

Hand Replantation Following Complete Amputations. A Study of Both Form and Functional Outcome

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ABSTRACT

The aim of this study was to evaluate both form and function of replanted hand in cases of complete amputation at the level of metacarpal bone and wrist joint with shedding light upon some points that would improve results of replantation at these levels. The study was carried out between January 2006 and October 2008 where 6 patients (7 hands) suffering from complete amputation at the level of metacarpal bone and wrist joint were replanted. Their age ranged from 22 to 29 years. Injury was bilateral in one case and unilateral in five cases (Lt Side=3, RT=2). Follow-up was done for at least six month. Assessment was in the form of recording 1/satisfaction of patient as regard hand form by comparing it with contralateral side 2/ability to return to work 3/total active motion of digits 4/thumb opposition 5/sensation using 2PD. Six hands survived out of seven. Amputations at the transmetacarpal and wrist level is a solid indication for replantation with an expected good form and function and every microvascular team has a preference in some points that may share in replantation success.

INTRODUCTION

The success of surgical replantation rank among the most spectacular achievement in the field of accident surgery during the past 40 years. In 1960 Jacobson and Swarez introduced the operating microscope into vascular surgery [1]. The first successful limb replantation in man was performed in 1962 by MALT in Boston. This incidence involved a patient whose arm had been completely amputated; repair was done without the use of microscope [2]. In 1965 komatsu and Tamai in Japan were the first in history to replant a severed thumb [3]. In the first half of 1970s reports of successful replantation came fast. The commercial production of serviceable microsurgical instruments, minute vascular clamps and ultrafine atraumatic suture material was critical for the continued rapid spread of micro vascular surgery. Meyer started transmetacarpal replantation in 1976, these injuries have been considered as a strong indication for replantation in order to restore the functions

of the hand, up till now little is known about the long-term subjective, functional and occupational outcome in transmetacarpal subtotal or total amputation injuries [4,5]. Poor outcomes after transmetacarpal revascularizations/replantation have been reported recently [6]. Despite high standards now attained in replantation surgery, there exists points that are controversial especially in hand replantation according to the preference of micro vascular surgery team. In this study we present our experience in the relatively rare cases of hand replantation following amputations at the level of wrist joints and metacarpal bones pointing out to controversial points that could influence the post operative outcome.

PATIENTS AND METHODS

A total of six consecutive patients with seven hand replantation were performed in the last few years between January 2006 and October 2008 with a minimum follow-up period of 6 months. All six cases were included in this study; all were men whose ages ranged from 20 to 29 years. All amputations were complete at the level of metacarpals or at wrist joint. All cases were due to sharp trauma. One case was bilateral (Fig. 1), three cases involved the right hand and two cases involved the left hand. In three cases there was good preservation of the amputated parts with ischemia time about eight to twelve hours, in the remaining three cases preservation was bad with ischemia time of about six to nine hours (Table 1).

Surgical procedure:

In all cases, replantation was performed under general anesthesia with a tourniquet on the affected upper limb. Debridement was done and anatomical structures (arteries, tendons, veins and nerves)

were allocated and tagged in both stumps. Bone shortening less than one cm were done and osteosynthesis using k wires and interosseus wires were done. Two kirschner wires (k-wires) were used for metacarpal fixation, interosseus wire together with k wire were used in phalangeal fractures. Both tendons (flexor digitorum superficialis and profundus) were repaired except in one case where proximal tendon of index finger was not found. In seven hands the superficial palmar arch was repaired under magnification of about 20x using 10/0 nylon. In 6 hands full revascularization of digits were observed after 3-5 minutes, only in one hand there was a delay of about 10 minutes before full revascularization occurred, neurography was done using epineural sutures to both median and ulnar nerve or their branches using 9/0 nylon suture. The hand was turned and extensor tendons were repaired followed by 2 big veins. Skin closure and drainage were done with light bandage; the hand was placed in a plaster splint in anticlaw position for 10-14 days with first dressing after 5 days.

Postoperative management:

Postoperative medications were identical for all patients and include broad spectrum antibiotics, metronidazole for 7 days, low molecular weight heparin (25,000/24h) for 5 days, aspirin 75mg/day

for 10 days, analgesic in the form of pethidine in the first 48 hours then paracetamol 1.5g/day for 7 days. The postoperative period in 6 hands were smooth with no problem. Severe edema occurred in one patient where loosening of stitches were done together with elevation. k wires were removed after 4-6 weeks guided by clinical and radiological healing. Physiotherapy started 10 days postoperative and continued for 4-6 months.

Assessment:

The postoperative results as regard the form were evaluated by comparing the replanted hand to normal one except in case no. 1, as regard function the following points were evaluated A- The general performance of the patient using his replanted hand and his overall satisfaction by noting his work stability B- The recovery of flexor and extensor mobility of digits by measuring the total active motion which is equal active flexion-extension deficit of fingers by using the goniometer. C- The recovery of thumb opposition. D- Recovery of sensitivity of the fingers supplied by median and ulnar nerve by using the 2 point discrimination test using paper clip-the ability to do daily activity by allowing the patient to hold objects of different shape and dimension, writing, picking up a coin and buttoning.

Table (1): Clinical characteristics of the cases.

Pt no.	Age	Sex	Level of amputation	Side	Cause	Ischaemia time	Part preservation
1	22	Male	Metacarpal	Lt & Rt	Electrical saw	6	Bad
2	20	Male	Metacarpal	Lt	Paper machine	12	Good
3	29	Male	Wrist	Rt	Saw	6	Bad
4	25	Male	Metacarpal	Rt	Saw	10	Good
5	26	Male	Wrist	Lt	Saw	8	Good
6	29	Male	Wrist	Lt	Paper knife	9	Bad

RESULTS

Five patients (6 hands) were replanted successfully with total loss of one hand. All patients with successful replantation except for case no. 1 were satisfied with cosmetic appearance of replanted hand in relation to normal one Fig. (2). Three patients were highly satisfied and resume their same work again, two cases preferred to change their old work, one case was out of work Table (2), Fig. (3). Thumb opposition was possible in

three cases with no difficulty, one case had difficulty while doing opposition and the remaining case had no thumb injury Table (3), Fig. (4). The total active motion in five patients was calculated and ranged from 100 degree to 175 degree Table (4). As regard sensation the range of 2PD was from 6-12mm Table (5). Four patients (four hands) were able to do the daily activity tested as writing buttoning and holding different sized objects, one had difficulty in doing so (case no. 1) Table (6), Fig. (5).

Fig. (1): A case of bilateral hand replantation A,B preoperative picture of bilateral amputated hand, C preoperative plain X-ray of amputated hands, D postoperative picture of replanted hands after 1 year, E postoperative plain X-ray after 1 year.

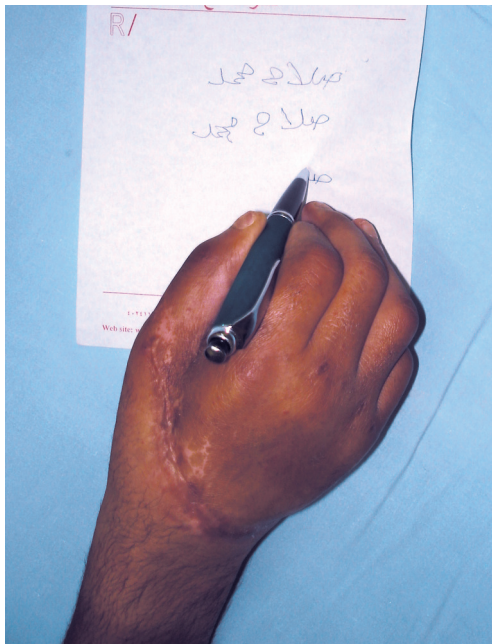
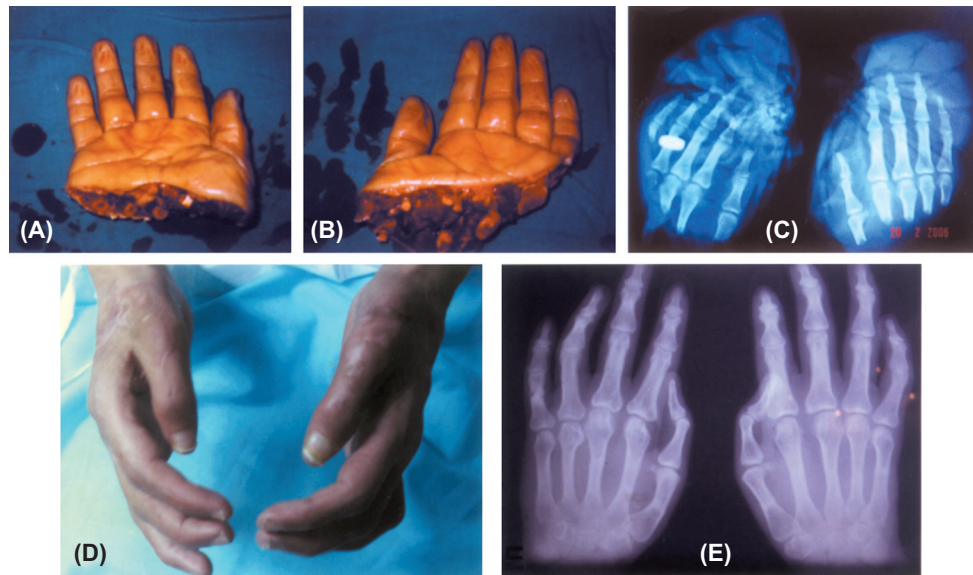


Fig. (2): Cosmetic appearance and function of replanted hand.



Fig. (4): Functional outcome represented in patient's ability to write his name.



Fig. (3): Cosmetic appearance and function of a patient with bilateral replantation.



Fig. (5): The patient demonstrating ability to hold objects.

Table (2): Patient employment after replantation.

Case number	Type of work		
	Same work	Change work	No work
Case 1		•	
Case 2	•		
Case 3		•	
Case 4	•		
Case 5	•		
Case 6			•

Table (3): Thumb opposition after replantation.

Case number	Thumb opposition		
	Possible	Difficult	Impossible
Case 1		√	
Case 2			
Case 3	√		
Case 4	√		
Case 5	√		
Case 6			

Table (4): Range of active motion following replantation in metacarpophalangeal joint (MCP), proximal interphalangeal joint (PIP) and distal interphalangeal joint (DIP).

Pt no.	Flexion				Extension				Range
	MCP	PIP	DIP	Total	MCP	PIP	DIP	Total	
1	70	70	50	190	25	10	10	45	145
2	70	80	70	220	35	15	10	60	160
3	50	50	60	160	30	20	10	60	100
4	60	80	70	210	35	10	10	55	155
5	70	90	70	230	30	15	10	55	175
6									

Table (5): Recovery of sensation in replanted hands using two point discrimination (2PD).

Pt no.	Two point discrimination
1	8mm
2	7mm
3	6mm
4	10mm
5	12mm
6	

Table (6): Ability of doing daily activity using replanted hand (writing, buttoning, holding different objects).

Case number	Daily activity		
	Possible	Difficult	Impossible
Case 1		√	
Case 2	√		
Case 3	√		
Case 4	√		
Case 5	√		
Case 6			√

DISCUSSION

In the literature there are few reports selectively concerning hand replantation. It is usually discussed as a part of a series of replantation of digits and more proximal replantation at the arm and forearm level, this leads to misinterpretation about such condition. In this study we present six cases (7 hands) which had amputation at the level of metacarpal bones and wrist joint, trial of replantation was done in all cases. There are some points which in our opinion would increase the survival of replanted parts and enhance their functional outcome; these points could be subdivided into three categories a- preoperative b- operative c- postoperative.

Although the indications for replantation have not changed significantly over the years, experience with the techniques and results have refined these indications. Tark [6] have stressed that major replantation including hand replantation is a worthwhile procedure. In our study hand amputation is an absolute indication for trial of replantation; the indication is not based solely on potential viability but is predicted on the potential for long term function. Tonkin [7] stated that any hand amputation from zone III (distally) to zone V (proximally) offers the change of reasonable function after replantation which is superior to prosthesis.

In this study we had a survival rate of about 85.7%, five cases survived (6 hands) with failure

of one case. Paavilainen et al. [8] reported a survival rate of about 86% which coincide with our results, they reported 43 patients with complete transmetacarpal injuries between 1978 & 2002 (38 males, 5 females), mean age was 34 years, seven were left handed 32 of them were workers and the most common cause of trauma was the circular saw. In this study all patients were males; their age ranged between 16-29 years old, all are manual workers with the electric saw being the most common tool resulting in trauma. It is obvious that transmetacarpal amputations occur commonly in manual workers, young males and less in females. We suggest this is due to dominance of working males using electric saw in factories especially in Egypt.

Scott et al. [9] reported poor outcomes after transmetacarpal revascularizations/replantations and mentioned that Amputations at this level contain a muscle mass (small muscles of hand) that would make the ischemic tolerance of hand significantly shorter than digits. Pederson et al. [3] mentioned that the warm ischemia tolerance of digits is generally believed to be in the range of 8 hours and the absolute maximum warm ischemia tolerance for major amputations is in the range of 4-6 hours. In our study the warm ischemia time ranges from 3 to 6 hours which is considered one of main causes of good functional outcome. In case number six where there was a failure of replantation although ischemia time was 9 hours, bad preservation (amputated part was in direct ice contact) of hand has led to its freezing and was a direct obvious cause for failure.

Weinzweig et al. [10] noted that in most cases metacarpal level revascularization is not technically difficult, because a reliable vascular repair can usually be done in vessels of 1.5-2mm in diameter. Tonkin [7] reported that one common digital artery can provide blood flow to all fingers through transverse commissural vessels in transmetacarpal amputations. Paavilainen et al. [8] reported the same phenomenon but preferred to perform more than one artery repair in order to increase the reliability of revascularization. In our study 6 of 7 hands had superficial palmar arch repaired which resulted in good vascularization of all digits excepts for one case there was a need of doing another artery due to delayed filling of thumb. In our opinion in cases of hand replantation, the sequel of anastomosis would differ a little than the traditional description, this would make a great difference in survival, we prefer to do the artery first to allow for some bleeding from veins to get rid of any anaerobic metabolite and easily identify and anastomose the veins. This anastomosis would be

followed by nerve anastomosis to finish repair of all palmar structures and then dorsal structures are repaired.

The reported sensory recovery in transmetacarpal replantation assessed by 2 point discrimination has been generally poor (≥ 10 mm) as prescribed by weinzweig et al. [10], contradictory to this earlier finding our study showed good recovery of sensation with 2 point discrimination ranging from 6-12mm.

The reported TAM of survived digits after transmetacarpal injuries has varied from 94 degree to 192 degree Russell et al. [11]. Scott et al. [9] reported total active motion for replanted fingers to be 120 degree and thumb MP & IP motion combined was 59 degree. In our study the TAM for fingers apart from thumb was from 100 to 175 degree, these results mimic previous studies. Poor function of intrinsic muscles is still reported in most cases of transmetacarpal replantation either due to direct injury, ischemia or postoperative scarring. In our study there was impairment of intrinsic muscle function yet not to the degree to impair finger abduction and flexion of MP joint. Weinzweig et al. [10] attempted to improve the TAM and intrinsic function by the trial of intrinsic tendon repair or resection of devitalized muscle. Scheker et al. [4] reported the grip strength ratio of the injured/uninjured hand to be about 32%. In our study all patients except the patient with bilateral amputation had a good grip and pinch activity which allowed them to do most daily activities as writing Fig. (5), buttoning and holding different objects. The ability of thumb opposition was determined as a separate entity where the return of thumb opposition is very important in regaining the grip and pinch action even with little improvement of the TAM. In 3 cases out of 5 (one case the thumb was spared, other case there was failure of replantation) thumb opposition was regained and patients were satisfied.

Scheker et al. [4] attempted to improve the postoperative function of hand replantation by the use of a two days postoperative protocol which includes early protective active mobilization with antic law splinting; the mean of TAM was 189 degree in four patients. In our study the physiotherapy protocol began after 10 days with the use of early controlled movements followed later by active and passive mobilization.

Chen [12] described four criteria to evaluate functional recovery after hand replantation, 1/total range of joint motion 2/recovery of sensibility

3/muscular power and 4/the ability to return to work which in our opinion is a practical tool in the evaluation of both form and function of replanted hands, five of our patients had return to work, three of them were back to same work. All of these patients were satisfied and would do the operation with its difficult postoperative care rather than have prosthesis.

Primary survival in metacarpal and wrist level replantation is very high, not only so but functional recovery seems to be an additional reliable benefit that makes replantation at this level more of a solid indication for both form and function. In our opinion the mentioned preoperative, operative and postoperative points would lead to reproducible results.

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