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Secondary procedures following digital replantation and revascularisation

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SUMMARY. In this retrospective study, 79 digits of 55 patients received 102 secondary procedures following replantation. We divided the procedures into two groups, occurring before or after 2 months following replantation. The procedures in the early group were mainly for soft tissue coverage (92%), and those in that late group were mainly for tendon (67%) to improve function. Factors associated with higher incidence of early secondary procedures included multiple-finger injury, avulsion or degloving injury and level of injury proximal to zone III in finger replantation ($p < 0.05$). However, younger patients and those with proximal level replantation in fingers had more late secondary procedures ($p < 0.05$). Flexor tenolysis procedure significantly improved the digital function after replantation ($p < 0.05$). © 2003 The British Association of Plastic Surgeons. Published by Elsevier Science Ltd. All rights reserved.

Keywords: secondary procedures, digital replantation, tenolysis.

Introduction

The causes of poor functional result after digital replantation include scar contracture, tendon adhesion, joint stiffness, malunion of the fracture site, and, poor sensory recovery. In addition to the rehabilitation program, secondary procedures are sometimes needed in order to achieve better functional recovery. The incidence of secondary procedures following replantation reported in the literatures ranged from 15 to 80%, mostly around 50%.[1–9] The primary reasons for the secondary operations are for soft tissue coverage, improvement of range of motion, and to release contracture.[1–4,9] Only a few papers discuss in detail secondary procedures after replantation.[1,7–9] Different secondary procedures are needed in different post-operative periods. For instance, exploration and revision of the vascular anastomosis are commonly encountered in the first few days. In the following period, secondary procedures for treating soft tissue defect may be needed especially for degloving or avulsion injuries. Tenolysis may be beneficial to the functional recovery of the replanted digits yet cannot be done early lest there be rupture of the repaired tendon.

This study reviews the experience of secondary operations after replantation in our series. We reviewed those patients who needed secondary procedures to determine the factors associated with higher incidence of secondary procedures, and, the differences in the secondary procedures performed at the early and late period after replantation surgery. The effectiveness of flexor tendon tenolysis following digital replantation, which was the most common late secondary procedure, was also evaluated by comparing the pre-tenolysis and post-tenolysis results.

Patients and methods

From August 1990 to December 1997, 287 procedures were performed distal to wrist level in 187 patients at National Cheng Kung University Hospital (NCKUH), which include either replantations in complete amputations or revascularisations in incomplete amputations with vascular compromise. A total of 79 digits in 55 patients received 102 secondary procedures following replantation. Patients receiving salvage procedures for vascular complications and stump management in failed replants were excluded. All charts were reviewed. Data reviewed included sex, age, mechanism of injury, level of amputation, number of injured digit, number and nature of secondary procedures. The final functional results of flexor tendon tenolysis were collected by chart review and patient call back.

Secondary procedures were divided into two groups: early and late in which procedures were performed before or after 2 months following replantation. Type of injury is classified based on its mechanism as guillotine, crushing, and avulsion or degloving. The level of amputation was defined according to the classification of the International Society of Reconstructive Microsurgery in 1980.[10] There were 17 patients with 35 replantations receiving tenolysis. The results of tenolysis were evaluated

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by total active motion (TAM[11]) and Tamai's scoring system.[3]

We used the Chi-square test to analyse the statistical significance of the factors related to the incidence of secondary procedures following replantations. If the sample numbers were too small, Fisher's exact test was used for correction. The functional results of tenolysis following replantation were analysed by paired *t*-test.

Results

Among the 287 replantations distal to the wrist level performed in 187 patients, 174 patients received 260 successful replantations with an overall success rate of 91%. A total of 55 patients (32%) with 79 digits (30%) received 102 secondary procedures. 42 male and 13 female patients had 75 and 27 operations, respectively. Based on the number of secondary procedure, 22 patients had one, 21 patients had two, 10 patients had three procedures, and 2 patients had four secondary procedures.

Secondary procedures were divided into early and late (Table 1). In the early group, 44 (92%) out of the 48 operations were performed for skin coverage, while in the late group, 36 (67%) out of the 54 procedures were tendon-related procedures for functional improvement.

As shown in Table 2, the age distribution for those who received secondary procedures in both groups showed that younger patients had more secondary procedures than the older patients, yet, it is statistically significant only in the late group ($p < 0.05$). The patients with multiple-digit replantation had significantly more secondary procedures than those with single-digit replantation in both early and late groups, and this different was statistically highly significant in the early group ($p < 0.001$).

Concerning the other factors associated with the incidence of secondary procedures following replantation (Table 3), avulsion or degloving type of injury had more early secondary operations than guillotine and crushing type of injury ($p < 0.05$). Proximal replantation in fingers (zone III, IV and V) needed more of both early and late secondary operations than distal replantations (zone I and II) ($p < 0.05$). For replantations of thumbs, this trend was present too yet without statistical significance. This may be due to the small sample size for thumb replantations.

Among the 17 patients who received flexor tendon tenolysis, there were 11 patients with 21 digits who had long-term follow up (from 3 months to 83 months, mean period of follow up is 36 months). The mean age of patients receiving tenolysis is 26.5 years of age (range from 10–50 years old). The general timing for tenolysis was 6 months after replantation or 3 months after corrective osteotomy in 2 patients with malunion of fracture requiring correction. There were 14 digits receiving tenolysis in Zone III, 6 in Zone IV and 1 in Zone II.

Table 1 List of secondary procedures based on tissue and timing of operation (early vs late)

Tissue	*Early procedures*	*No. & ratio*	*Late procedures*	*No. & ratio*	*Total (no. & ratio)*
Skin	Debridement	6 (92%)	Scar release with		51 (50%)
	Skin graft	32	Skin graft	2	
	Flap	6	Z-plasty	5	
Tendon	Tendon repair	1	Tenolysis	35 (67%)	38 (37%)
	Tendon transfer	1	Tendon transfer	1	
Bone	Bone graft	1	Osteotomy	7	10 (10%)
			Stump shortening	2	
Joint	Arthrodesis	1	Arthrodesis	1	2 (2%)
Nerve		0	Nerve graft	1	1 (1%)
Total number		48		54	102 (100%)

Table 2 Incidence of secondary procedures related to age and number of digit involved

Factors	*No. of patients*	*No. of patients with early SP*[a]	*No. of patients with late SP*[a]
Age			
< 20	39	11(26%)	11(26%)
20–40	83	18(22%)	13(16%)
> 40	52	8(15%)	4(8%)
No. of injured digit			
Single finger	100	10(10%)	16(16%)
Multiple fingers	74	43(58%)	33(45%)

SP: secondary procedures.
[a] Parentheses indicate the incidence of patients received secondary procedures

Table 3 Incidence of secondary procedures in each replanted digit related to type of amputation, mechanism of injury, and level of injury

Factors	*No. of digits*	*Early SP*[a]	*Late SP*[a]	*Total no.*[a]
Type of amputation				
Complete	121	22(18%)	25(21%)	47(39%)
Incomplete	139	26(19%)	29(21%)	55(40%)
Mechanism of injury				
Guillotine	47	5(11%)	10(21%)	15(32%)
Crushing	179	30(17%)	35(20%)	65(37%)
Avulsion/degloving	34	13(38%)	9(27%)	22(65%)
Level of injury in finger				
Zone 1	1	0	0	0
Zone 2	41	1(2%)	2(5%)	3(7%)
Zone 3	141	24(17%)	34(24%)	58(41%)
Zone 4	32	4(13%)	11(34%)	15(47%)
Zone 5	2	3(150%)	1(50%)	4(200%)
Level of injury in thumb				
Zone 1	2	0	0	0
Zone 2	17	4(23%)	1(6%)	5(29%)
Zone 3	19	8(42%)	5(26%)	13(68%)
Zone 4	5	4(80%)	0	4(80%)

[a] Parentheses indicate the incidence of secondary procedures in each successful replanted digit.

We evaluated the functional results of the replanted digits by TAM score and Tamai's score before and after tenolysis, respectively. The mean TAM increased from 119° pre-tenolysis to 159° post-tenolysis. Fifteen digits improved in TAM grading, five digits did not change, but one digit became worse after tenolysis due to tendon rupture. The mean Tamai's score increased from 67 pre-tenolysis to 84 post-tenolysis. 19 digits improved in Tamai's scoring system, and two remain the same grading (Table 4).

Table 4 Results of flexor tenolysis after replantation

	Pre-tenolysis	*Post-tenolysis*
Mean TAM score (SD)	119 (30)	159 (36)
Excellent (>195)	0	5
Good (130–194)	7	12
Fair (65–129)	13	4
Poor (<65)	1	0
Mean Tamai's score (SD)	67 (5)	84 (6)
Excellent (80–100)	0	19
Good (60–79)	20	2
Fair (40–59)	1	0
Poor (0–39)	0	0

Discussion

During replantation surgery, primary reconstruction of all the important anatomical structures is necessary to achieve a good functional result. The tissues encountered include skin, soft tissue, tendon, nerve, bone and joint. Secondary reconstruction is technically more difficult and achieves poorer results. However, secondary procedures are usually required, as for soft tissue coverage, correction of malunion or malalignment, for better sensory recovery, and, improving range of motion. Most of the literature mentions secondary procedures in the reports of functional results of replantation[2–6], but few papers focused on it.[7–9]

Procedures for vascular complications were most commonly encountered within two weeks after replantation. In this series, there were 20 digits that underwent revision due to vascular complications including bleeding and thrombosis. The revision rate was 7% and the salvage rate was 80%. Unlike other series, re-explorations and revisions for vascular compromise, and salvage amputations for the failed replantations were excluded. We have discussed only the secondary procedures that are needed for better functional recovery in the survived replantations.

The incidence of patients with successful replantations receiving secondary procedures in this study was 32%, which was comparable with the other series.[1–9] Considering the tissue operated, Whitney and Buncke[1] reported that tendon was the tissue most often involved in secondary operation (ranged from 35 to 62%). Some other reports mentioned that bone and joint were most often involved (ranged from 38% to 50%).[1] In the study of Tark et al[5], soft tissue defect was most often encountered (79%). In this study, 50% of secondary operations were performed on skin and soft tissue. 37% of the procedures were done on tendon. Procedures for bone, joint and nerve were apparently less than reported in other series[1–8] (Table 1).

We divided the secondary procedures into early and late groups. The reasons why we chose the interval of 2 months after replantation were that almost all the primary work to achieve survival for a replantation were completed within this period, and the secondary work will not be performed by 3 months to 6 months following replantation to allow tissue healing and adequate physical therapy. The secondary procedures showed significant difference in the early and late groups. The most common early secondary procedures were procedures for treatment of the unhealed open wound. And the most common late secondary procedures were procedures for treatment of the adhered tendon. This difference is easily understood since skin sloughs or necrosis caused by crush injury required soft tissue procedures in the early postoperative period. For tendon, we preferred to undertake secondary procedures after the injured tendons had healed with good tensile strength.

We did not observe as many secondary procedures such as arthroplasty, arthrodesis, tendon graft, tendon transfer, and nerve graft as other studies.[1,3–5,7,8] This could be because we performed bone shortening routinely for about one centimeter before bone fixation, and, primary arthroplasty when the joint was involved or arthrodesis when joint preservation was not possible. The principle of management and the influence of joint injury had been discussed in our previous reports.[12,13] Also we have tried our best to repair severed nerves during the replantation surgery. It is difficult to do secondary nerve procedure in such circumstances.

Several articles have reported that mechanism, level of injury and multiple-digit injury will affect the functional outcome of replantation[3,14], and, the incidence of secondary operations after replantation as well.[3,8] In our study, the factors associated with higher incidence of secondary procedures are similar to the previous reports, however, according to our interval grouping, we could identify what kinds of secondary procedures were needed in each circumstance (Tables 2 and 3).

Flexor tenolysis is a major surgical procedure requiring wide exposure, extensive dissection, and assiduous postoperative rehabilitation. However, the scar after finger replantation involves all structures including skin, subcutaneous tissue, bone, flexor and extensor tendons. The extent of adhesion and scarring is usually more severe than in isolated flexor tendon injury. The results of tenolysis after replantation reported in the literature were inconclusive in some studies.[3,8] However, Jupiter et al[9] supported flexor tenolysis after replantation of fingers, but not replanted thumbs. The factors associated with poor results were crush or avulsion amputations, multiple digital injuries, and those requiring proximal interphalangeal joint capsulotomy. Their indications for flexor tenolysis of replanted digits paralleled the general indications for flexor tenolysis, including a discrepancy between passive and active range of motion after a period of 4 to 6 months to allow wound healing and maximal hand therapy. In addition, return of sensibility evidenced by an advancing Tinel's sign was necessary.

The indications for flexor tenolysis in our series were the same as described by Jupiter et al[9] In those selected cases who have received tenolysis, 85% of them regained excellent or good functional recovery by TAM grading post-tenolysis. The functional improvement of tenolysis after replantation is of statistically significance ($p < 0.05$).

In conclusion, excluding the procedures for vascular complications, we divided the secondary operations after replantations into early and late groups in this retrospective study. Procedures were mainly for skin coverage in early group and for functional improvement in late group. The younger patients had more late secondary operations than elder patients. Factors associated with higher incidence of secondary operations included avulsion injury, proximal level replantations, and multiple-digit injury. In the selected patients, flexor tenolysis would improve the functional outcome significantly after replantations in fingers.

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