Case Reports

Thumb Reconstruction Using Amputated Fingers

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Abstract Reconstruction of an irreparably amputated thumb in multiple digit amputations using amputated fingers can considerably improve hand function and allows creation of a newly transplanted thumb with acceptable cosmetic and functional attributes. However, the surgery is challenging and rarely reported. We report six cases using this procedure in patients with crushed thumbs unsuitable for replantation. In four of the patients, the remnant of the index finger was replanted on the thumb stump and in another two patients, an amputated middle finger and ring finger were used. The patients had a minimum followup of 12 months (mean, 18 months; range, 12–45 months). All

newly transplanted thumbs survived resulting in the patients having satisfactory postoperative hand function and appearance.

Introduction

The loss of a thumb results in considerable functional disability and thus requires surgeons to make every possible effort to reconstruct the amputated thumb to preserve hand function. For thumb reconstruction, there are several well-established procedures for elective reconstruction after thumb amputation such as soft tissue coverage, gradual thumb metacarpal lengthening with or without bone grafting, pollicization of an adjacent digit, or free microvascular toe or partial toe transfer [3].

In the clinical routine of multiple digit amputations, there are, however, situations in which the amputated thumb has been totally crushed and is not suitable for replantation, whereas amputated parts of other fingers are available and replantable. To restore optimal hand function in these particular types of injuries, surgeons should consider transplanting a suitable remnant portion from other amputated fingers onto the thumb stump by means of replacing like with like [2, 7].

We describe procedures and report our preliminary results and experiences of microsurgical thumb transplantation using amputated portions of fingers after severe multiple digit amputations.

Materials and Methods

We retrospectively reviewed the records of six patients who sustained severe multiple digit amputations between

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September 1999 and April 2006. All patients sustained injury during manual labor caused by a power saw (three patients), iron press (one patient), machine press (one patient), or drill (one patient). All patients were men whose ages ranged from 18 to 42 years. The left hand was affected in four patients, whereas the right hand was affected in two patients. We transplanted four remnants of the index finger onto the thumb stump and two remnants of the middle finger and ring finger. Proper cold storage was performed for only two patients and the length of ischemia (with proper and improper storage) ranged from 8 to 14 hours. No patients were lost to followup; patients had a minimum followup of 12 months (mean, 18 months; range, 12–45 months).

Shortly after the patients' arrival and preoperative examinations, the procedure was considered and performed only after débridement of devitalized tissue under general anesthesia with a tourniquet for blood control placed on the distal third of the affected upper arm. We identified and marked all anatomic structures such as arteries, veins, nerves, and tendons of the thumb and long finger stumps. Bone shortening was performed for a suitable length of 1 to 4 cm and bone fixation was performed using Kirschner wires. After bone fixation, we routinely transposed the flexor pollicis longus and extensor pollicis longus tendons of the thumb stump on the flexor digitorum profundus and extensor digitorum tendons of amputated finger remnants using primarily end-to-end techniques. Microsurgical anastomosis of nerves, arteries, and veins was done with no tension under $\times 25$ magnification using Nylon 10-0 (Ethicon GmbH, D-Norderstedt, Germany). We performed vein grafts in all cases. The average operative time was 6 hours.

After skin closure and drainage, the affected limb was placed in a plaster splint and elevated for 10 to 15 days after surgery. Skin grafts were indicated when prior skin closure was impossible.

Identical postoperative medication was prescribed for all patients including antibiotics (3 g cefotaxime per day for

7 days), 500 mL dextran (low-molecular weight of 40,000) per day for 3 days, 3000 IU heparin per day for 5 to 7 days, 1 g aspirin per day for 14 days, analgesics (1.5 g paracetamol per day for 5 days), and vitamins as needed. A physical rehabilitation program was started on the eighth postoperative day and continued daily on an outpatient basis after discharge until the third postoperative month. We usually removed bone fixation based on radiographic evaluation.

Postoperative functional results were evaluated based on the following goals of the procedure: (1) the patients' attitude toward newly transplanted thumbs; (2) motion recovery evaluated by total active motion compared with the counterpart; (3) sensitivity recovery evaluated using a two-point discrimination test; and (4) the patient's ability to perform daily tasks with objects of different shape and dimension with the newly transplanted thumb.

Results

All six patients had successful revascularization at followup (Table 1). However, reoperations resulting from postoperative arterial or venous insufficiencies were performed in two patients, which occurred on Days 3 to 5 after surgery. The replanted thumbs were successfully salvaged using vein grafts.

Except for removal of the bone fixation device, secondary procedures were performed in two patients, including wound débridement associated with secondary thick skin grafts (one patient) and tenolysis (one patient).

The total active motion of newly transplanted thumbs ranged from 30% to 65% compared with the contralateral thumb. Recovery of sensation, as measured by the static two-point discrimination test, ranged from 10 mm to 30 mm. No painful paresthesias were experienced by any of the patients.

Table 1. Summary of patient data and postoperative functional outcomes with an average followup of 18 months

Patient number, age (years), and gender	Site	Cause of injury	Amputated fingers	HFT	Secondary procedures	Result
1, 48, M	L	Power saw	Thumb (PIP), index	Index	None	TAM, 65%; Sens, 15 mm
2, 24, M	L	Power saw	Thumb (PP), index	Index	None	TAM, 50%; Sens, 20 mm
3, 18, M	L	Power saw	Thumb (PP), index, middle	Index	None	TAM, 60%; Sens, 20 mm
4, 32, M	L	Drill	Thumb (MPJ), index, middle, ring	Ring	Tenolysis	TAM, 40%; Sens, 25 mm
5, 21, M	R	Iron press	Thumb (MS), index, middle, ring, little	Middle	Débridement and thick skin graft	TAM, 30%; Sens, 30 mm
6, 26, M	R	Machine press	Thumb (PP), index, middle	Index	None	TAM, 40%; Sens, 30 mm

HFT = heterotopic finger transplantation; M = male; L = left; R = right; PIP = proximal interphalangeal joint; PP = proximal phalanx; MPJ = metacarpophalangeal joint; MS = metacarpal shaft; TAM = total active motion; Sens = sensitive recovery.

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Patient 1

A 48-year-old man who was a manual laborer presented to our department with complete amputations of the left

thumb at the interphalangeal joint and the index finger at the proximal interphalangeal joint caused by a power saw (Fig. 1A–B). The injury resulted in soft tissue avulsion with completely destroyed local joints. The amputated thumb was severely crushed and thus replantation was impossible, whereas the amputated part of the index finger

Fig. 1A–H A 48-year-old manual laborer experienced complete amputations at the level of the IP joint of the (A) left thumb and (B) PIP joint of the index finger caused by a power saw. The amputated thumb was crushed and irreparable. Postoperative (C) lateral and (D) palmar views show the transplanted thumb using an amputated part of the index finger. Good form and acceptable function in (E) extension, (F) opposition, (G) opposition again, and (H) flexion are evident in these photographs obtained 3 years after the procedure.

appeared relatively undamaged. Because the amputated thumb was irreparable, we considered the index finger remnant for transplantation onto the thumb stump to restore length and optimize function of the injured hand. After meticulous soft tissue débridement, we performed bone shortening to match the original length of the thumb, and osteosynthesis was performed between the proximal phalanx shaft of the thumb and the middle phalanx shaft of the remnant using two crossed Kirschner wires. We sutured the extensor pollicis longus of the thumb to the extensor digitorum indicis and the flexor pollicis longus was sutured to the flexor digitorum profundus. Two lateral digital arteries, two dorsal veins, and two lateral nerves were repaired end-to-end using Nylon 10-0 (Ethicon). During the postoperative course, an acute venous thrombosis appeared on Day 5, which was detected in time and reoperation was performed using a vein graft to replace the damaged vessels. The subsequent postoperative course was uneventful and the two Kirschner wires were removed after 2 months (Fig. 1C–D). A useful functional thumb with a good cosmetic outcome was achieved. The patient was able to satisfactorily perform all grasping and pinching tasks using the newly transplanted thumb (Fig. 1E–H). Three years after the procedure, the total active motion of the transplanted thumb was 65% compared with the uninjured counterpart, whereas the two-point discrimination was 15 mm. Mild cold intolerance of the new thumb was reported during the first 2 years after surgery.

Patient 2

A 21-year-old man who was a manual laborer sustained a severe crush-avulsion injury to the right hand caused by an iron press. Skin, soft tissue, and hand muscles were severely crushed. Carpal and metacarpal bones were intricately fractured and dislocated. All digits of the right hand were avascular with no circular refill in the fingertips (Fig. 2A–C). This patient was refused treatment at two other hospitals before coming to us. By that point, the ischemia period was 6 hours and the damaged hand had not been properly stored.

Under general anesthesia and tourniquet for blood control, we performed débridement of all devitalized soft tissues and bones. The thumb was completely crushed at the distal half of the metacarpal bone and thus irreparable. The index, middle, and ring fingers also were completely amputated at the metacarpophalangeal joint. The little finger was incompletely amputated at the distal third of the metacarpal bone, avascular as a result of the fact that both lateral neurovascular bundles were severely damaged, and connected to the proximal stump only by a small dorsal skin bridge. The triquetrum, capitate, hamate, trapezoid,

and metacarpal bones II, III, and IV and the distal half of metacarpal I were so irreparably broken and dislocated that they had to be removed. Most of the hand muscles were severely injured and nonviable. The devitalized muscles caused by the injury were spread over the wrist and reached the distal third of the affected forearm (Fig. 2D–G).

Examining amputated parts of the fingers revealed a remnant of the middle finger that was slightly damaged but transplantable and could be used for thumb reconstruction to create a pincer's jaw for the right hand. After débridement of soft tissue, we performed bone shortening of both ends and fixation between metacarpal I and the proximal phalanx of the amputated middle finger in opposable position using Kirschner wires. We performed heterotopic thumb transplantation and replantation of the little finger in the usual manner (Fig. 2H–K). Because of extensive vessel damage, vein grafts harvested from the affected forearm were used for vascular repair in both digits. The postoperative course was uneventful, although some damaged muscles became necrotic in the hand and distal third of the right forearm that continued until the third postoperative week. We excised the necrotic muscles and secondarily obtained skin coverage using a thick skin graft. Kirschner wires were removed after 10 weeks. One year after the initial injury, the patient could perform tasks with his newly reconstructed pincer's jaw (Fig. 2L–M) including necessary grasping activities of daily life (Fig. 2N–O). The total active motion of the replanted little finger was 60% and the total active motion of the newly transplanted thumb was 30% compared with the uninjured counterpart.

Discussion

The thumb provides 40% to 50% of total hand function[8]. Thumb transposition using amputated finger remnants is a salvaging procedure in which the greatest functional digit is reconstructed using discarded remnants of other fingers [6]. The major advantages of this surgery are the use of the most suitable resource without donor-site morbidity, allowing creation of a newly transplanted thumb with acceptable function, which helps the patient avoid multiple secondary operations and reduces hospitalization costs.

Although heterotopic digit transplantation to optimize hand function and form in multiple digit amputations was first performed in 1971 [4], this surgical procedure is rarely reported. In 1985, Chiu et al. [5] reported two successful cases of digital transplantation in which the amputated middle finger was replanted onto the index finger stump, and in another case, the amputated little finger was replanted on the thumb stump. A dramatic case of cross-hand replantation was published by Adkins et al. [1] in 1992. They reported successful emergency replantation of the amputated intact

Fig. 2A–O Preoperative (A) palmar, (B) dorsal, and (C) lateral views show the severe right hand injury caused by a machine press in a 21-year-old man. Most hand muscles were totally crushed. Carpal and metacarpal bones had complicated fractures and dislocation, and the thumb was crushed, amputated, and therefore irreparable. The index, middle, ring, and little fingers were avascular and severely injured. Preoperative (D) lateral and (E) anteroposterior radiograms were obtained. Photographs show the hand condition from the (F) palmar and (G) dorsal views after debridement of devitalized soft

tissue and bone. Postoperative (H) anterior and (I) medial views of the newly formed hand and digits following heterotopic replantation are shown. (J) Osteosynthesis was performed using Kirschner wires. (K) A postoperative view of the newly replanted thumb and finger after 2 months is shown. Photographs of the hand (L) in palmar and (M) dorsal views were obtained 1 year after surgery and show the pincer's jaw of the right hand. The patient has effective use of the reconstructed pincer's jaw to perform most activities of daily life (N) such as writing or (O) holding objects.

right hand to the left distal forearm after an extensive crushing injury in a patient with a followup of 9 years. An et al. [2], Bartlett et al. [3], and Schwabegger et al. [7] also have reported results of replantation.

Microsurgery and replantation surgery are fairly new procedures in Vietnam. After 4 years of microsurgical training (1995–1999) in the Department of Plastic and Reconstructive Surgery at the University Hospital “rechts der Isar” of the Technical University of Munich, Germany by the first author (NTH), and through training programs sponsored by the Operation Smile International microsurgery missions of the United States in Vietnam from 1989–2004, our microsurgical team in the Department of Reconstructive Surgery and Hand Surgery at the

University Hospital 108 in Hanoi, Vietnam is capable of independently and effectively performing almost every microsurgical procedure such as limb replantation after amputations and free tissue flap transfer. For replantation procedures, there is an available microsurgical team on call 24 hours a day to perform the surgery shortly after patient arrival.

Thumb reconstruction using amputated finger remnants in severe hand injuries or multiple digit amputations are not established nor mentioned in the literature of hand surgery in Vietnam. In the current series, six patients undergoing thumb reconstruction using finger remnants during a 7-year period were included. In four cases, we had the opportunity to restore length and function and normal appearance of the

thumb, including the nail, soft tissue, and bone, in a one-stage operation by using an amputated part of the index finger. In these patients, as a result of the osteosynthesis performed between the proximal phalanx of the thumb and the middle phalanx of the index finger, both joints of the newly transplanted thumb were preserved such that the distal interphalangeal joint of the index finger functioned as the interphalangeal joint of the original thumb. Postoperative functional recovery showed the total active motion was from 40% to 65% compared with its uninjured counterpart and two-point discrimination was 15 mm to 30 mm. All patients were satisfied with the favorable function and form of the newly transplanted thumb. We used a ring finger remnant in one thumb reconstruction to achieve a more useful hand for grasping and handling objects.

For extremely and severely injured hands as that of our patient in whom the middle finger remnant was used, the indication should be determined only after débridement of devitalized tissues. In this case, the amputated thumb was irreparably injured; however, the middle finger remnant was transplantable. The patient was young, affected in the right hand, and strongly desired replantation. The goal of surgery in this case was to create a pincer's jaw in the new hand to achieve better manipulation in performing daily tasks. Despite an unsightly cosmetic appearance, the patient nonetheless was satisfied with the new hand's pincer jaw and could use it effectively in most daily tasks. If the procedure had not been performed, there would have been a considerable functional deficit of the right hand requiring multiple secondary reconstructions. The postoperative functional results in this patient were far better than those provided by prosthetic devices or other reconstructive procedures.

In our experience with cases in which only two fingers are replanted to create a pincer's jaw, as in our patient, the position of both remaining fingers must be correctly designed such that the opposing fingertips are slanted toward each other to be able to hold small objects. Furthermore, the postoperative appearance of the hand must be discussed with patients before surgery. Based on the survival rate and postoperative final functional outcomes, our first results relating to the procedure are encouraging.

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