

Vascularized toe-to-finger joint transplantation

11 patients followed for 4 years

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Since 1983, we have transplanted 11 free vascularized joints in 8 men and 3 women, mean age 32 years. The causes of joint involvement were trauma in 9 cases and infection in 2. One MP and 10 PIP joints of the second toe were transplanted to 3 MP and 8 PIP joints of the fingers. After a mean postoperative follow-up period of 4 years, the mean postoperative range of motion was 31° compared with 16° preoperatively. Radiographs showed destruction of 4 PIP

joints, probably caused by vascular failure in 2 joints and infection in 2. In spite of no evidence of arthrosis, some of the joints had gradually undergone a loss of extension.

Although there are some problems that should be overcome, we advocate a free vascularized toe-joint transplantation for severe finger-joint destruction without extensive surrounding soft-tissue damage.

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Free vascularized toe-joint transplantation for reconstruction of destroyed finger joints was described in 1980 by Watanabe et al. Since 1983, we have carried out this procedure for 11 joints in 11 patients.

The purpose of this paper is to report our results and to discuss the problems associated with vascularized toe-to-finger joint transplantation.

One MP joint of the second toe was transplanted to one MP joint of the thumb. Ten PIP joints of the second toe were transplanted to two MP and eight PIP finger joints. Extensor tenolysis was performed postoperatively because of adhesions in 3 cases and bone grafts were performed because of delayed union in 2 cases.

Materials and methods

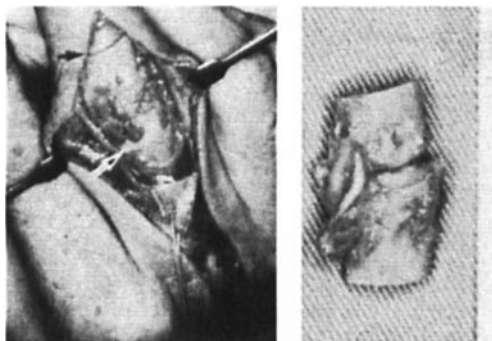
11 patients (8 men and 3 women) with finger-joint destruction were treated by free vascularized toe-joint transplantation (Table 1). Their mean age was 32 (18-48) years at the time of surgery. The thumb was affected in 1 case, the index finger in 3, the long finger in 4, the ring finger in 1, and the little finger in 2 cases. Three MP joints and eight PIP joints were affected. The causes of joint involvement were trauma in 9 cases and infection in 2 cases.

The mean preoperative range of motion of three MP joints was 20° (0°-40°): 23° of flexion and -3° of extension. The mean preoperative range of motion of eight PIP joints, which included five ankylosed joints, was 14° (0°-70°): 27° of flexion and -13° of extension. The patient who had a 70° range of motion had severe pain with marked instability. Seven patients complained of joint pain. Joint instability was seen in 7 patients. Preoperative radiographs showed joint destruction in 6 patients, a joint defect in 4 patients, and bony ankylosis in 1 patient.

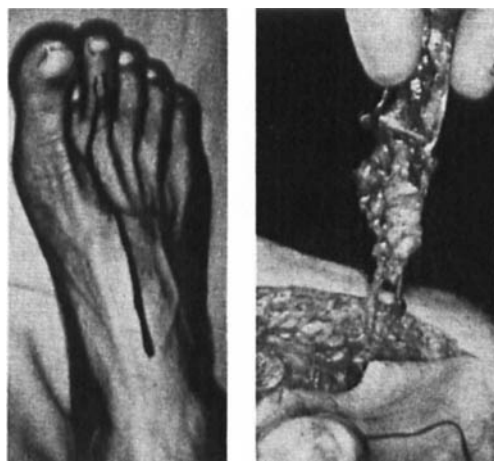
Table 1. Patients' data and results

A	B	C	D	E	F	G	H	I	J	K	L
1	35	F	I	M	1	0	0	73	65	-35	0
2	30	M	III	P	1	-10	10	71	80	-30	0
3	20	M	II	M	1	20	0	63	65	-20	0
4	48	M	II	P	2	0	0	60	30	-20	1
5	35	F	V	M	1	50	-10	47	45	-10	0
6	26	M	II	P	1	15	-15	42	75	-50	0
7	42	M	III	P	1	30	-10	40	65	-40	0
8	29	M	III	P	2	60	-40	33	65	-35	1
9	35	M	IV	P	1	70	0	32	90	-40	1
10	36	F	III	P	1	50	-50	31	30	-15	1
11	18	M	V	P	1	0	0	29	80	-50	0

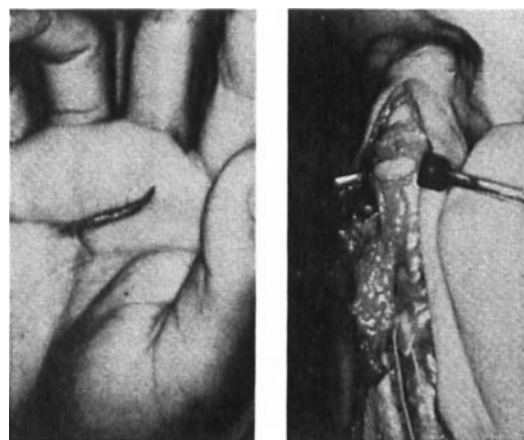
A Case	H Preoperative extension (degrees)
B Age	I Follow-up time (months)
C Sex	J Postoperative flexion (degrees)
D Affected finger (I-V)	K Postoperative extension (degrees)
E Affected joint M MP P PIP	L Arthrosis of transplanted joint 0 no 1 yes
F Cause of finger involvement 1 trauma 2 infection	
G Preoperative flexion (degrees)	



The injured joint is excised, including the volar plate and collateral ligaments.



An incision is made on the dorsal aspect of the foot with a small skin island over the PIP joint as a monitoring flap of the transplanted joint. First, the dorsal metatarsal artery and the dorsal cutaneous vein are dissected to serve as nutrient vessels.



The toe joint is transplanted and stabilized with Kirschner wires. Nutrient vessels of the transplanted joint are anastomosed to the cutaneous vein and common digital artery of the hand.

At follow-up 4 (3-6) years postoperatively, we examined and evaluated the range of motion, pain, stability of the finger, gait disturbance, and radiographic appearance.

Operative technique

Recipient site. A longitudinal incision is made on the dorsal aspect of the affected finger joint. The injured joint is excised, including the volar plate and the collateral ligaments, while the flexor tendon sheath is preserved undisturbed (Figure 1). The lateral band of the extensor mechanism should be preserved if possible. The dorsal cutaneous vein and common digital artery are identified in the dorsal and palmar aspects of the hand for anastomosing with the donor vessels.

Donor site. An incision is made on the dorsal aspect of the foot preserving a small island of skin over the PIP joint as a monitoring flap of the transplanted joint. The first dorsal metatarsal artery and dorsal cutaneous vein are identified and divided distally. The tibial-side digital artery is dissected together with the transplanted joint, while the fibular-side neurovascular bundle is preserved to maintain the circulation of the distal part of the second toe. After elevating the middle phalanx by a disarticulation through the DIP joint, the transplanted joint, including the floor of the flexor tendon sheath and a suitable length of extensor tendon, is dissected from the surrounding soft tissue. After an osteotomy of the proximal phalanx, the transplanted joint is sutured to the foot only via the nutrient vessels, and its circulatory condition should be confirmed. The donor joint defect can be treated either

by a resection arthroplasty or by an arthrodesis with corticocancellous bone from the ilium.

Transplantation. The toe joint is transplanted and stabilized with Kirschner wires. The extensor tendon is reconstructed with strong tension with full extension of the DIP and PIP joints. Nutrient vessels of the transplanted joint are anastomosed to the cutaneous vein and common digital artery of the hand using microsurgical techniques.

Postoperative management. Active exercises are encouraged 4 weeks postoperatively.



Figure 1. Vascularized toe-to-finger joint transplantation.

Results

The mean postoperative range of motion of three MP joints was 37° (30°–45°), with 58° of flexion and –21° of extension. The mean postoperative range of motion of eight PIP joints was 29° (10°–50°), with 64° of flexion and –35° of extension. One patient complained of mild joint pain. Instability was seen in 4 patients who showed joint destruction in postoperative radiographs. No one complained of a gait disturbance, but some patients had a partial skin necrosis on the dorsal aspect of the second toe; all of these necroses subsequently healed with or without a skin graft.

In postoperative radiographs, four PIP joint showed joint destruction that was suspected as being vascular failure in 2 cases and infection in 2. Seven joints, three MP and four PIP joints, which did not have a vascular problem or an infection, did not manifest arthrosis.

The relation between the range of motion of 7 non-arthrotic patients and the follow-up period was analyzed (Figure 2). The mean range of motion was 11° preoperatively and 55° one year after the operation, but reduced gradually in the course of time. The mean flexion was 15° preoperatively, which improved to 71° one year after the operation, and then changed nominally thereafter. The mean extension deficit was 4° degrees preoperatively, but this had increased to 23° one year after the operation. The extension lag advanced gradually as time went on.

The range of motion was compared between three MP joints and four PIP joints of the finger without arthrosis. In the MP joints, the mean range of motion was 37° (58° of flexion and –21° of extension), whereas in the PIP joints it was 33° (75° of flexion and –42° of extension). Thus, the range of motion (flexion + extension) showed little difference between the MP and the PIP joints.

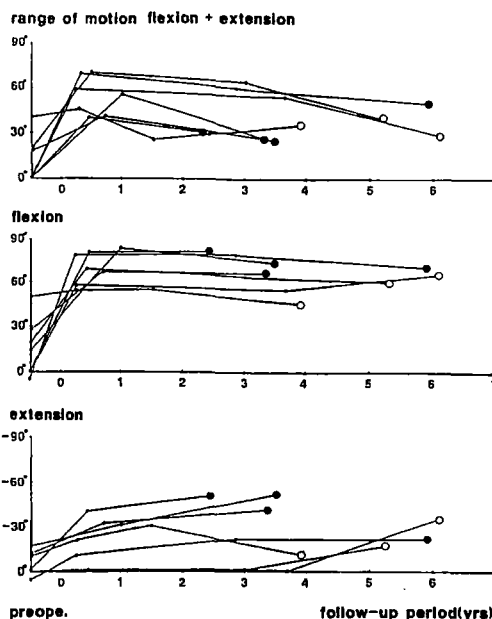
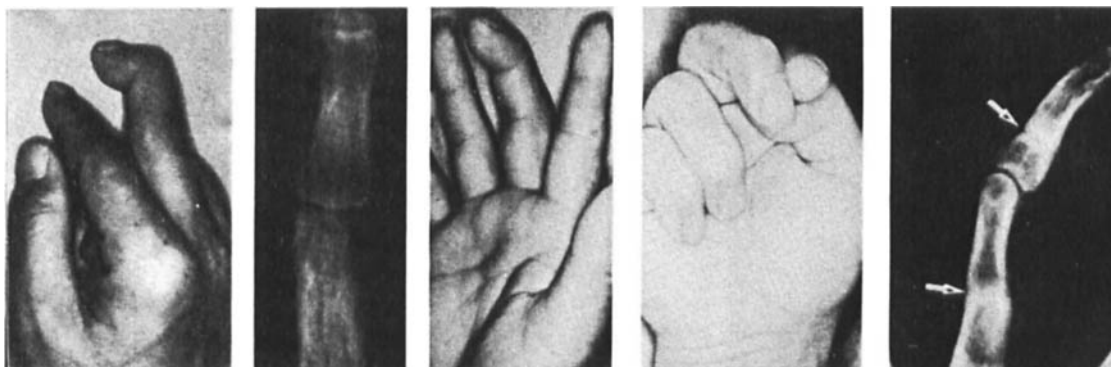


Figure 2. Relationship between the range of motion and the follow-up period. ○ MP joint of the finger. ● PIP joint of the finger.

Case reports

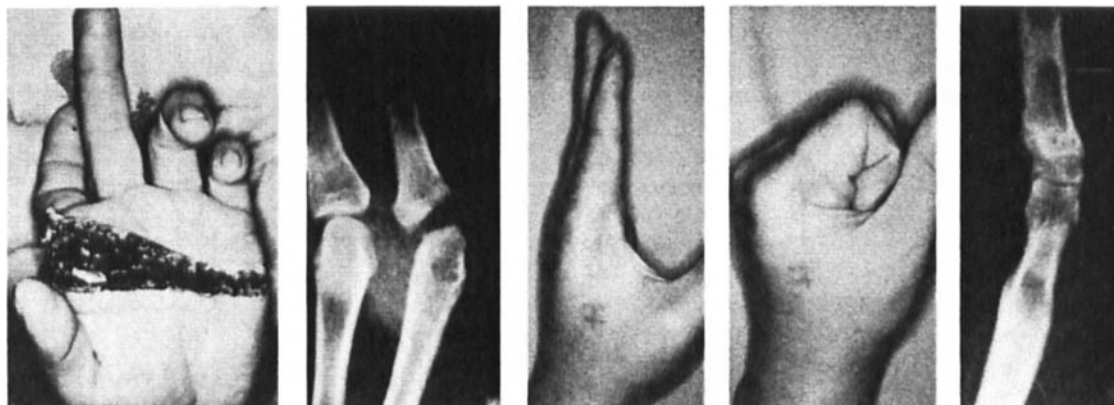
Case 2. A 30-year-old man. The PIP joint of his right long finger had been severed by an electric saw. The PIP joint was ankylosed on his first visit to our hospital 4 weeks after the injury (Figure 3). The PIP joint of the second toe was transplanted to the PIP joint of the long finger. Three years after the operation, the PIP joint had 80° of flexion and –20° of extension. Radio-



Destroyed PIP joint of the right long finger. The joint was ankylosed in 10° of hyperextension.

3 years after the operation. The PIP joint could be flexed to 80° and extended to –20°. Bone union was complete, and the transplanted joint displayed no arthrosis.

Figure 3. Case 2. A 30-year-old man. Electric saw accident.



Radiographs showed the defect of the MP joint of the index finger. A ceramic-implant arthroplasty was carried out 2 months after the injury. However, the movement of the MP joint of the index finger was restricted with pain.

3 years after the transplantation of the PIP joint of the second toe. The MP joint could be flexed to 65° and extended to -5°. The joint space of the transplanted PIP joint was maintained.

Figure 4. Case 3. A 20-year-old man. The palm of the left hand was severed by an electric saw.

graphs showed no arthrosis. Six years after the operation, the range of motion was 50°, with 80° of flexion and -30° of extension; there was no arthrosis.

Case 3. A 20 year-old man. His left hand had been severed by an electric saw (Figure 4). Tendon sutures, neuroorrhaphies, and anastomoses of vessels were carried out immediately in our hospital. Two months after the injury, an arthroplasty was performed using a ceramic implant for the defect of the MP joint of the index finger. However, because of loosening of the implant and painful limited joint motion, a joint transplantation was carried out. The PIP joint of the second toe was transplanted to the MP joint of the index finger. Three years after the operation, the range of motion was 60°, with 65° of flexion and -5° of extension. Also in this patient, there was an additional 15° loss of extension 5 years after surgery.

Discussion

A vascularized toe-to-finger joint transplantation is one of the most difficult procedures in vascularized tissue transplant surgery, for it is necessary for the transplanted joint not only to be viable, but also to move effectively. In our study, the mean range of motion was 37° in the MP joints and 29° in the PIP joints at the follow-up examination. The unsatisfactory results were attributed to a preoperative infection in two joints and circulatory insufficiency postoperatively in two joints, which had severe stiffness or instability. Etin et al. (1962), Kettelkamp (1972), and Masear et al. (1988) emphasized that the vascularity of

the transplanted joint is indispensable for the viability of the articular cartilage.

In spite of no evidence of arthrosis, some of our cases underwent extension loss. This is one of the most difficult problems to be solved. The suturing of the extensor tendon while it is subjected to strong tension and the prolonged use of a night splint postoperatively have been recommended. However, it is very difficult to restore the extensor mechanism perfectly, and the power of the flexor is usually stronger than that of the extensor. Therefore, it is difficult to prevent an extension lag.

The total range of motion showed little difference between the MP and the PIP joints; however, flexion was better in the PIP joints and extension was better in the MP joints. Because the extensor mechanism of the PIP joint is more complicated than that of the MP joint, it is more difficult to reconstruct the extensor mechanism of the PIP joint. After the transplantation of a PIP joint, it is sometimes difficult to close the skin over the transplanted joint, especially when the finger is swollen. For this reason, the donor vessels, which lie beneath the skin, risk being compressed. On the other hand, at the MP joint the skin can be closed easily, and the risk of vascular problems is less. We had no case of a circulatory disorder in the MP joints, but two of eight PIP joints had vascular insufficiency. We consider a PIP joint with contracted skin, loss of tendon, and diffuse infection to be a poor indication for a toe-to-finger destruction of joint transplantation.

Although our results were not as fruitful as we had expected them to be, a free vascularized joint transplantation is an alternative for the treatment of finger-joint destruction.

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