (Kojima et al., 1990; Lai et al., 1992), island heterodigital (Adani et al., 1999) or even a cross finger flap). For the reasons mentioned earlier in this article I also think that the little finger pulp deserves similar treatment, but I would not

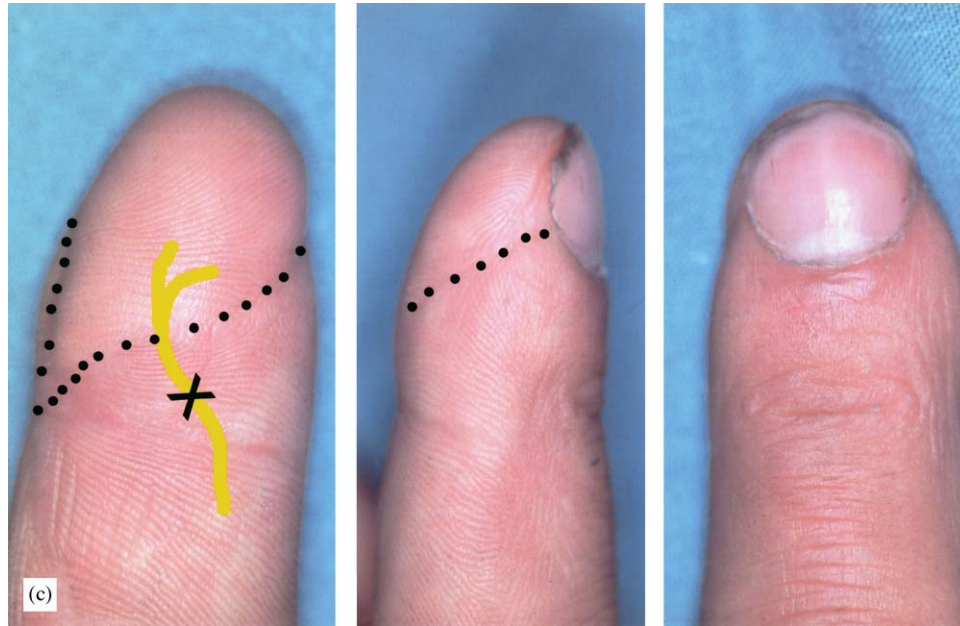


Fig 6 (continued).

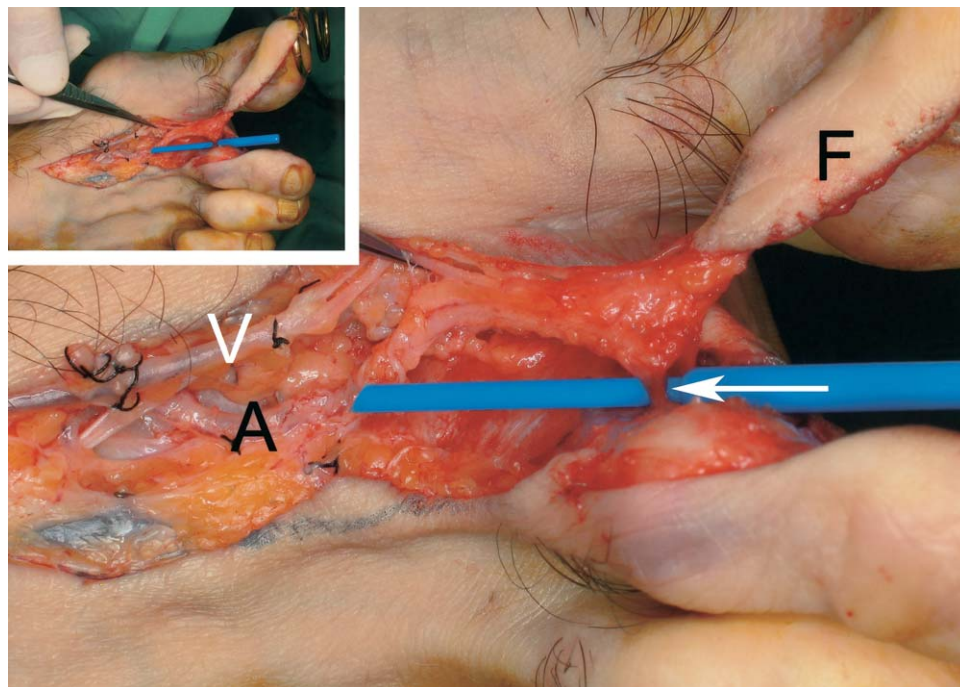


Fig 7 Intraoperative view showing the proximal transverse digital artery and vein (arrow). Inset: corresponding panoramic view (F, flap; A, first dorsal metatarsal artery; V, subcutaneous vein).

recommend this procedure for central digits where sensibility is not such an important issue, and thus a major endeavour is not justified.

These types of flaps are very difficult to dissect as the vessels are fragile and tear easily (Piñal et al., 2000). This difficulty can be reduced by retaining fat around the vessels during the dissection, but this will produce an unsightly and chunky finger. For this reason every effort should be made to dissect the fragile veins from the very proximal edge of the flap (Fig 6b), as this will allow a smooth transition from the toe to the finger. Another technical point worth emphasizing when dissecting very small toe flaps is the need to isolate and ligate a constant but tiny arterial branch of the digital artery that is located just proximal to the toe's proximal interphalangeal joint. After a very short course from its origin this branch dives deep into the tendon sheath, and it is equivalent to the proximal transverse digital artery of a finger (Strauch and Moura, 1990). This branch can be a source of bleeding and spasm, if inadvertently cut or avulsed. The surgeon should specifically look for it, and dissect it for 2 to 3 mm so as to gain enough room to pass a ligature around it (Fig 7). This sometimes requires one to open the tendon sheath. As for the other flaps the first dorsal or plantar metatarsal, or the true digital artery, is used as the donor. This makes the anastomosis difficult but the dissection in the foot is quicker and less destructive.

In summary, in my opinion toe transfer should always be considered as an option when reconstructing minor finger injuries. The procedure should be carried out in the acute period, not only because it is technically easier and better for hand function, but above all also because the surgeon can save structures that will be lost if the transfer is delayed. We need to change our perspective when dealing with these minor, but incapacitating, injuries and accept that the loss of a toe and time-consuming reconstructive surgery may be of enormous benefit to the hand in the long term.

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