Microsurgical Toe to Thumb Transplantation for Traumatic Thumb Loss

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Abstract

Toe-to-thumb transfer was performed on 13 patients with traumatic thumb loss, using microvascular technique. Of those, 9 patients had industrial injury, 3 patients had a sharp cut injury and the remaining one had animal bite injury. The toes used for the transfer were the great toe(5), and the second toe(8). There were twelve successes, and one partial success. Ten patients have been followed-up for more than 12 months, and they are reviewed in detail. Total active motion after great toe and second toe transfer was 45° and 68° respectively. Static two-point discrimination was 10-15 mm in 10 patients. The donor foot did not suffer functionally. All of the patients returned to gainful employment postoperatively.

Key word : Toe to Thumb Transplantation, Microsurgical Technique, Traumatic Thumb Loss

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Toe-to-hand transfer has passed its century mark since Carl Nicoladoni transplanted the second toe to substitute for the missing thumb on June 8,1898[1]. This pedicled toe transfer has had many disadvantages such as patient discomfort as to position, multiple stages operation, as well as poor motion and sensation due to inaccurately sutured nerves, so it was not popular although further refinements have been attempted to improve this situation[2-5]. Jack E- Davis, with his nicely written article for those interested in this toe-to-hand transfer, anastomosed the small artery for his toe-tube transfer before the microsurgical era, although this was not a single stage transfer[6]. When the microsurgical era begun, single stage toe-to-hand transplantation proved possible after successful replantation. Harry J Bunke in 1964 successfully performed great toe-to-hand transplantation in Rhesus monkeys[7]. The first clinical case of great toe to thumb transplantation was performed by Cobbett JR in 1968[8]. In 1973, the American Replantation Mission to China reported that Yong had performed the first successful clinical transfer of a second toe to the thumb in 1966[9]. Then reports of successful toe-to-hand transfer appeared from many parts of the world[10-14].

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The authors have a number of cases with traumatic thumb loss which were reconstructed by toe transfer. This includes the first case of toe-to-thumb transplantation in Thailand on January 7, 1983. Our experience in toe-to thumb transfer also included great toe and second toe transfer, which are presented here. Furthermore, the great toe wrap-around procedure will be reported separately.

MATERIAL AND METHOD

From January 1983 to December 1998, 13 toe-to-thumb transplantations were performed. There were 12 males and one female with their ages ranging from 13 to 45 years with a mean age of 25 years. The dominant hand was involved in 9 patients, the nondominant hand in 4. The majority of the absent thumbs had been amputated traumatically, in 9 patients by industrial injury and in 3 by sharp cut. Only one case had lost the right thumb by animal bite.

Thumb reconstruction was performed using the great toe in 5 patients and the second toe in 8 patients (Table 1).

The method applied was that described by O'Brien et al[15,16], with minor modifications.

Preparation of the recipient site included isolation of the two volar digital nerves and dorsal digital nerves, the radial artery at the anatomical snuffbox, and dorsal veins (Fig. 1C). We preferred to transfer the dorsal veins from the index finger, because we harvested a very short pedicle of the veins from the foot. The flexor pollicis longus and the extensor pollicis longus were identified at the wrist level.

A Y-shaped incision was made in the dorsum of the foot but in some cases the flaps were used also to cover the skin defects on the hand. The foot dissection was begun proximally, and the dorsalis pedis artery, the first dorsal metatarsal artery, the deep peroneal nerve, the short dorsal veins and extensor hallucis longus or the long extensor of the second toe were harvested. Plantarly, the flexor hallucis longus or the long flexor tendon of the second toe was drawn from behind the medial malleolus, and two digital nerves were taken. The metatarsophalangeal joint was then disarticulated or the metatarsophalangeal joint was removed, and the toe was brought up to the hand for transfer. (Fig. 1D).

Bone fixation was performed by using interfragmental screws (Fig. 1E) or two oblique Kirschner wires. The long flexor and extensor tendons of the toe were repaired to the tendons of the hand at the wrist level. With the operating micro-

Table 1. Patient demographics.

Patient No	Age (Years)	Sex	Hand Dominant	Injured side	Level of amputation	Operation	Remarks
1.	20	M	R	R	D/3 MC	Second toe	-
2.	25	M	R	L	MP joint	Second toe	-
3.	19	M	R	R	M/3 MC	Second toe	Post operative infection.
4.	45	M	R	L	M/3 MC	Great toe	-
5.	40	M	R	R	P/3 MC	Great toe	First web space reconstruction
6.	27	M	R	L	P/3 MC	Great toe	First web space reconstruction
7.	30	M	R	R	D/3 MC	Second toe	
8.	22	M	R	R	D/3 MC	Second toe	
9.	21	M	L	L	M/3 MC	Second toe	First web space reconstruction
10.	24	M	R	R	M/3 MC	Second toe	
11.	18	M	R	R	M/3 MC	Second toe	
12.	22	M	R	R	C	Great toe	Iliac bone graft and posterior interosseous flap for palm reconstruction
13.	13	M	R	L	P/3 MC	Great toe	

Legend: MP, metacarpophalangeal; MC, metacarpal; C, carpus; P, proximal; M, middle; D, distal.

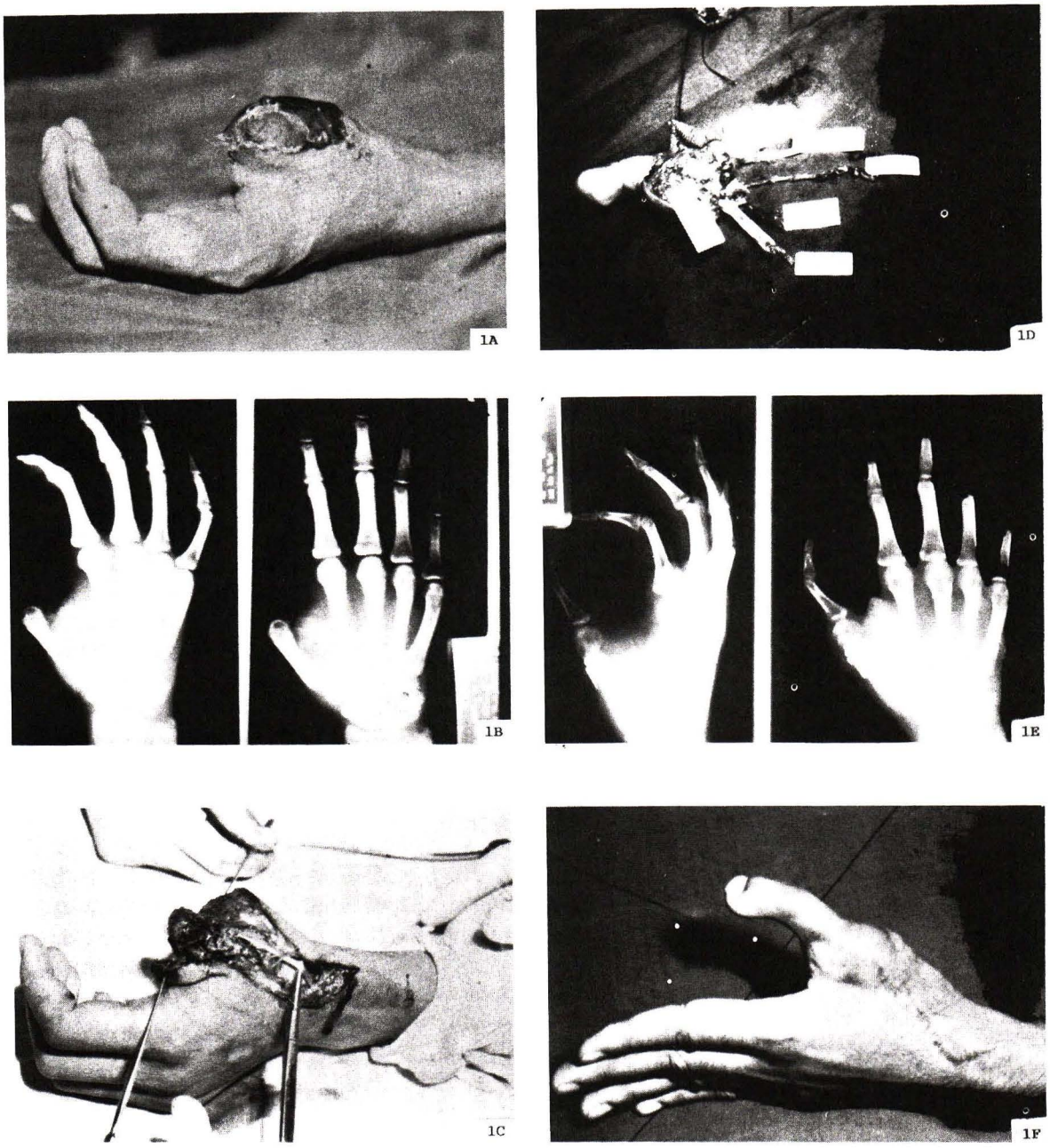


Fig. 1. (A,B) A 25-year-old male who sustained an amputation of his left thumb through the metacarpophalangeal joint. (C), The dissection of the recipient structures in the thumb. (D), The completely separated second toe transplant with all structures. (E) Bony stability was achieved with the interfragmental screws. (F,G), Six months after surgery. The healed second toe transplant in position, showing good opposition and good pinch.

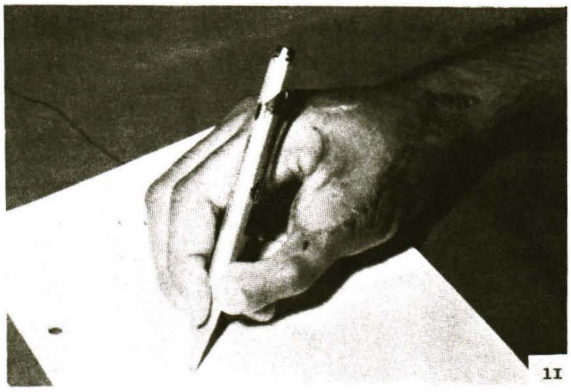


Fig. 1. (F,G), Six months after surgery. The healed second toe transplant in position, showing good opposition and good pinch. (H), The strong tubular grasp and grip have been restored. (I), Is shown writing.

scope, the digital nerves and the deep peroneal nerve were anastomosed. The dorsalis pedis artery was anastomosed to the superficial radial artery at the snuffbox, and the short one or two dorsal veins were anastomosed at the amputated site. The split-thickness skin graft was placed dorsally to cover a portion of the wound which could not be covered with simple suture.

The patients were given 900 mg of aspirin daily for 2 weeks, 500 ml of intravenous dextran daily for 3 days and antibiotic therapy for one week. Immobilization by splint was maintained for 2 weeks.

RESULTS

Survival of the transplant was complete in 12 patients. There was only one partial loss of the second toe, because of postoperative infection. Ten patients were followed-up for more than 12 months and the details of these patients are given in Table 2.

Some typical results are shown in Fig. 1 to 2.

DISCUSSION

For traumatic amputation of the thumb, no reconstruction can do better than the original one, so we are convinced again that replantation of the thumb should always be attempted and that only when the thumb has been lost which means that 40-50 per cent of hand function has been lost, will we consider thumb reconstruction, which should provide position, stereognosis and motion (2). According to Graham Lister(17), the thumb requires even more attributes, i.e. position, stability, strength, length, motion, sensibility and appearance. We think that all aspects are equally important so nowadays we preserve thumb lengthening and osteoplastic reconstruction which cannot give motion, sensibility and good appearance for those patients who do not agree to sacrifice the toes. Pollicization regarding sensation, is superior to any other procedure, was proposed for proximal thumb loss with the basal joint destroyed and enough digits intact. The metacarpophalangeal joint of the pollicized digit can replace the basal joint and it can be performed with or without tendon transfer, but it also has many drawbacks.

Aside from the complexity of the procedure, for toe transfer, patient acceptance was very important. Hemipulp or wraparound procedure did

Table 2. Results of active range of motion and static two-point discrimination.

Patient No	Follow-up (Mo)	Active ROM (degree)				Static two-point Discrimination (mm)
		MP	PIP	IP	DIP	
1.	18	0/30	20/60		15/25	12
2.	20	0/10	25/70		20/25	11
3.	Postoperative infection and partial necrosis	-	-	-	-	-
4.	12	0/20	-	25/50	-	15
5.	16	10/30	-	20/40	-	12
6.	18	10/30	-	20/55	-	8
7.	14	0/20	25/60	-	15/30	13
8.	12	0/25	20/50	-	20/30	12
9.	14	10/35	30/65	-	15/25	12
10.	13	0/20	30/70	-	20/20	11
11.	13	10/35	20/70	-	15/25	10

Legend : MP, metacarpophalangeal; PIP, proximal interphalangeal; IP, interphalangeal; DIP, distal interphalangeal.

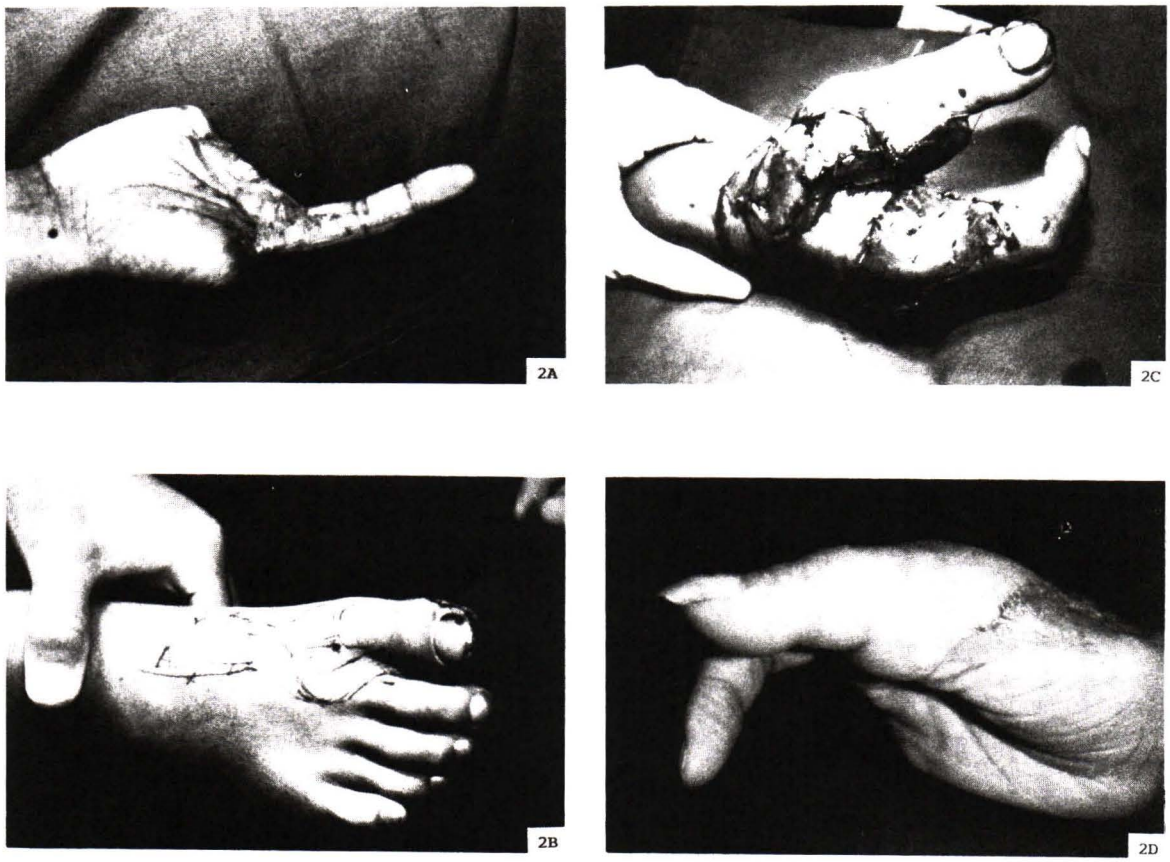
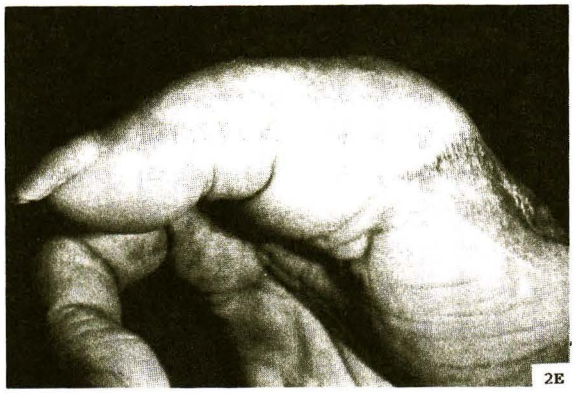


Fig. 2. **(A) Loss of thumb, middle, ring and little fingers in a 40-year-old male. (B) The great toe was together with the skin flap from the dorsum of the foot. (C), Findings immediately after surgery. (D,E), Interphalangeal joint and metatarsophalangeal joint motion.**



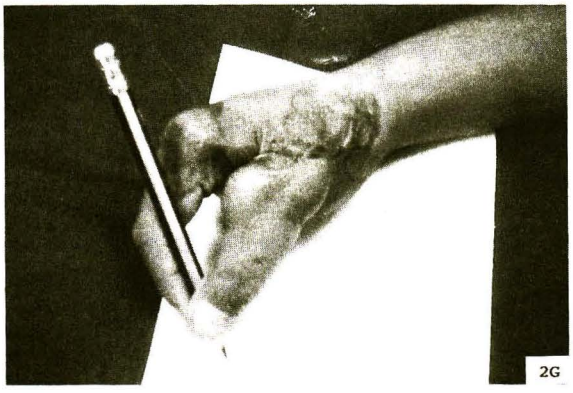


Fig. 2. (D,E), Interphalangeal joint and metatarsophalangeal joint motion. (F), The ability to grasp a large object has been restored. (G), He is able to write again.

not pose any problems, but when the whole toe was discussed, most of the patients were reluctant. Firstly, most of our patients are Buddhists, they believe that the foot can not be used to pray to the LORD Buddha. Secondly, they were afraid of losing not only the thumb but also the toe. Thirdly, they can return to their birthplace, be free from competition and find support from their family.

In cases of subtotal amputation with preserved metacarpophalangeal joint, actually we prefer the great toe wraparound procedure because the cosmetics are nicer, the patients prefer that the whole toe not be sacrificed, but its use is limited due to the lack of growth potential and immobility of the distal joint which is important to some patients. Therefore, in cases of subtotal amputation with preserved metacarpophalangeal joint in children or in adults for whom the interphalangeal motion is critical, such as with craftsmen or in the oligodactylous hand, we choose toe transfer for reconstruction.

It is amputation at or proximal to metacarpophalangeal joint that toe transfer plays a major role. A controversy exists as to which toe and which procedure should be appropriate for the patient, the great toe might be too big while the second toe might be too small. The final decision was influenced by the patient when everything about the operation, both donor and recipient sites were discussed in detail. The second toe was preferred because of the excellent foot cosmetics with no impairment of gait even in a high performance athlete. In Asian countries like Japan, because of the custom of wearing "zori" slippers which is compromised by a loss of the great toe[11] and China where acceptable appearance can be provided by the second toe, the additional advantage is that the entire metatarsus can be taken without impairing foot activity[18]. The three main drawbacks are the appearance on the hand, claw deformity, less strength, and the cosmetic result when compared to the great toe.

When the hand function is severely impaired, as with an oligodactylous and metacarpal hand, we prefer the great toe transfer because it results in a stronger grip, palmar and lateral pinch (19). Whether the great toe can be harvested proximal to metatarsophalangeal joint without preserving the head of the first metatarsal bone is another concern. Many reports were concerned about preserving it or at least preserving its plantar

surface[13,20] .This should be decided by the demand of the new thumb, whether movement of metacarpophalangeal joint is critical or not. Frequently we harvested the whole metatarsophalongeal joint and these patients are doing quite well except for the foot deformity, they can walk well but can not run as fast as before. Also for amputation with violated carpometacarpal joint, the choice of reconstruction was the whole great toe transferred with part of the metatarsal bone at the corresponding length. In this group, movement of the great toe interphalangeal joint and metatarsophalangeal joint is quite adequate when the basilar joint was fused in a good position. The thumb is less mobile but more stable and functions much better. The cosmetics of the whole great toe transfer was quite pleasing for us, although the trimmed toe transfer was superior as published by Fu-Chen Wei[21]. Gary K Frykman's report showed that the transferred great toe shrinks an average of 5 per cent in circumference, which is calculated as 10 per cent reduction in volume[13]. But in those who demonstrate an obvious size difference between their great toe and the remaining normal thumb, we will wait and see whether the new thumb size will be reduced satisfactorily with time, if not we will trim it later.

Pre-operative angiography is not essential if the case is uncomplicated, for we always find the radial artery in the snuffbox suitable as the recipient vessel. If the dorsalis pedis and the first dorsal metatarsal pulse are not easily palpable in the donor foot we should be prepared to harvest plantar vessels. It depends on the history prior to the foot trauma that we agree to perform preoperative angiography but in our patients, we have not had such a case.

Our operative technique resembles that of the pioneers in this field who pointed out several things such as rigid osteosynthesis, secure tenorrhaphy at the wrist to avoid adhesion and as many nerve sutures as possible[20]. Most interesting is that for vessel anastomoses, we anastomose only one artery and one vein, although most authorities have emphasized anastomosing as many vessels as possible. Chen Zhong-Wei performed digital replantation with one artery and one venous anastomosis[9] and we are quite confident with this procedure as we have the experience of over 1,500 digital replantations[22].

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ย้ายนิ้วเท้าแทนที่นิ้วหัวแม่มือโดยวิธีจุลศัลยกรรมในผู้ป่วยที่นิ้วหัวแม่มือขาดเนื่องจากอุบัติเหตุ

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การผ่าตัดย้ายนิ้วเท้าไปแทนที่นิ้วหัวแม่มือโดยวิธีจุลศัลยกรรมในผู้ป่วย 13 ราย ที่ประสพอุบัติเหตุนิ้วหัวแม่มือขาดหายไป ผู้ป่วย 9 รายได้รับอุบัติเหตุจากเครื่องจักรในโรงงานอุตสาหกรรม 3 ราย เกิดจากของมีคมบาด และ 1 รายเกิดจากเสือกัด การผ่าตัดใช้นิ้วหัวแม่เท้า 5 รายและนิ้วเท้าที่สอง 8 ราย ได้รับความสำเร็จ 12 ราย มีเพียง 1 รายที่มีบางส่วนของนิ้วเท้าที่สองเสียไป ได้ติดตามผลการรักษามากกว่า 12 เดือนในผู้ป่วย 10 รายพบว่า ในผู้ป่วยที่ย้ายนิ้วหัวแม่เท้าขึ้นมามีการเคลื่อนไหวของข้อต่อรวมกัน 48 องศาและ 68 องศา ในรายที่ย้ายนิ้วเท้าที่หนึ่งและสอง และความรู้สึกของปลายนิ้วทั้ง 10 ราย ได้ค่า static two-point discrimination 10-15 มม. ผู้ป่วยทุกรายพอใจในผลการรักษา สามารถใช้เท้าได้ดีและสามารถกลับไปทำงานเดิมได้

คำสำคัญ : การย้ายนิ้วเท้าแทนที่นิ้วหัวแม่มือ, การผ่าตัดด้วยวิธีจุลศัลยกรรม, นิ้วหัวแม่มือที่ขาดเนื่องจากอุบัติเหตุ

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