

Original article

FINGER REPLANTATION: GOOD AND BAD RESULTS

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Received 17/1/2020

Accepted 23/4/2020

Abstract

There are different causes for finger amputation. Causes are starting from clean cut amputation up to avulsion. There are many factors affecting the results of finger replantation, as cause of injury, age of the patient, level of amputation, time passed after injury, methods for preservation of the amputated part, trained surgeons, and surgical equipments. Other factors affect the results of finger replantation are number of digital amputation, surgeon comfortability, and patient cooperation. This study included 38 patients presented by amputation of 57 fingers. The average age was 23 years old. The main cause was machine injury. The dominant hand was the right hand. The dominant finger was the thumb. The level of injury was proximal to the proximal interphalangeal joint in most of cases. The average time passed between injury and replantation was 2 hours. The average time of surgery for one digit replantation was 4 hours. The principles of treatment was exploration of the neurovascular and tendons in the amputated digit initially then that of the stump. The order of treatment was bone fixation by 2 kirschner wire, digital artery, digital vein, flexor tendon, digital nerve, extensor tendon. Skin closure should be loose. The average follow up was 58 months. All fingers have been survived except five. The average time for bone union was 8 weeks. According to Chen's criteria, the overall results were classified as grade I (excellent) in 20 cases, grade II (good) in 16 cases and grade III (fair) in 2 cases. The tendon function was excellent in 20 fingers, good in 26 fingers fair in 3 fingers, poor in 2 fingers and failure in 6 fingers. The 2 point discrimination was 6 mm in 9 fingers, 7-10 mm in 29 fingers, and 12-15 mm in 13 fingers. The mean grip and pinch strengths were 80 % and 85% respectively compared to contralateral hand. All of patient had returned to their normal daily activities. Finally, finger replantation is not an easy job and it is considered as challenging procedure even for the specialist. I think that many factors affecting the results of finger replantation have not been discovered yet.

Keywords: Digital amputation, Microvascular anastomosis, Replantation, Discrimination.

1. Introduction

There are many factors affecting the results of finger replantation [1-3]. Many authors [1-4] described these factors but the absence of ideal and standards measurements for comparison was seemed to be the main problem. The results of finger replantation were variable and the recorded successful rate was ranged between 70-

90 % [1-4]. The common factors affecting the results were the age of the patient, the level of injury, the causative agent, the number of amputated finger in the same patient, the associated injuries, and time elapsed between injury and replantation, methods for preservation, surgical equipments, and surgeon experience. The aim of

this study is to conclude that there are still factors affecting the functional outcome of finger replantation which did not described

2. Patients and Methods

This study included 38 patients presented by amputation of 57 fingers. This study had been done in academic level 1 trauma center, from January 2012 to January 2018. The average age was 23 years old. The majority was male affection (30 out of 38). Right hand was involved in 26 patients. The cause was machine injury in 14 patients, clean cut amputation in 9 patients, fire arm injury in 5 patients, electrical saw in 4 patients, and motor car accident in 6 patients. Avulsion amputation, tip finger amputation, polytraumatized patients, and associated chronic medical diseases were excluded from this study. The injured finger was the thumb 19, index 13, middle 12, ring 8, and little 5. The level of injury was proximal to the proximal interphalangeal joint in most of cases. The average time passed between injury and replantation was 2 hours. The average time of surgery for one digit replantation was 4 hours. The average hospital staying was 7 days postoperatively, tab. (1). Every patient was assessed clinically and radiologically to exclude further injuries, to assess the general condition, to discover or treat other medical diseases. All patients obtained general anesthesia. The patient position was supine. The involved upper limb was sterilized and draped up to the tourniquet. The affected hand was put on side arm table with tourniquet. Exploration of the digital artery, digital nerve, subcutaneous vein, flexor tendons and extensor tendons in the amputated digit was done respectively. Then the same work was done in the proximal stump. Bone fixation was the first step. Two Kirschner wires were used to fix the bone in most cases. This was followed by digital artery repair, fig. (1). Sometimes the digital artery was too short or thrombosed or even macerated leaved gap. This was managed by doing anastomosis of the

in the literature as surgeon comfortability and patient cooperation.

contralateral digital artery, reverse vein graft, transportation of the digital artery from the adjacent intact finger, or bone shortening. Digital vein anastomosis or graft was the difficult step in most of cases. This was facilitated by doing repair of the digital artery first then deflate the tourniquet and then the vein will engorge and appear obviously. Tendon repair was also important and it was taken cautiously to improve the functional outcome of digital replantation. Sometimes the proximal stump of the tendon was retracted and it was difficult to get it from the wound. Surgical wound over the transverse carpal ligament was the solution to get it and passed it through the lumbrical canal closely. Skin closure was done meticulously to avoid tightness of the wound and it may lead to ischemia of the finger. Below elbow slab was done for 4 weeks. Monitoring of finger was performed every hour in the first day, every 2 hours in the second day and every 6 hours for 5 days. The patient was discharged from the hospital one week postoperatively. Below elbow slab was removed after 4 weeks. Kirschner wires were removed after 6 weeks. Home physiotherapy was done for 2 weeks after kirschner wires removal, followed by physiotherapy. We used tendon function scale to assess both joint range of motion and tendon gliding. It is considered as excellent when the tip of the involved finger reached at or distal to the proximal palmar crease by one cm, good when the tip of the involved finger is far from the proximal palmar crease by more than 1 cm, poor when there was inappropriate finger movement and bad if there was no movement of the involved finger. The sensation was assessed clinically using the 2 point discrimination, excellent when it was less than 6 mm, good 6-10 mm, fair more than 10 mm, and poor if there was trophic change.

Table (1) Patient's data.

Patient	Age	Sex	Affected hand	Amputated digit	Cause	Time elapsed before surgery (h.)	Operative Time (h.)
1	22	M	R	Thumb	Knife	3	4
2	12	M	R	little	Motor car	2	4
3	19	M	L	Index, Middle	Firearm	1	6
4	18	M	R	Thumb	Glass	2	4
5	26	M	L	Little, ring, middle	Saw injury	3	7
6	32	M	R	Thumb	Motor car	4	5
7	24	F	L	Thumb	Knife	2	4
8	8	M	R	Thumb, index and middle	Saw injury	1	6
9	35	M	R	Ring	Glass	1	4
10	37	M	R	Middle	Machine	3	5
11	7	M	R	Thumb	Machine	2	6
12	41	F	L	Index	Glass injury	2	4
13	6	M	L	Index	Machine	1	4
14	15	M	R	Thumb	Machine	2	5
15	17	M	R	Thumb	Motor car	4	5
16	36	F	R	Ring	Glass injury	5	4
17	42	M	R	Thumb, index, middle, ring	Motor car	3	8
18	23	F	R	Little	Meat grinding machine	6	3
19	21	M	R	Index	Glass	4	4
20	22	M	L	Index	Firearm	2	4
21	11	M	R	Middle	Firearm	3	4
22	19	F	R	Thumb, index middle ring, little	Grinding corn machine	7	7
23	36	M	R	Middle, ring, little	Saw injury	3	7
24	38	M	R	Thumb	Firearm	2	4
25	24	M	L	Thumb, index, middle	Motor car accident	4	7
26	39	M	R	Middle	Knife	1	3
27	30	M	R	Thumb, index	Grinding corn machine	2	5
28	25	M	L	Thumb	Machine	3	4
29	27	F	L	Thumb	Meat grinding machine	5	5
30	36	M	R	Middle, ring	Motor car	4	6
31	35	M	L	Index	Firearm	2	4
32	24	M	R	Thumb	Saw injury	1	3
33	12	M	R	Index	Biscuit paste machine	4	4

34	21	F	R	Thumb	Knife	3	4
35	25	M	L	Ring	Machine	2	4
36	20	M	R	Index, middle	Grinding meat machine	5	5
37	35	F	L	Thumb	Kitchen machine	3	4
38	38	M	R	Thumb	Machine	6	5

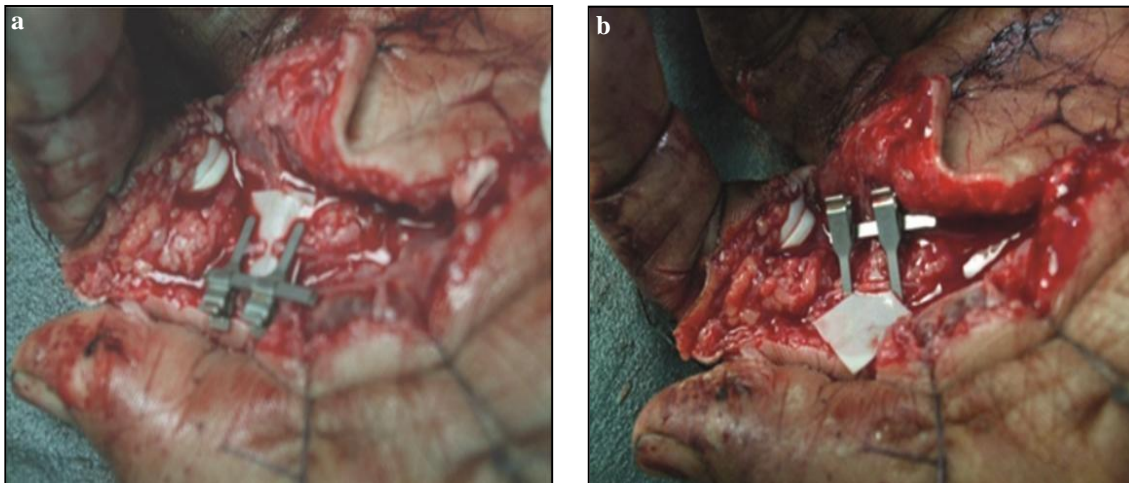


Figure (1) Shows **a.** intraoperative photo showing the digital artery of index finger between double vascular clamp prior to repair, **b.** after the repair

3. Results

The average follow up was 58 months. All fingers have been survived except six. The average time for bone union was 8 weeks. According to Chen's criteria, tab. (2) [5], the overall results were classified as grade I (excellent) in 20 cases, figs. (2 and 3), grade II (good), figs. (3 and 4) in 16 cases and grade III (fair) in 2 cases, tab. (3). The tendon function was excellent in 20 fingers, good in 26 fingers fair in 3 fingers, poor in 2 fingers and failure of 6 fingers. The 2 point discrimination was 6 mm in 9 fingers, 7-10 mm in 29 fingers, and 12-15 mm in 13 fingers. The mean grip and pinch strengths were

80 % and 85% respectively compared to contralateral hand. All of patient had returned to their normal daily activities. The tend on function was excellent in 20 fingers, good in 26 fingers fair in 3 fingers, poor in 2 fingers and failure of 6 fingers. The mean grip and pinch strengths were 80 % and 85 % respectively compared to contralateral hand. Tenolysis was performed in 6 digits, split thickness skin graft (Thiersch) in 3 digits with proximal level of amputation, and full thickness skin graft for 4 digits. All of patient had returned to their normal activities of life.

Table (2) Chen's criteria of functional evaluation after replantation

Grade I (Excellent)	A	Ability to resume original work with a critical contribution from the reattached parts
	B	Collective range of joint motion exceeds 60 % of normal, including the joint immediately proximal to the reattached part
	C	Recovery of sensibility to a high grade without excessive intolerance of cold
	D	Muscular power of 4 to 5 on a scale of 1 to 5

Grade II (Good)	A	Ability to resume some gainful work but not original employment
	B	Range of joint motion exceeds 40 % of normal
	C	Recovery of near normal sensibility in the median and ulnar nerve distributions without severe intolerance of cold
	D	Muscular power of grade 3 to 4
Grade III (Fair)	A	Independence in activities of daily living
	B	Range of motion of joints exceeds 30 % of normal
	C	Poor but useful recovery of sensibility
	D	Muscular power of grade 3
Grade IV (Poor)	A	Tissue survival with no recovery of useful function



Figure (2) Shows **a.** "Patientno.1" preoperative photo showing complete amputation of the thumb at PIPJ, **b.** immediately postoperative replantation, **c.** postoperative follow up photo with thumb flexion, **d.** postoperative follow up photo with thumb extension **e.** postoperative follow up photo with opposition

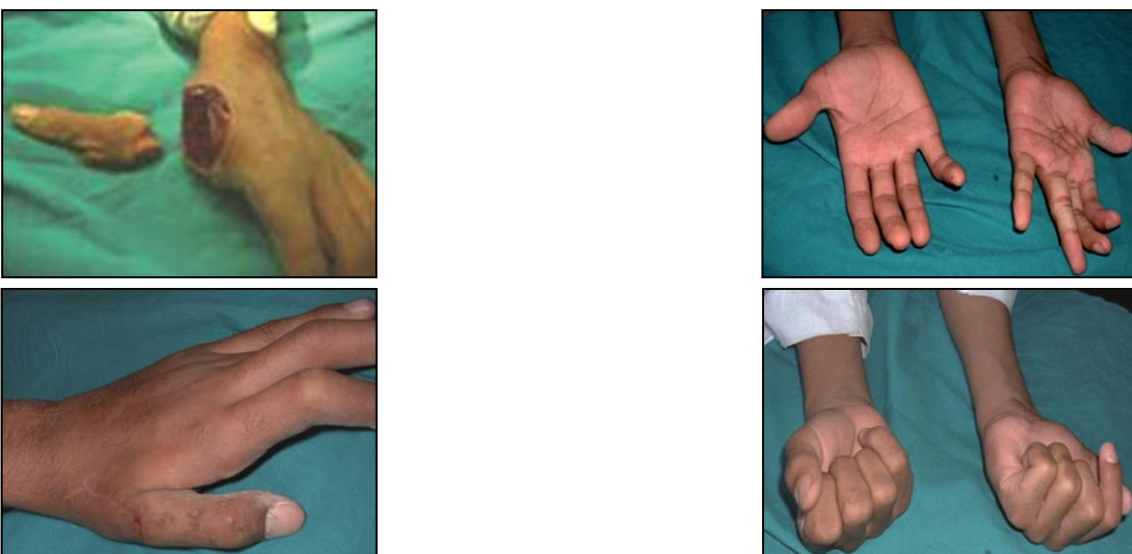


Figure (3) Shows **a.** "Patient no. 7" preoperative photo showing totally amputation of the left thumb at CMC joint **b.** follow up photo showing complete thumb extension **c.** scar on the dorsum of thumb **d.** flexion of the thumb and lack of flexion of index finger due to adhesion of flexor tendon

Table (3) Functional outcome after finger replantation.

Patient	Failed finger	Secondary procedure	Follow up (Ms)	Chen's grade	Grip %	Pinch %	Two points discrimination (mm)
1	--		72	I	85	90	6
2	--	Full thickness skin graft	86	I	90	95	7
3	--	Full thickness skin graft	90	I	86	90	8
4	--		48	I	75	80	8
5	-		92	I	90	95	6
6	--		88	I	87	90	6
7	--		69	I	85	80	7
8	--	Tenolysis of index and middle	56	II	70	75	10
9	--		60	I	88	90	7
10	-	Tenolysis	75	II	80	85	8
11	-		48	I	80	80	6
12	--		62	I	90	90	7
13	--		68	I	85	90	6
14	--		42	I	90	90	7
15	--		66	I	85	90	8
16	--		90	I	90	90	6
17	Index, middle		48	III	50	55	12
18	--		36	I	90	90	6
19	--		65	II	80	85	8
20	--	Tenolysis	56	II	70	75	9
21	--	Full thickness skin graft	70	II	75	80	9
22	Ring, little	Thiersch graft	74	II	60	60	12
23	--		86	I	85	85	8
24	--	Tenolysis	68	II	75	80	10
25	Middle		54	II	70	70	12
26	--		36	I	90	95	6
27	--		48	II	80	85	10
28	-		36	I	90	90	8
29	--	Thiersch graft	68	II	70	70	12
30	--		64	II	75	75	10
31	--	Full thickness skin graft	45	II	75	80	9
32	--		33	I	85	85	7
33	--		38	II	80	80	8
34	--		56	I	85	90	9
35	-		60	II	75	80	10
36	--		72	III	60	65	12
37	--		78	II	75	75	10
38	--	Tenolysis	60	II	75	80	11



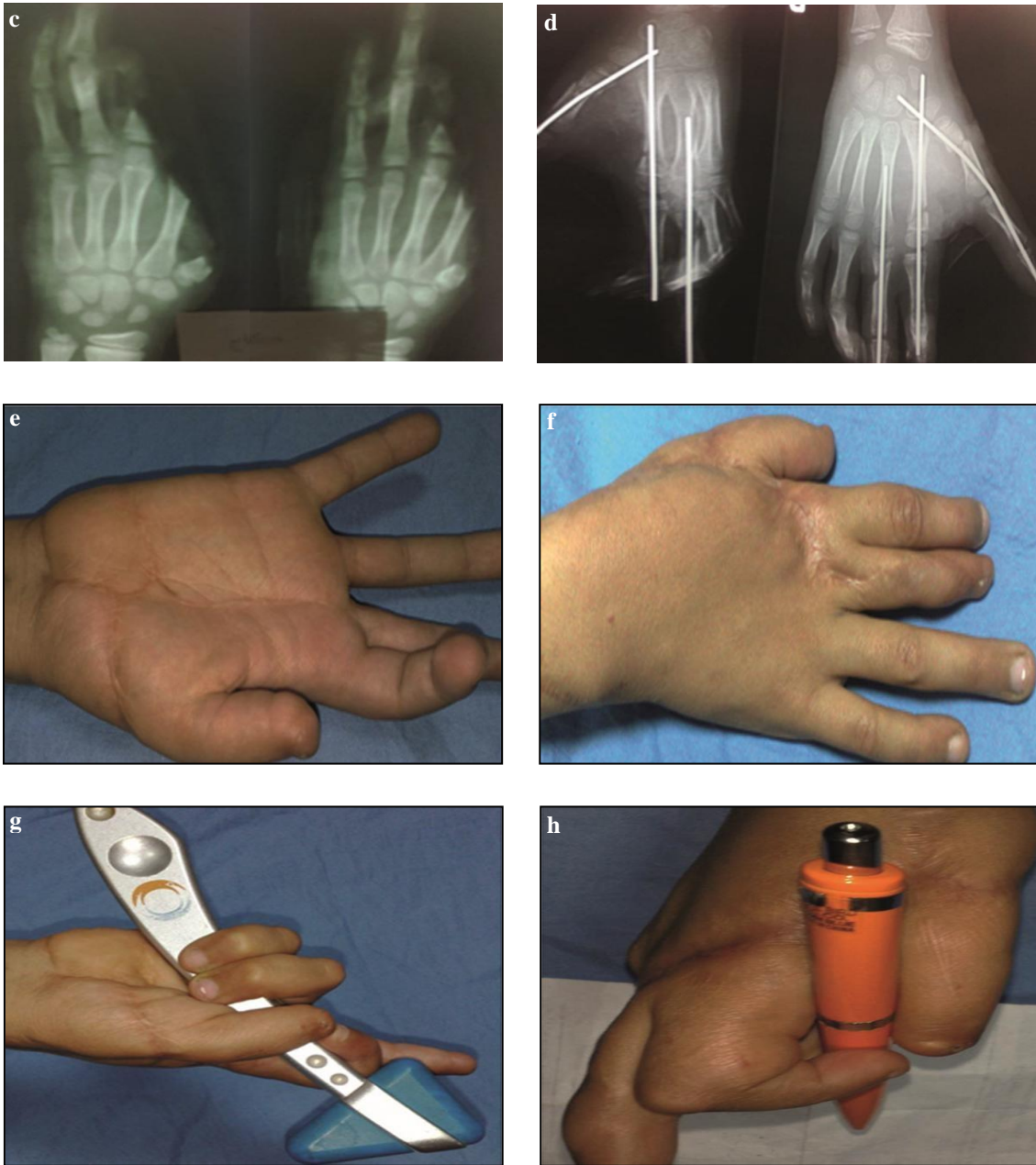


Figure (4) Shows **a.** Patient No. 8 preoperative photo showing amputation of thumb, index and middle finger **b.** preoperative photo showing dorsum of the hand and amputated fingers **c.** preoperative x-ray showing the level of amputation of lateral three fingers **d.** postoperative x-ray with k-wire fixation **e.** postoperative follow up photo showing survive of the lateral-3 fingers **f.** postoperative follow up photo showing complete extension of the lateral three fingers **g.** Good grasp inspite of middle finger stiffness. **h.** postoperative follow up photo with writing position of the thumb and index fingers.

4. Discussion

Finger replantation is considered as a major task. On account of cultural beliefs amputation is not tolerated well in Eastern cultures. People with traumatic loss of fingers subjected to be blamed

from others [6]. The willing to hide the hand with amputated finger is the solution in such cases [6]. Even social deprivation is highly seen among these patients. The patient can pay a lot to save or replant the

amputated finger [6]. Thus, a high rate of single finger replantation is seen. The goal of surgery is not only to save the finger but also to obtain reasonable functional outcome. Immediately after amputation the patient is looking forward to save the finger but later, is looking for meaningful finger function. Although there is advent in microsurgery, the functional outcome of finger replantation is still beyond the effort [6]. The survival rate of finger replantation is ranged between 80-90 percent as described in the literature [1-3]. The different types of tissue, and different surgical procedure (bone fixation, vascular repair, tendon repair and skin coverage) makes it difficult than single tissue transplant. The order for repairs was the osteosynthesis, digital artery, flexor tendon, dorsal vein, digital nerve, and extensor tendon can be repaired later, once blood flow has been reestablished to the injured finger. The lack of similarity in the cause of amputation and method for revascularization between different authors makes the study unbalanced and difficult to compare. There are different factors affecting the results of finger replantation. One of the most important factors is the age of the patient. Finger replantation is an absolute indication for replantation in children because of the development of the sensation and the need for high intellectual function. It well known that finger replantation in children is more difficult and gives functional result lowers than that of adult. This is due to the type of trauma because the child is usually subjected to crush injuries, for example machine (biscuit making machine, meat grinding machine, and corn grinding machine), door hinges, and kits (knife and kitchen machine). The second is the size of vessels specially that of the vein which is more delicate and smaller than that of the adult. The third is the lack of child cooperation and awareness which make it difficult for rehabilitation and followup [7,8]. In this study

the number of involved children was 6, their average age was 9 years. The number of involved fingers was 8. The functional outcome according to Chen's criteria was excellent (grade I) in 3 cases (3 fingers), and good (grade II) in 3 cases (5 fingers). Cause of injury is also has to be considered an important factor affecting functional outcome of finger replantation. In this study, the number of patients subjected to clean cut amputation (knife, glass, and electrical saw) was 13 (30 %) patients. The number of digital amputation was 19 (30 %) fingers. Their functional outcome according to Chen's criteria was excellent (grade I) in 11 patients (15 fingers), and good (grade II) in 2 patients (4 fingers). The number of patient subjected to crushed amputation (motor car accident, firearm injury, and machine injury) was 25 (70%) patients. The number of affected fingers was 38 (70 %) fingers. Their functional outcome according to Chen's criteria was excellent (grade I) in 9 patients. Good (grade II) in 14 patients, and fair (grade III) in 2 patients, and loss of 5 fingers after replantation. Clean sharp amputation gives better result than that of crushed or avulsed amputation [9]. Although there are multiple procedures to save avulsed finger amputation but still the results are lower than that of clean cut amputation [10]. In crushed and avulsed amputation, the healthy zone is usually beyond the level of injury, specially the neurovascular structure. The proximal level of amputation gives better result than that of distal amputation. Both digital artery and vein have wide caliber proximally than distally. The incidence of secondary skin coverage is higher in the proximal replantation than that of distal amputation. Digital amputation at or distal to the distal interphalangeal joint was excluded in this study. Surgical experience is considered as an important factor to improve the functional outcome of finger replantation. It is not only important to try

to replant but also very important to know which digit is candidate for replantation. The trial to do replantation for every case of amputation increases the failure rate and this will be burden on the functional outcome. The success rate for digital replantation is increasing by the development of learning curve and this also will come by experience. The surgical time for replantation is also decreased by experience. Surgical equipment is also play an important rule in the functional outcome of finger replantation. In certain cases especially in children, the use of surgical loupe is not sufficient enough to do vascular anastomosis. In some cases, the diameter of digital artery is smaller than the diameter of 10/0's needle. Also the general condition of the patient and the associated medical disease is also considered as an important factor affecting the result of replantation [11]. In this study, we exclude cases with polytrauma and cases associated with medical diseases that increased the incidence of thrombosis. Surgeon comfortability plays an important factor to improve the functional outcome of finger replantation. Team work is one of the most important factors to avoid boring and improve the functional outcome for digital replantation specially in multiple digital amputation [11,12]. For this reason it is essential to do replantation by more than one team [11]. To improve the functional outcome of digital replantation, to relieve some stresses on the surgeon, the order of repair for multiple digital replantation should be considered. We advise to start with finger with best chance for successful replantation, best expected recovery and most significant contribution to function [12,13]. We prefer to repair the thumb, then the index, then the middle, then the ring and lastly the little

finger, if all the fingers are injured equally and have the same chance for successful repair. While the order of repair done by Salah and Khalid [12] was the middle, then index, then ring and lastly the little finger. Patient cooperation is important, not only immediately after replantation but also during follow up. Because of the lack of cooperation between the children on one hand and both of the surgeon and the parents on the other hand, the functional outcome of digital replantation in children is lower than that of adult. Lindfors and Marttila [7] presented 29 patients with 38 finger injuries. Eight had a severe amputation injury. The success rate after total amputation was 6/14 (43 %), and after subtotal amputation was 13/15. The success rates have been reported as 91.4 % in guillotine amputations, 68.4 % in crush injuries, and 66.3% in avulsion type injuries [4,9]. Matsuzaki et al. [13] reported that the success rate for complete replantation was 93 % (27/29) and 95 % (39/41) for near-amputation. This study was included 70 digits came from 43 patients (average age, 46 years; range, 19 to 78 years; 37 men). In all 39 digits from 21 patients required 48 secondary surgeries; skin grafts, tenolysis, joint fusion, bone graft, osteotomy, and web-plasty. The incidence for secondary soft tissue coverage increased with proximal amputation. In this study, the success rate for complete replantation was 90.5 % (52/57). Tenolysis was performed in 6 digits, split thickness skin graft in 4 digits with proximal level of amputation while full thickness skin graft in 4 digits. To improve the functional outcome of finger replantation, the surgeons have to be comfortable, alert in assessment and repair, work under ease in good team and with suitable surgical equipment.

5. Conclusion

Fingers amputation commonly occur secondary to different modes of trauma which affect the prognosis after reconstruction of the amputated digit. The prognosis is better in clean cut injury rather than avulsion injury.

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