

## CLINICAL EXPERIENCES ON REPLANTATION OF DIGITS

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*Accepted for Publication on 21, April, 1977*

### Abstract

Present reports include 15 completely amputated digits and 7 incompletely amputated digits in 15 patients who received replantation of digits with microvascular surgery.

Overall survival rate of digits was 82 percent but results with children of smaller diameter of digits vessels less than 0.5 mm were unsatisfactory and these were left for the further discussion. Trazolin was useful for the vasodilatation to preserve effective blood supply for the replanted digits.

### INTRODUCTION

In 1960 Jacobson and Suarez introduced the usage of surgical microscope for the performance of microvascular surgery. Since the first successful report on the replantation of a completely amputated thumb with microvascular anastomosis by Komatsu and Tamai<sup>1)</sup>, many challenges have already been reported on digital replantation and or free transfer of toe-to-finger with rather high survival rate. Tamai<sup>2)</sup>, O'Brien<sup>3)</sup>, and Ikuta<sup>4)</sup> *et al.* emphasized to limit the indication of digit replantation both to thumb or index finger in case of single digit amputation and to cases of multiple digits amputations. Patients, however, especially women, ordinary ask replantation of any of their digit whatsoever when surgery is indicated. The authors therefore studied to reconfirm the operative indications of replantation of digits in 15 cases of 16 complete and 6 incomplete amputations. Cumulative successful number of digits amounted up to 18 out of 22 digits with the high survival rate of 82%. Practically replantation could be influenced by multiple factors such as causes of injury, grades of tissue damages, amputation levels of digits and age of patients etc.

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TABLE 1. Summary of

case no.	age & sex	* site of amputation	** grade	*** nature of injury	† repair of vessels
1	27 F	r-I-P-Ph	incomp	C	A-1, V-1
2	3 $\frac{3}{12}$ M	l-I-P-Ph	incomp	C	A-1, V-2
		l-III-DIP	comp	C	A-1, V-1
3	23 M	(r-II-M-Ph)	comp	C	
4	41 F	r-III-M-Ph	comp	C	A-1 V-graft
		r-IV-PIP	comp	C	A-1, V-1
		(r-V-D-Ph)	comp	C	
		r-IV-PIP	incomp	C	A-2
5	3 $\frac{1}{12}$ M	l-III-DIP	comp	C	A-1 cross suture V-1
6	58 M	r-I-D-Ph	incomp	C	A-graft
7	40 M	l-II-P-Ph	comp	C	A-2, V-2
8	60 M	l-III-PIP	incomp	C	A-1
		r-I-P-Ph	comp	C	A-2 V-cross suture
9	45 F	r-II-M-Ph	incomp	A	A-2, V-1
10	1 $\frac{9}{12}$ F	r-II-P-Ph	incomp	A	A-1, V-1
		r-III-PIP	comp	A	A-1
11	2 $\frac{2}{12}$ M	r-IV-P-Ph	comp	C	A-2, V-1
12	3 F	r-I-IP	comp	C	A-1, V-1
		(r-II-M-Ph & P-Ph)	comp		
		(r-III-M-Ph & P-Ph)	comp		
		(r-IV-DIP & P-Ph)	com		
		(r-V-D-Ph)	comp		
13	35 M	r-II-P-Ph	comp	G	A-2, V-1
		r-III-P-Ph	comp		A-1, V-1
		r-IV-P-Ph	comp		A-1, V-1
		r-V-P-Ph	comp		A-1, V-1
14	38 F	r-III-D-Ph	comp	C	A-1, V-0
15	27 F	r-II-PIP	comp	C	A-1, V-graft

\* D-Ph: distal phalanx, DIP: distal interphalangeal joint ( ): without replantation

\*\* M-Ph: middle phalanx, PIP: proximal interphalangeal joint

P-Ph: proximal phalanx

\*\* incomp: incomplete amputation comp: complete amputation

\*\*\* C: crush injury A: avulsion injury G: guillotine amputation

15 cases of digital amputation

post-operative course	†† PPT	PTT	††† results
milking on the belly of the thumb	14.0 (12.1)	100 (32.5)	S
no trouble			S
vein thrombosis [re-operation]	13.9	22.7	F
no systemic hepazinzation	(11.7)	(23.7)	late toe to finger transfer
edma			S
no trouble			S
edema	12.1	37.4	S
necrosis of the skin edge [skin graft]	(12.6)	(29.3)	
no trouble	13.3	31.7	S
	(12.3)	(31.0)	
			give up
no trouble	13.4	79.8	S
	(11.7)	(31.1)	
no trouble			S
hematoma			S
[reoperation, hemostate, & skin graft]			
hematoma in belly of M. Flex. dig. prof.	22.6	100	S
[fasciotomy in forearm]	(11.7)	(31.5)	
no trouble			S
thrombosis			F
infections thrombosis	11.3	28.5	F
	(11.6)	(28.1)	
no trouble			S
no trouble	11.2	28.0	S
	(11.1)	(28.4)	
			S
			S
			S
prolongation of venous bleeding	12.7	48.0	S
	(11.6)	(29.6)	
milking on the belly of the finger tip	12.2	24.9	S
	(12.0)	(29.4)	

† A: artery  
 V: vein  
 †† ( ): control  
 ††† S: survivable  
 F: failure

### MATERIALS AND METHODS

Patients consist of 8 males and 7 females. Their age ranges from 1 year and 3 months to 60 years. Single amputation of digits was in 10 cases and multiple amputations of digits were in 5 cases. The level of amputation varied from the proximal phalanx to the distal phalanx; proximal phalanx in 10, proximal interphalangeal joint in 6, middle phalanx in 2, distal interphalangeal joint in 2, and distal phalanx in 2. Fourteen had crushed injuries, 4 had avulsion injuries and 4 had guillotine injuries. Operations for 4 to 9 hours were performed on brachial plexus block anesthesia of single shot of 20 ml of 0.25% bupiracaine hydrochloride with adrenaline except children.

It is conclusively essential to preserve as many artery and vein anastomoses as possible, however in our individual cases we could perform 2 arteries and 2 veins for a digit, 2 arteries and 1 vein for 4 digits, one artery and one vein for 11 digits, one artery and 2 veins for a digit, and then only one artery for 4 digits. In the digits amputated patient whose vessels were severely damaged arterial and venous reconstructions were tried with grafts in 3 digits, and crossing anastomoses from another side were also performed for a couple of digits.

### CASE PRESENTATIONS

Case 2; One year and 3 months old male suffered complete amputation with severe crush injury of the left middle finger at the distal interphalangeal joint level by electric sewing machine. Replantation was started under systemic anesthesia 1 hour after the injury. For the preservation of the joint, bones were fixed with Kirschner-wire to temporary purposes without shortening. Outer diameters of vessels were from 0.3 to 0.4 mm, therefore 11-0 atraumatic nylon sutures were used to each artery and vein anastomosis. When microvascular clump was released the finger became pink and warm, and this suggested satisfactory circulation for the finger which was kept until cyanosis was recognized at 8 hours late. Reoperation revealed spasm in an anastomosed vein, and once improved by the direct milking with microforceps. After 3 days, the finger again became cyanotic, after the ceased heparinization, this replantation ended in failure. Heparin of 1000 units in the first operation, and 1000 units in every 6 hours during 3 days after the second operation were given in this case. As the summary of the causes of this failure of replantation, both the lack of systemic heparinization

and too small a diameter of vessels for the present surgical microvascular technics remained to be solved in the future trials.

Case 9; Forty-five year old woman was injured to incomplete amputation of right index finger remaining deep flexor tendon at the middle phalanx by weaving machine during her menstruation period. During the operation two arteries and a vein were reconstructed by anastomosis for the preservation of blood supply for the replantation of the finger. On the second day it was noticed that the development of swelling of forearm with severe pain. To avoid Volkmann contracture the volar fascia of flexor muscles was incised to restore the circulation. She had laceration of flexor muscles at the forearm besides the incomplete amputation of the right index finger from the beginning. A large hematoma found in the right forearm which probably due to systemic anticoagulant therapy of 20,000 units of daily heparin, may be aggra-

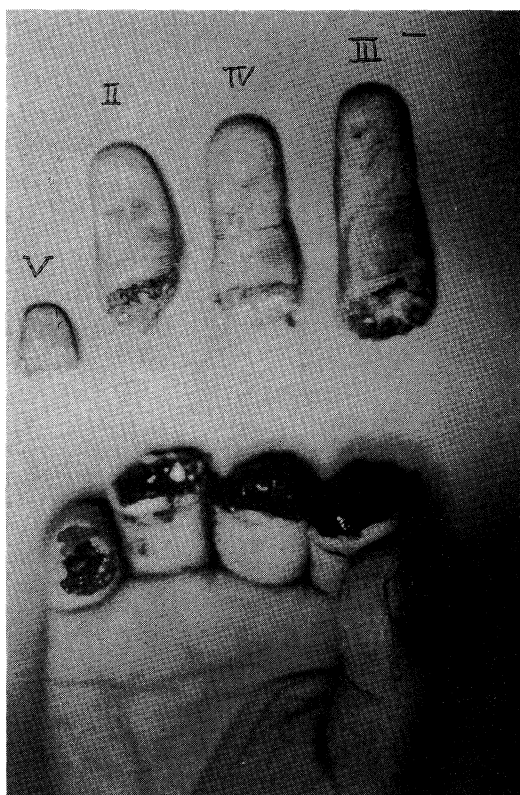


Fig. 1-A

vated by her period. Prothrombin time was 100 minutes, and this value indicates that patient was in the state of hyperanticoagulation.

Case 3; Twenty-three year old male had shearing machine crush of right second to fifth fingers. The dorsal veins of the middle finger were reconstructed with an arterial graft from ulnar side of artery of the finger. For the ring finger an artery was isolated and pulled proximally, then anastomosed end to end on rather high tension. Following the release of microvascular clump, satisfactory blood supply could not be kept probably due to vascular spasm. Finally administration of torazoline  $\alpha$ -adrenagic blocker resulted in release of spasm to restore the effective circulation. For the replanation of the index finger no available blood vessels were found in or nearly the crushed area. After seven months toe to finger transfer was tried under the reconstruction of two arteries, but blood supply through anastomosis from vein was

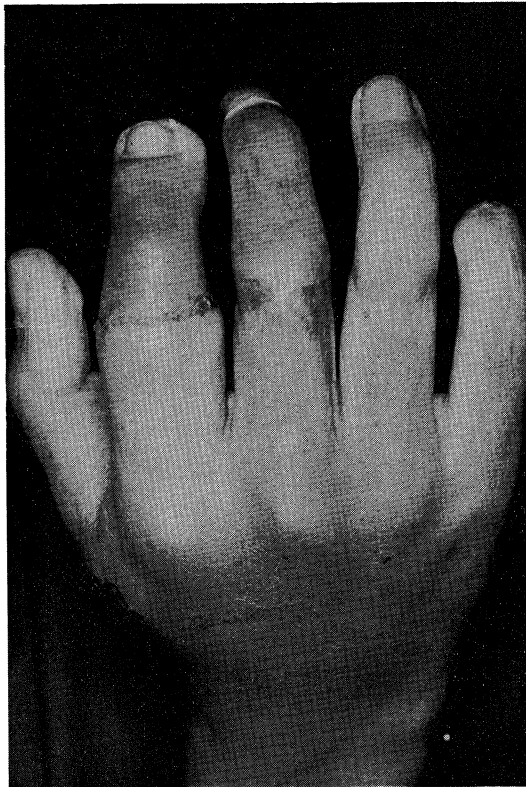


Fig. 1-B

scanty, and milking of both fingertip and anastomosed artery was not effective, then patient was placed finally on intravenous trazolin to 100 mg with gradual increase of blood supply.

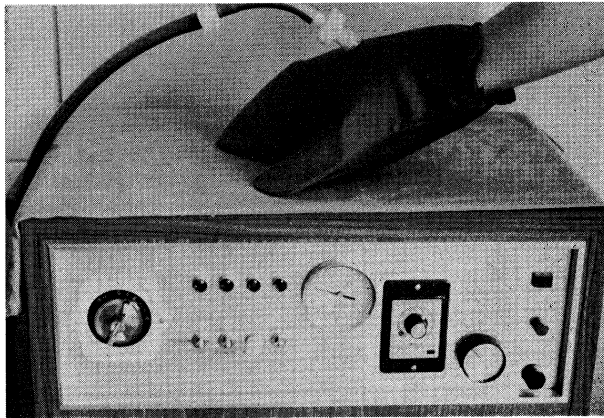
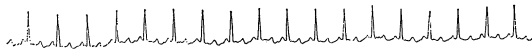


Fig. 2-A

before treatment by "compression therapy"



replantation on complete amputation at the index finger



after treatment by "compression therapy"



replantation on complete amputation at the index finger

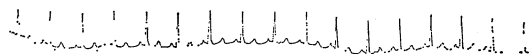


Fig. 2-B

Case 14; Thirty-eight year old female cut her middle finger at the distal phalanx when working with electric vegetable cutter. Only one artery was available for anastomosis. No vein was found for anastomosis, therefore cut end of vein was left expecting revascularization. To keep bleeding from this vein end systemic heparinization and local dropping of saline with anticoagulants were carried out for seven days. Blood transfusion of 600 ml was done until survival of replanted finger was assured.

Case 15; Twenty-seven year old female was amputated right index finger at the proximal phalanx, and had laceration of the flexor tendon and digital nerve of the thumb, and also open injury of the digital nerve of the middle finger. The index finger was replanted with anastomosis of an artery using the graft of dorsal vein of the hand. For the preservation of blood flow through this finger an intermittent air compressor was applied for three weeks after replantation. Plethysmography suggested apparent increase of blood supply after the application of the air compressor.

#### RESULTS

Cummulative success rate was 94 percent out of 16 fingers of 10 adult patients. A case of unsuccessful replanation was due to incomplete amputation of thumb at the distal pharanx with laceration. A vein graft was used for blood supply without success and reoperated for finger tip plastic.

In children ranged from 1 year and 3 months to 3 years and 1 month old, 3 out of 6 fingers of 5 children were succassfully replanted. Slenderness of vessel diameter and insignificant local postoperative immobilization were seemed to be causative factors for failure of replantation.

Concerning the survival rate the more distal level of the amputations were, the worse yields of replantation resulted. Clear amputation by guillotin showed the higher survival rate than those from crush injuries or avulsions. Judging from the reconstruction of blood supplying vessels, cases with reconstruction of arteries only, two arteries and one vein, both an artery and a vein were unsuccessful. Treating measures for the replantation of severely injured fingers the use of venous graft or cross suture was thought to be effective for the survival of the replanted fingers with the success rate of 75 percent.

The digital nerve suture in general resulted in good sensory recovery



except crushed cases of case 5, and case 10. Sensory test for 2-point discrimination also recovered up to from 3 to 10 mm in all cases operated. Suture of flexor muscle tendon was carried out in all cases except case 1. Though in some cases movement of joints were limited to some extent, all reached to the extent as usable as digital joints. As for the osteosynthesis 2 cases were treated with microscrews and others were treated with Kirschner-wire with good results without pseudoarthrosis.

#### DISCUSSION

It is generally agreed that a greater number of anastomoses would yield better results for the survival of replanted fingers. Tsai<sup>6)</sup> reported anastomoses of arteries to those of vein to be one to 2 and to 2 to 5 respectively, and O'Brien<sup>3)</sup> recommended twice the numbers of vein anastomoses to arteries for digit survival. Vein anastomoses are more difficult than arterial anastomoses in fragility of vessel walls from practical view point of suture per se and easy development of thrombosis. Failure of replantation was mainly due to failure of vein reconstruction according to O'Brien, Tsai and Tamai *et al.* In the present report many cases except 2 of them the replanted digits have survived with only one vein reconstruction. Therefore, accurate and careful vein reconstruction seemed essential for the higher survival rate of replanted digits.

The vessels of the amputated digits inclines to spasmophilic partly due to denervation hypersensitivity. Authors used 100 mg of trazoline, vasodilator by way of  $\alpha$ -adrenergic blocking<sup>7)</sup>, intravenously or locally as routine when open the microclamp. In expectation of antivasospasmodic action stellate block was negatively reported by Katai<sup>8)</sup>. Systemic heparinization is helpful as experienced in case 2, but a large hematoma in case 8, or increased tendency of hemorrhage in case 9 were also noticed and followed by reoperation on reduced heparin administration. During and after the heparinization PTT and plasma clotting time should be performed repeatedly.

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