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Microsurgical reconstruction of distal digits following mutilating hand injuries: results in 121 patients

F. C. Wei, M. D. Epstein, H. C. Chen, C. C. Chuang and H. T. Chen

Microsurgery, Extremity Reconstruction Center, Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, Taipei, Taiwan, R.O.C.

SUMMARY. **From 1982–1989, 152 mutilated distal digits were reconstructed with microsurgical foot tissue transfers in 121 patients. These various foot tissues included wrap-around flaps or pulp from the great toe, second toe, or third toe, as well as partial toe, nail, web space skin, and other portions of the foot. The reconstructions were carried out primarily and secondarily in 78 and 74 patients respectively. The immediate success rate was 98%. Most of the patients were satisfied with both the cosmetic appearance and the functional result. This relatively minor microsurgical foot tissue transfer proved to be an ideal reconstructive option for distal digital defects.**

Replantation of the amputated distal digit was once a matter of controversy, but has recently become common practice for many hand and microsurgeons. The replanted distal digit always demonstrates a functional result superior to that obtained with other reconstructive methods. The diminished need for postoperative rehabilitation and secondary surgery, as well as the shorter recovery period, are distinct advantages in favour of distal digit replantation. The replanted digit recreates a visually more normal hand, thus enhancing the patient's acceptance and use of the digit. For the same reasons mentioned above, reconstruction of non-replantable distal digits with like-tissue transfers from the feet yields a superior result which other conventional techniques cannot afford. This article presents these microsurgical alternatives for the restoration of digital form and function of unreplantable digits in 121 patients.

Anatomy

The distal digit in this article is defined as the portion of the terminal digit distal to the insertion of the flexor pollicis longus (in the thumb) or flexor digitorum superficialis (in the fingers).

The important structures of the distal digit include the sensate, glabrous pulp skin and a stable, adherent nail. A mobile distal interphalangeal joint is desirable, but not absolutely essential. Pulp skin is necessary for a firm grip and pinch. The nail stabilises the dorsum of the finger tip, as does the pulp volarly. The nail is also important in tactile sensation.[1]

Reconstructive requirements

During the acute phase of the injury, careful thought is required to develop a comprehensive reconstruction plan. This must be initiated prior to any surgery, although it may certainly be modified later. Acute care requires attention to skin cover, skeletal stability, joint, nerve and tendon function. Digital length and function must be preserved as much as possible. Excessive shortening and use of local flaps should be avoided to facilitate definitive reconstruction.

Tissues that may be deficient, such as bone, perionychium, skin and overall length should all be carefully evaluated.[1]

In 1931, Bunnell outlined the four major requirements for thumb reconstruction, namely, opposability, stability, length and sensibility.[2] When considering requirements for finger reconstruction, for the most part, this also holds true. With current microsurgical techniques, appearance is a realistic, achievable requirement which may be added to the list.[3–6]

Material and methods

From January 1982 to December 1989, 152 foot tissue transfers for distal digital reconstruction were carried out in 121 patients. There were 90 male (114 transfers) and 31 female (38 transfers) patients. The average age was 24 (ranging from 7–54 years).

All procedures were used to reconstruct traumatised digits, which consisted of 56 thumbs and 96 fingers. 78 transfers were performed primarily while the wound was still open, either in the acute or subacute phase of injury and 74 transfers were performed secondarily after wound healing. In the primarily reconstructed group, the wounds required 1–3 debridements prior to microsurgical foot tissue transfer. Porcine skin was used as a biological test of cleanliness of the wounds if in doubt. The recipient arteries consisted of 43 radial, 8 palmar arch, 33 common digital and 68 proper digital arteries.

Donor sites used were 52, 80 and 20 tissues respectively from the great toe, second toe and first web space (Table 1).

Table 1 Donor foot tissues for distal digital reconstructions

Donor tissue	*Number*
1. From the great toe	
Great toe wrap-around (modified)	42
Great toe pulp	10
2. From the second toe	
Partial second toe	15
Second toe wrap-around	20
Nail	4
3. From the third toe	
Partial third toe	7
Third toe pulp	6
4. From the web space and other part of the foot	20
Total	152

Table 2 Immediate result

Transplant survival	149 (98%)
Complications	
Reexploration	12 (7.9%)
Failure	3 (2%)
Complete	2
Incomplete	1
Major infection	8 (5%)

Table 3 Functional results

Sensory recovery (2 P-D)	5 mm Protective sensation (> 15 mm)
Active range of motion (PIP joint of the finger or IP joint of the thumb)	60% of pre-op. value (50–100%)
Use of reconstructed digit	100%
Significant cold intolerance	0
Significant donor site morbidity	0

Operative techniques

Distal digital injuries were assessed to evaluate bone, joint, tendon, nail, dorsal and pulp skin as well as overall length. Next the specific defects were outlined on the surgeon's own hand in order to produce an

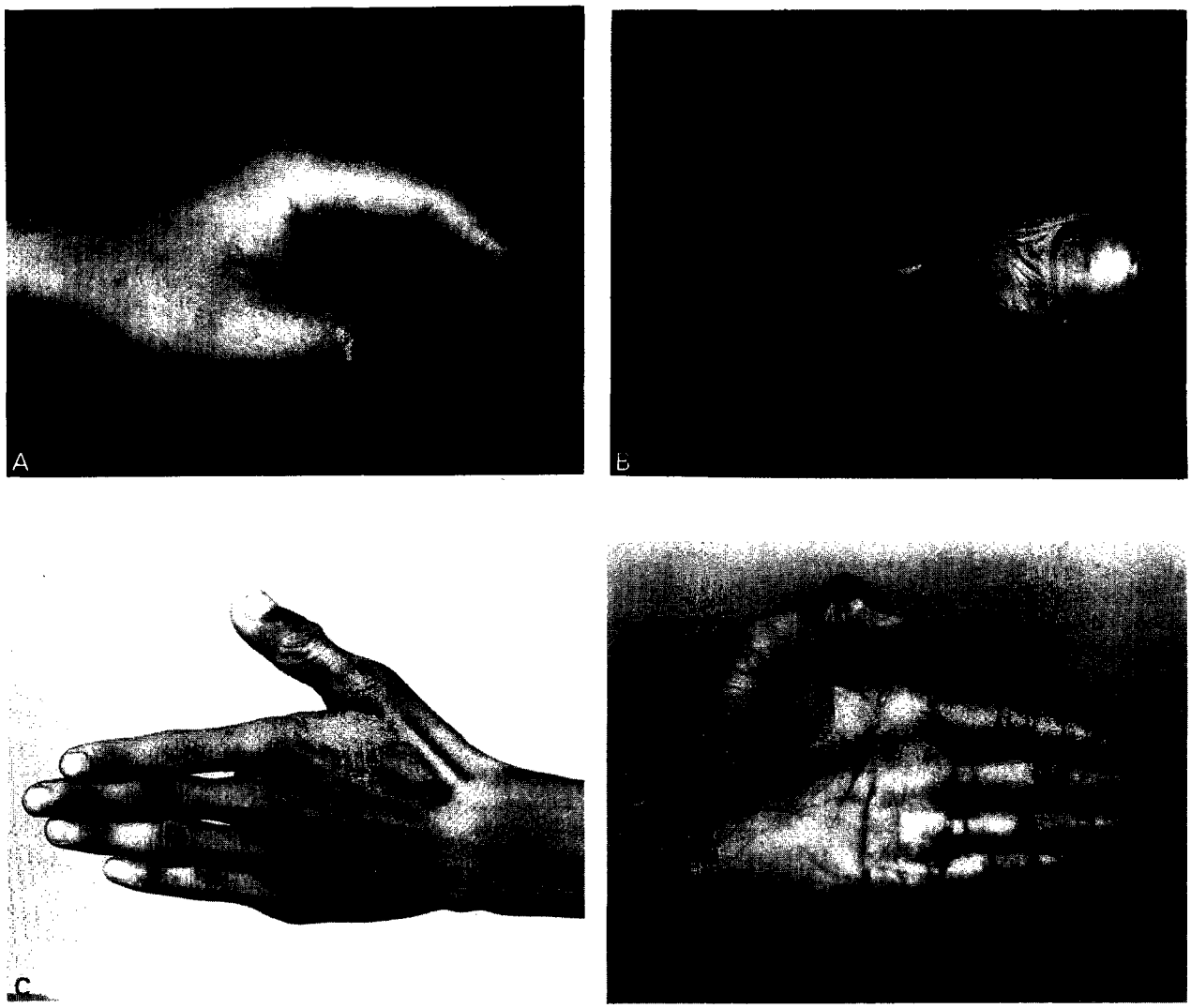

Fig. 1

Figure 1—(A) Traumatic amputation of right thumb at distal phalanx. (B) Harvested modified great toe wrap-around flap (including thinned distal phalanx). (C, D) Appearance and function 18 months postoperation.

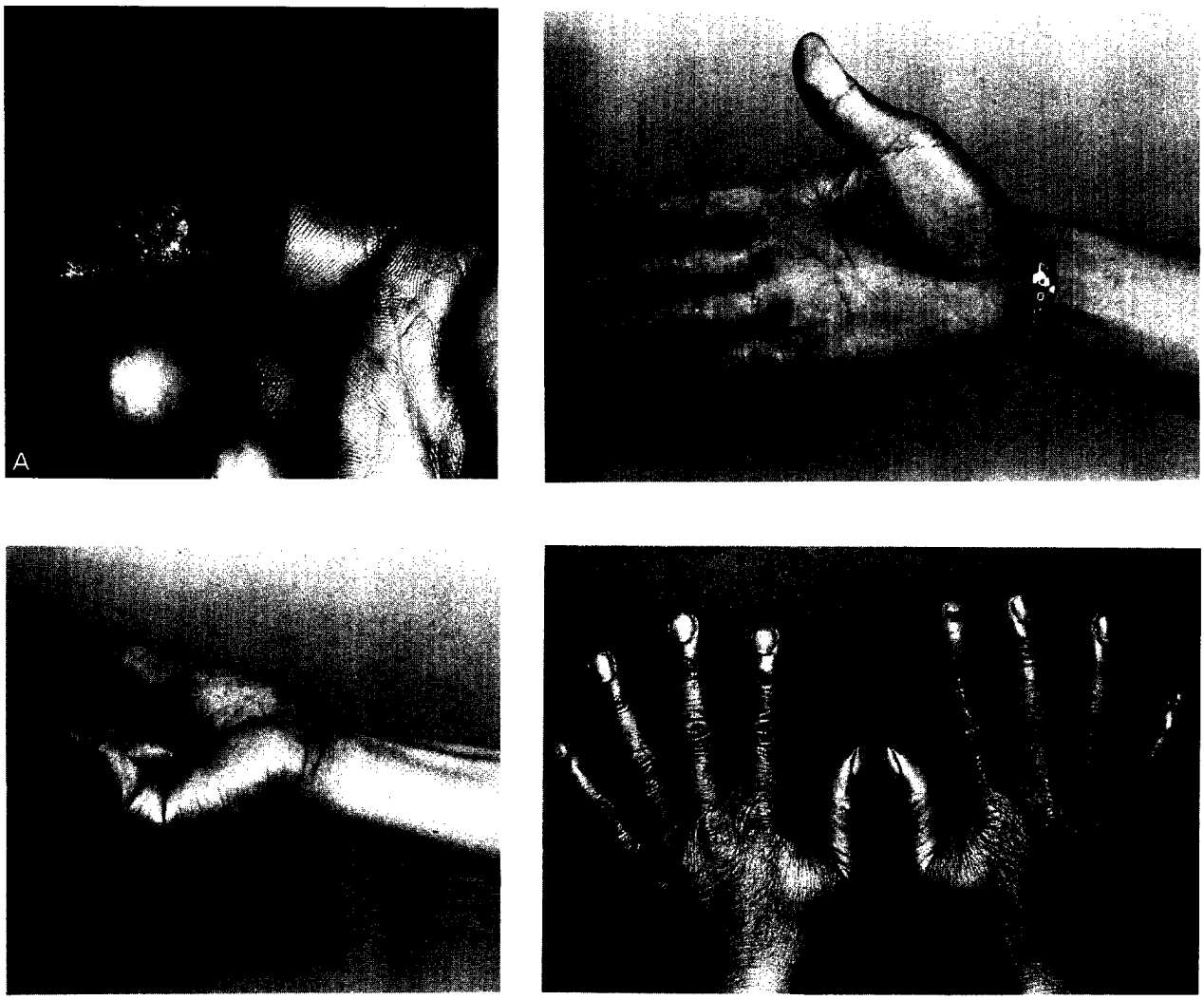

Fig. 2

Figure 2—(A) Right index fingernail loss and circumferential skin avulsion at distal interphalangeal level. (B, C, D) Appearance and function of the hand 2 years after second toe wrap-around flap reconstruction.

accurate template which was used to design the tissue transfer.

The dissection of the vascular pedicles, various structures and transplantation of foot tissues were all similar and have been described elsewhere.[4, 6–11]

Skeletal stabilisation was achieved with either interosseous wiring, bone dowelling, or K-pin fixation. A longitudinal K-pin placed through the distal interphalangeal joint or the proximal interphalangeal joint (if any) was used in order to keep the transferred lesser toe in extension, the purpose of which is to overcome the natural flexion habitus of the lesser toe.

Results

149 transfers (98 %) were completely successful despite reexploration of 12 (7.9 %) anastomoses. Two complete and one partial failures (2 %) occurred in the primarily reconstructed group. Eight transplants developed major infection which resulted in sequelae requiring immediate additional reconstructive procedures. All major infections occurred in the subacutely reconstructed group (7 days) (Table 2). 75 patients with 90 transfers were available for follow-up at least 6 months postoperatively. All patients were either satisfied or felt comfortable with the appearance of their reconstructed digits. Sensory recovery ranged from 5 mm two-point discrimination to protective sensation (15 mm). Among the 54 completely normal proximal interphalangeal joints of the fingers (or the interphalangeal joints of the thumbs), the average postoperative range of motion of that joint was 60 % (50–100 %) of the preoperative measurement. There were no significant problems with cold intolerance in either the hand or the foot. All patients described successful use of their reconstructed digits in most of their daily activities. Some patients noted mild foot discomfort while walking with bare feet, otherwise there was no significant morbidity in the donor foot (Table 3).

Case reports

Case 1: Modified great toe wrap-around

A 20-year-old male sustained a traumatic amputation of the left thumb 0.5 cm distal to the interphalangeal joint. Four

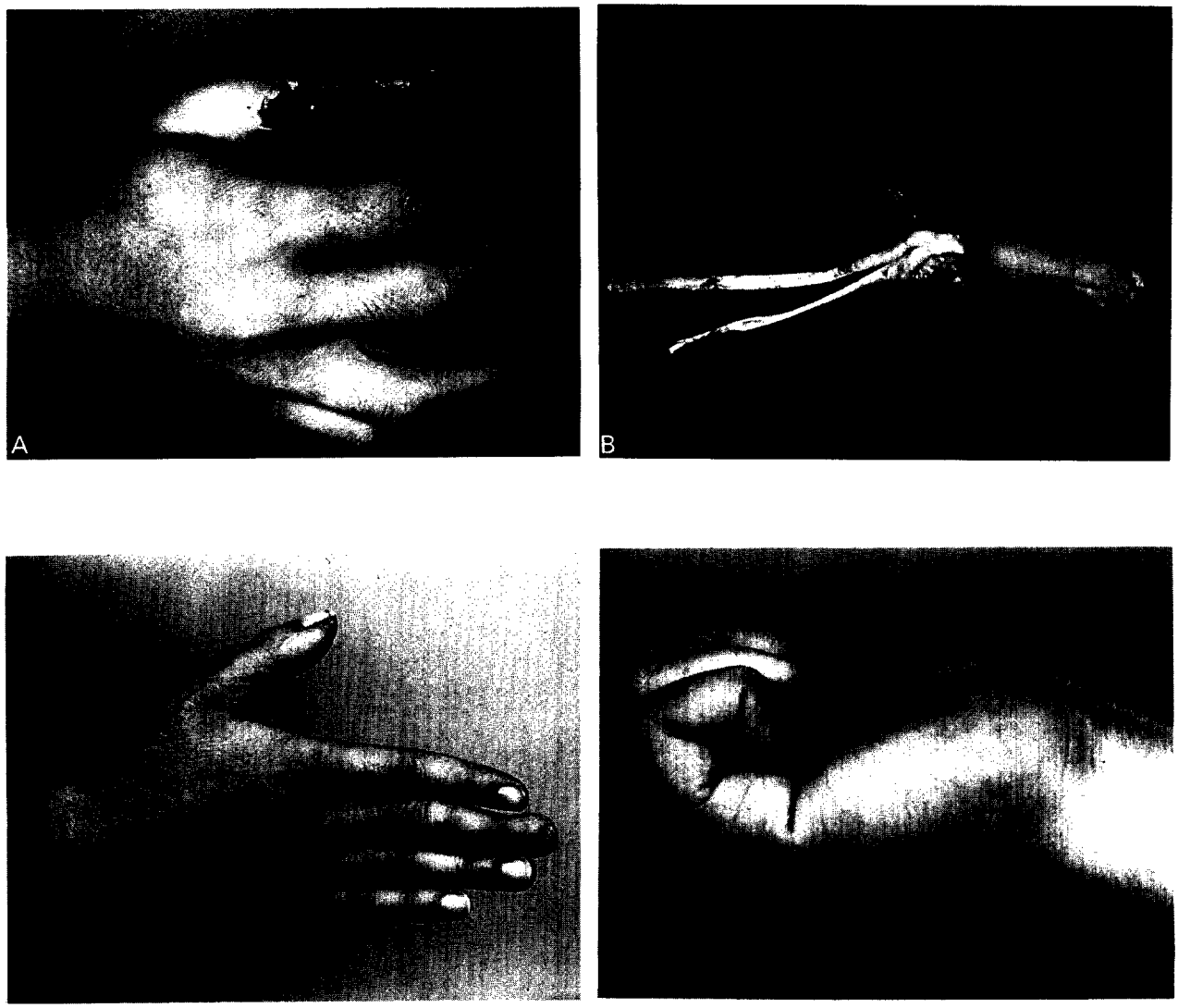

Fig. 3

Figure 3—(A) Traumatic amputation of right middle finger at middle phalangeal level. (B) Elevated partial second toe. (C, D) Appearance and function 2 years postoperation.

days later a modified wrap-around flap from the left great toe, based on the plantar metatarsal artery, was transferred to the left thumb. The plantar metatarsal artery was anastomosed to the ulnar digital artery of the thumb. The patient is currently doing well. Functional evaluation 18 months postoperatively revealed a 10 mm static two-point discrimination of sensory recovery and an active range of motion of 55 degrees in the interphalangeal joint (Fig. 1A–D).

Case 2: Second toe wrap-around

A 36-year-old female had a crush injury to her right index finger at the distal interphalangeal level, resulting in fingernail loss and circumferential skin loss. The tendons were all intact. The finger was initially debrided and covered with porcine skin. The following day she was returned to the operating room where a left second toe wrap-around flap was performed. Her postoperative course was unremarkable. She currently has sensory recovery of 10 mm static two-point discrimination and 90 and 60 degrees of range of motion in the proximal and distal interphalangeal joints. The appearance of the reconstructed digit is good (Fig. 2A–D).

Case 3: Partial second toe transfer

A 19-year-old male with an electric saw injury to the right hand lost his middle finger at the middle phalangeal level and had a fracture-dislocation of the interphalangeal joint of the thumb, accompanied by a disruption of the flexor pollicis longus tendon and a volar, ulnar soft tissue defect.

The digits were initially debrided, the fraction dislocation reduced and the ruptured flexor pollicis longus repaired. A partial second toe transfer for middle finger reconstruction was carried out 5 days later.

He required tenolysis of the right middle finger 8 months postoperatively. Follow up at 2 years postoperatively revealed a 12 mm static two-point discrimination of sensory recovery and no lack of finger (transferred toe) tip to palm distance (Fig. 3A–D).

Case 4: Second toe hemipulp transfer

A 25-year-old male was referred to us because of pulp instability of his left index finger following a pedicled groin flap reconstruction performed elsewhere. A hemipulp from the tibial side of the left second toe was transferred to replace the swivelling pulp. The postoperative course was smooth.

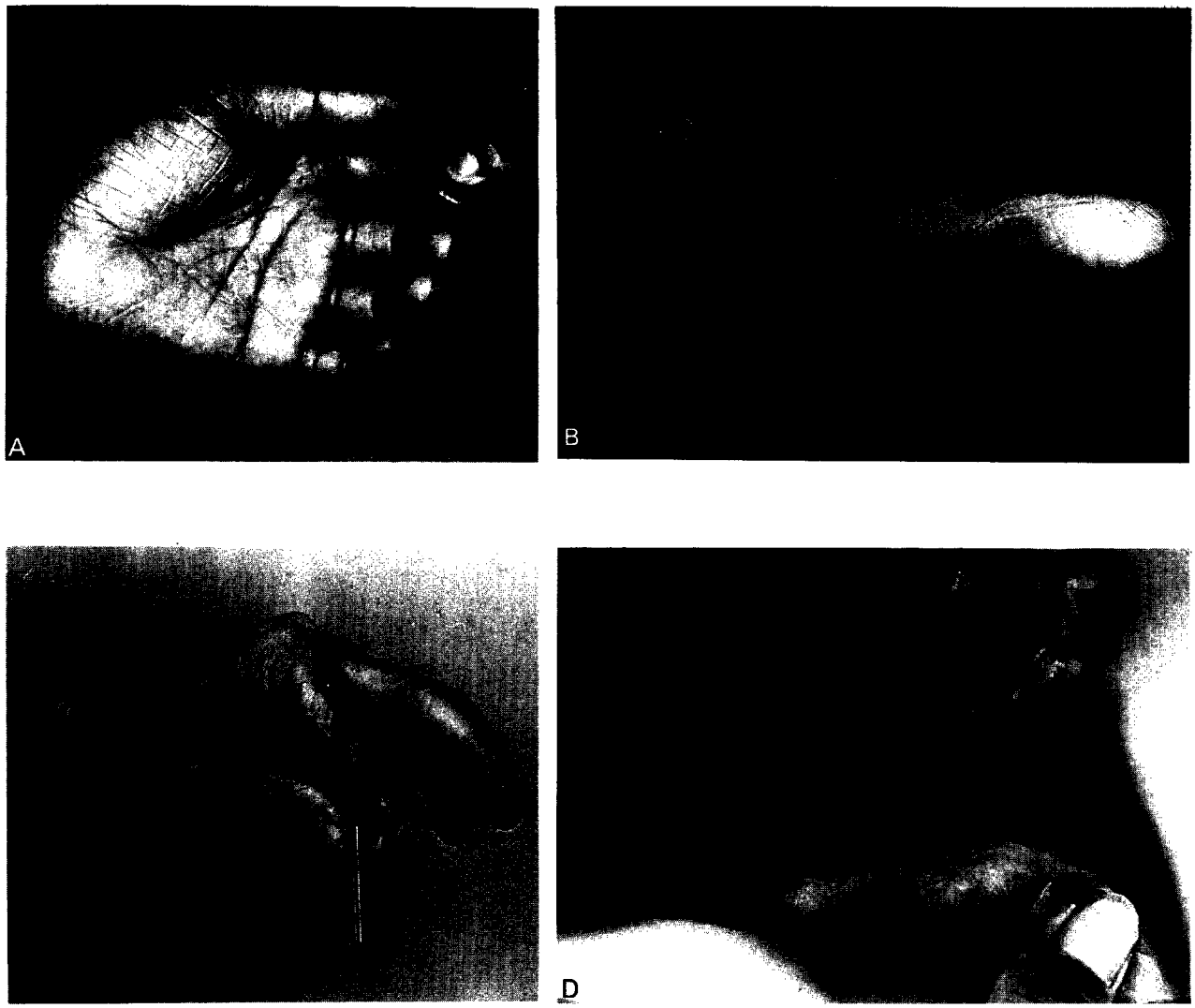

Fig. 4

Figure 4—(A) Unstable pulp of left index finger following groin flap reconstruction. (B) Elevated second toe hemipulp. (C) Function of the reconstructed index pulp. (D) Appearance of the donor site.

Follow-up at 18 months postoperation revealed a stable index finger pulp with sensation of static 12 mm two-point discrimination, and an inconspicuous donor site (Fig. 4A–D).

Discussion

The problem of post-traumatic distal digital defects has been overlooked in the past. All conventional reconstructive options left much to be desired for an acceptable functional and aesthetic result.

Several authors have reported excellent results following distal digital replantation, both in terms of survival and function. In 1982, May *et al.* reported their series of 18 digits replanted distal to the proximal interphalangeal joint.[12] Survival was 96% with excellent function. Goldner *et al.*[13] reported their experience with replantation of 42 digits distal to the distal interphalangeal joint, achieving 81% viability with satisfactory function. Yamano[14] reported similar results in his experience with 87 amputations distal to the distal interphalangeal joint.

The incomparable results achieved by distal digital replantation have encouraged us to investigate the use of corresponding parts of the foot as free tissue transfers in order to attempt the reconstruction of non-replantable or irreparable distal digits. The minimal donor site defect, excellent functional and cosmetic gain, as well as a diminution of the profound negative psychological impact[15] and improvement in interpersonal relationships of the patients has supported such reconstructive options. Furthermore, the rapid recovery from disability is even more advantageous.[7,12,13] Cold intolerance, although often presented as a significant problem in replantation and transplantation surgery, was not significant in any of our patients, probably because of the very mild winter in our area.

The brilliant pioneering work of Buncke *et al.*,[16] and Cobbett,[17] demonstrating the successful free transfer of a toe to a hand, in primates and humans respectively, paved the way for microsurgical reconstruction following non-replantable digital amputation.

As familiarity with microvascular foot tissue trans-

fer has improved, multiple simultaneous toe transfers have been implemented; combined second and third toe transfer,[5,9] combined second and third toe transfer from each foot[18] and multiple separate toe transfers.[8,19] Simultaneous multiple digit reconstruction has proved to be both time effective and economical in terms of inpatient time, recovery and in expediting return to work.

Distal digital reconstruction with foot tissues can be performed either primarily when the wound is still open or secondarily after the wound heals. Primary reconstruction is advantageous as there is less or no need at all to shorten the phalanx. Skin grafting and local or distant flap requirements are diminished as well. Primary reconstruction affords no statistically significant difference in terms of success, complications or ultimate functional result. Therefore, primary reconstruction is recommended if the local and general condition of the patient permits.

In conclusion, foot tissue transplantation provides a useful reconstructive alternative for non-replantable distal digits. Both functional and cosmetic results are superior to those obtained with other conventional techniques.

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The Authors

F. C. Wei, MD, FACS, Professor of Surgery, Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital and Medical College, 199 Tung-Hwa North Road, Taipei, Taiwan.

M. D. Epstein, MD, Chief Resident, Division of Plastic Surgery, Milton S. Hershey Medical Center, Pennsylvania State University, Hershey P.A., USA.

H. C. Chen, FACS, Associate Professor of Surgery, Chang Gung Medical College, Taipei, Taiwan.

C. C. Chuang, MD, Lecturer in Surgery, Chang Gung Medical College.

H. T. Chen, MD, Lecturer in Surgery, Chang Gung Medical College.

Requests for reprints to: Professor F-C Wei.

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