

## Original Article

# Functional outcome of patients undergoing replantation of hand at wrist level-7 year experience

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## ABSTRACT

**Background:** Replantation is defined as reattachment of amputated limb using neurovascular and musculoskeletal structures in order to obtain recovery of limb. Re-vascularisation involves all the above steps in case of limb injuries that result in a near total amputation. **Aim and Objective:** To study the functional outcome of patients undergoing replantation of hand at wrist level. **Material and Methods:** This is a retrospective study of patients who underwent replantation of total amputation of hand at wrist level within a period of Jan 2003-June 2010. We evaluated post operative functional outcome compared to uninjured hand taking into consideration: 1. The patient's overall satisfaction with the hand. 2. Recovery of flexor and extensor function of thumb and fingers. 3. Recovery of thumb opposition. 4. Recovery of sensations in the median and ulnar nerve distribution. 5. Ability of surviving hand to perform daily tasks. **Results:** There were total seventeen patients and age range was two years to 55 years. Out of 17 patients, 16 were males. All the replantations were successful except for one. **Summary:** The results showed that, although the replanted hands were never functionally as good as the contralateral hand the patients were able to perform most of the daily activities.

## KEY WORDS

Replantation; wrist amputation; hand amputation

## INTRODUCTION

Hand plays an extremely important role in body image and sense of identity, as well as in work (Francois *et al.*, 2000).<sup>[1]</sup> Although amputation of the hand is not a life-threatening event, it does, nonetheless, cause tremendous functional problems and psychological upset, which can lead to a distortion in the sense of self and result in significant conflicts with

respect to work, hope and quality-of-life.<sup>[2]</sup> After the first successful arm replantation, performed by Malt and Mckhan in 1962 and hand replantation that followed soon after by Chen in 1964, hand replantation has become an established and standard procedure.<sup>[3,4]</sup>

The purpose of this study was to evaluate the functional outcome in 17 patients who have undergone replantation of hand at wrist level between January 2003 and June 2010.

## PATIENTS AND METHODS

A total of 17 patients had undergone replantation of total amputation of hand at wrist level between January 2003 and June 2010 at our centre. Out of 17, 16 were males

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and age ranged from 2 to 55 years. All amputations were complete. Twelve were guillotine amputations and 5 were avulsion amputations. Right hand was involved in 11 of 17 cases. Cold ischaemia time ranged from ½ to 6 h with a mean of 2 h. In 10 patients parts were properly preserved while in 7 there was improper preservation of parts.

### Surgical procedure and evaluation

In all cases pre-operative work-up and radiography of both amputated and stump part was done to determine the level of injury and suitability for replantation and for medico-legal purposes a photographic record of both parts was kept [Figures 1-3].

Informed consent was taken and the positive and negative aspects of procedure were discussed with the patient and family including failure rate, duration of rehabilitation, a realistic expectation of sensation, mobility and function and also the cost involved.

In all cases replantation was performed in regional as well as general anaesthesia. After debridement, anatomical structures, viz. the arteries, veins, nerves and tendons were identified and tagged in both stump and amputate. Proximal row carpectomy was done for bone shortening, internal osteosynthesis was performed using k-wires. To avoid tendon adhesions between flexor digitorum profundus and flexor digitorum superficialis, which can influence post-operative recovery of motion negatively, the superficial flexor tendons were routinely resected. The deep flexor and extensor tendons of the fingers, the thumb tendons and flexor carpi radialis, abductor pollicis longus, extensor carpi ulnaris, flexor carpi ulnaris were repaired primarily. Both the radial and ulnar arteries and four dorsal veins were end to end anastomosed under microscope using 9/0 nylon. Neurorrhaphy of median and ulnar nerve was also performed primarily using an epi-perineural technique with 8-0 nylon. All replantations were successful except for one. None of the cases required use of a vein or nerve graft. After skin closure and drainage, the affected limb was placed in a plaster splint, which included hand and forearm and elevated for 4 weeks.

### Post-operative management

Post-operative medications included a broad spectrum antibiotics for 7 days, injection Microspan at 40 micro drops/minute (6 bottles) and tablet Clopivas-AP (Clopidogril and Aspirin) for 21 days. The k-wires were usually removed after 4 weeks post-operatively and then physiotherapy started.

### Assessment



Figure 1: The amputated part



Figure 2: The amputated proximal limb



Figure 3: X-ray of amputated part and stump

The post-operative functional results were evaluated using five main criteria:<sup>[5,6]</sup>

1. The recovery of flexor [Tables 1 and 2 and Figures 4-7] and extensor mobility by the thumb and fingers. This was evaluated by measurement of the total active motion (TAM) of each digit. (TAM = active flexion [metacarpophalangeal (MCP) + proximal interphalangeal



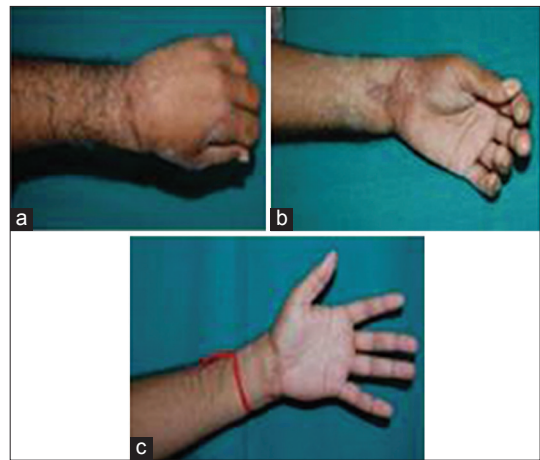
**Figure 4:** Post operative long term result - patient writing with replanted hand



**Figure 5:** Post operative long term results - grip between thumb and 4 fingers



**Figure 6:** Fully rehabilitated patient doing daily activities



**Figure 7a,b and c:** The cosmetic results of the replanted hand

(PIP) + distal interphalangeal (DIP)] – active extension deficit [MCP + PIP + DIP]) and expressing the total TAM for all five digits as a percentage of the total TAM of the five digits of the contralateral hand.

2. The recovery of thumb opposition. The thumb opposition was measured by the amplitude of the arc of circumduction with the thumb fully extended in the metacarpal plane, keeping the first and second metacarpals as far apart as possible and compared to the contralateral hand.
3. Recovery of sensitivity in the median and ulnar nerve distributions. This was evaluated using static two point discrimination (2PD) and an average value taken for each digital nerve within its territory in each finger.
4. The ability of surviving hand to perform daily tasks. This was examined using objects of different shape and dimension to test fine and tripod pinch, grip, span, grasp and hook grip.

5. The patients' overall satisfaction with the surviving hand using a questionnaire of subjective opinion using Carrol Michigan Hand Questionnaire.

Range of movements at various joints were evaluated using goniometer. 2PD in both median and ulnar nerve distribution was evaluated using caliper.

The results of the functional evaluations were classified into five categories:

**Level 1 (Excellent):** TAM and thumb opposition scores were  $\geq 70\%$  of those of contralateral hand, 2PD was 10 mm, the replanted hands could perform most daily tasks without pain or instability and the patient was highly satisfied with the replanted hand.

**Level 2 (Good):** TAM and thumb opposition scores were between 50% and 70% of those of contralateral hand, 2PD was 12 mm, the replanted hand could perform grasping and

**Table 1: Master Chart (A):**

| Patient no. | Age | Sex | Level | Hand  | Cause               | Ischaemia time | Storage  | Bony fixation | Follow-up period  |
|-------------|-----|-----|-------|-------|---------------------|----------------|----------|---------------|-------------------|
| 1           | 20  | M   | Wrist | Right | Tokka               | 2 h            | Cold     | K-wires       | 9 years           |
| 2           | 24  | M   | Wrist | Left  | Tokka               | 4 h            | Cold     | K-wires       | Lost to follow-up |
| 3           | 40  | M   | Wrist | Left  | Tokka               | ½ h            | Cold     | K-wires       | 8 years           |
| 4           | 18  | M   | Wrist | Right | Assault             | 1.5 h          | Improper | K-wires       | 7 years           |
| 5           | 2   | M   | Wrist | Right | Tokka               | 4 h            | Cold     | K-wires       | 7 years           |
| 6           | 50  | F   | Wrist | Left  | Agriculture machine | ½ h            | Improper | K-wires       | Replant failure   |
| 7           | 5   | M   | Wrist | Left  | Tokka               | 1.5 h          | Cold     | K-wires       | 7 years           |
| 8           | 55  | M   | Wrist | Right | Tokka               | 5 h            | Cold     | K-wires       | 6 years           |
| 9           | 20  | M   | Wrist | Left  | Agriculture machine | ½ h            | Improper | K-wires       | Lost to follow-up |
| 10          | 22  | M   | Wrist | Right | Tokka               | 4 h            | Cold     | K-wires       | 5 years           |
| 11          | 20  | M   | Wrist | Left  | Agriculture machine | 6 h            | Improper | K-wires       | 4 years           |
| 12          | 30  | M   | Wrist | Right | Tokka               | 1 h            | Improper | K-wires       | 4 years           |
| 13          | 21  | M   | Wrist | Right | Tokka               | 1.5 h          | Cold     | K-wires       | 4 years           |
| 14          | 40  | M   | Wrist | Right | Agriculture machine | 2 h            | Cold     | K-wires       | 3 years           |
| 15          | 23  | M   | Wrist | Right | Tokka               | 1 h            | Improper | K-wires       | 2 years           |
| 16          | 25  | M   | Wrist | Right | Knife               | ½ h            | Cold     | K-wires       | 2 years           |
| 17          | 18  | M   | Wrist | Right | Tokka               | 4 h            | Improper | K-wires       | 1 years           |

**Table 2: Master Chart (B) :**

| Patient no. | Satisfaction level | Total TAM of thumb and fingers % | Thumb opposition % | Sensory recovery  | Performance of daily activities |
|-------------|--------------------|----------------------------------|--------------------|-------------------|---------------------------------|
| 1           | Highly             | 75                               | 75                 | 10 mm             | All activities                  |
| 2           | Lost to follow up  | Lost to follow up                | Lost to follow up  | Lost to follow up | Lost to follow up               |
| 3           | Fairly             | 60                               | 60                 | 10 mm             | All activities                  |
| 4           | Fairly             | 60                               | 60                 | 10 mm             | All activities                  |
| 5           | Highly             | 65                               | 75                 | 10 mm             | All activities                  |
| 6           | Replant failure    | Replant failure                  | Replant failure    | Replant failure   | Replant failure                 |
| 7           | Highly             | 75                               | 75                 | 10 mm             | All activities                  |
| 8           | Fairly             | 65                               | 60                 | 10 mm             | Grasp and pinch only            |
| 9           | Lost to follow up  | Lost to follow up                | Lost to follow up  | Lost to follow up | Lost to follow up               |
| 10          | Fairly             | 60                               | 50                 | 10 mm             | Grasp and pinch only            |
| 11          | Fairly             | 60                               | 60                 | 10 mm             | All activities                  |
| 12          | Fairly             | 60                               | 60                 | 10 mm             | All activities                  |
| 13          | Fairly             | 60                               | 60                 | 10 mm             | All activities                  |
| 14          | Fairly             | 50                               | 50                 | 12 mm             | Grasp and pinch only            |
| 15          | Fairly             | 65                               | 60                 | 10 mm             | All activities                  |
| 16          | Poorly             | 50                               | 50                 | 12 mm             | Grasp and pinch only            |
| 17          | Fairly             | 65                               | 50                 | 12 mm             | Grasp and pinch only            |

TAM: Total active motion

pinching motions satisfactorily without pain or instability and the patients were very satisfied with the replanted hand.

Level 3 (Fair): TAM and thumb opposition scores between 30% and 50% of the contralateral hand, 2PD was 12 mm, the replanted hand could perform grasping motion without pain or instability and the patient was satisfied with the

replanted hand.

Level 4 (Poor): TAM and thumb opposition scores were <30% of those of contralateral normal hand. 2PD was >12 mm, the replanted hand was unable to perform either grasping or pinching motions, but the patient was satisfied with the replanted hand.



**Table 3: Summary of patient data and results**

| Parameters                      | Numbers<br>(Percentages) |
|---------------------------------|--------------------------|
| Total patients                  | 17                       |
| Study period                    | 7 years                  |
| Age range                       | 2-55 years               |
| Sex predominance                | Male                     |
| Mechanism of injury             |                          |
| Gullitone                       | 12                       |
| Avulsion                        | 5                        |
| Thumb opposition                |                          |
| 50%                             | 4 (28.57)                |
| 50-70%                          | 7 (50)                   |
| >70%                            | 3 (21.42)                |
| Total active motion of fingers  |                          |
| 50%                             | 2 (14.28)                |
| 50-70%                          | 10 (71.4)                |
| >70%                            | 2 (14.28)                |
| Wrist joint motion              |                          |
| 50%                             | 4 (28.57)                |
| 50-70%                          | 8 (57.14)                |
| >70%                            | 2 (14.28)                |
| Sensory recovery                |                          |
| 12 mm                           | 3 (21.42)                |
| 10 mm                           | 11 (78.57)               |
| Performance of daily activities |                          |
| Most activities                 | 9 (64)                   |
| Grasp and pinch only            | 5 (36)                   |
| Satisfaction level              |                          |
| Highly                          | 3 (21.42)                |
| Fairly                          | 10 (71.4)                |
| Satisfied                       | 1 (7)                    |

Level 5 (Unsatisfactory): The patient had a non-functional hand, experienced cold intolerance, pain or para-aesthesia, was not satisfied and requested reamputation.

## RESULTS

Table 3 presents a summary of outcomes following replantation at the wrist joint level in 17 patients with a minimum follow-up of 1 year.

The age range varied between 2 and 55 years with involvement of the right hand in 11 of 17 cases. There were 16 males, 12 were gullitone amputations and 6 were avulsion amputations. Cold ischaemia time ranged from ½ to 6 h with a mean of 2 h. In 10 of patients, there was proper preservation of amputated parts while seven patients had improper preservation. In one patient we had replant failure, 2 patients were lost to follow-up and results have been evaluated in 14 patients. Thumb opposition ranged between 50% and 70% in 7 patients as compared to contralateral hand. TAM of thumb and fingers ranged between 50% and 70% in 10 patients wrist joint motion was

50-70% in 8 patients and >70% in 2 patients.

Recovery of sensation, as measured by the static 2PD test, ranged from 10 to 12 mm and was comparable in the median and ulnar nerve territories. No painful parasthesiae were experienced in any of the replanted hands.

A total of 9 patients could perform most of the daily activities while 5 were able to grasp and pinch only without pain or instability. Three were highly satisfied while 10 were fairly satisfied. In our study, 2 patients had to change their job status.

The functional results were excellent in 2 and good in 10 patients.

Intrinsic muscle function was impaired in all the replanted hands. However no specific postural changes were observed post-operatively in the replanted hands, so no supplementary procedures, such as anti-claw operations were considered to be necessary.

## DISCUSSION

The aim of hand replantation is to restore function and appearance, regain sufficient sensation for the performance of normal daily tasks and allow patients to return to their previous employment [6-10]

Although technological advances over the past three decades have resulted in hand replantations becoming a routine procedure in reconstructive microsurgical centres around the world, reports of results following hand replantation at the level of the wrist joint are uncommon. In a multi-institutional retrospective study from Shanghai, Louisville and Zurich in 1985, Meyer<sup>[11]</sup> reported excellent and good post-operative functional results (Grade I and II) in 81% of hand replantations just proximal to the wrist joint. Vanstraelen *et al.* (1993)<sup>[13]</sup> reported satisfactory functional results with disappointing recovery of sensitivity in six hand replantations at the wrist or distal forearm level caused by both avulsing and sharp injuries. Scheker *et al.* (1995) reported three wrist joint level replantations with good or excellent post-operative results. Waikakul *et al.* 1998;<sup>[7]</sup> have also reported satisfactory functional outcomes after wrist joint level replantations. However most of these reports included both complete and incomplete hand amputations, mixed sharp and avulsion injuries or grouped arm, forearm, wrist and digital replantations together.<sup>[6]</sup>

Among macro replantations, amputations at the level of the wrist joint are thought to have the most favourable outcomes and to do better than replantations at other levels of arm and forearm (Meyer, 1985).<sup>[11]</sup>

The skeletal management in cases of wrist replantations has been considered by Chow *et al.* (1983)<sup>[9]</sup>, Meyer (1985)<sup>[11]</sup> and Vanstraelen *et al.* (1993)<sup>[13]</sup> who all feel that the most favourable procedure for bone management should be considered according to individual circumstances with options including primary arthrodesis of the wrist joint, proximal row carpectomy<sup>[14]</sup> or some type of primary arthroplasty. In our study, we have done proximal row carpectomy and stabilized the wrist with k-wires for a period of 4 weeks. This technique reduces the operation time and requires only minimal tissue dissection while providing good restoration of joint function.

There are many scoring systems for the functional evaluation of limb replantation (Tamai 1982),<sup>[12]</sup> but none is established as the standard system for the functional evaluation of replantations. We have evaluated the patients based on the goals of the procedure, which are to reconstruct all the functions of replanted parts to allow adequate performance of daily tasks.<sup>[6]</sup>

We have evaluated our seventeen cases of replantation of hand at wrist level over a period of 7 years and compared our results with the study by Hoang *et al.* 2006.<sup>[6]</sup> All our cases were complete amputations through the wrist joint. Although the movements in all of these replanted hands was reduced and the sensation was diminished when compared to uninjured counterpart, all our patients were satisfied with their replanted hands, which were able to perform grasping and pinching motions satisfactorily. One of our patients who had poor function and poor level of satisfaction had an amputation as a result of suicidal attempt and was not co-operative with physiotherapy.

Only one of our patients had replantation failure and this patient had avulsion amputation and was also a diabetic. Our minimum follow-up was 1 year and two of our patients were lost to follow-up.

We had impairment of intrinsic muscle function in all patients. Hoang *et al.* (2006)<sup>[6]</sup> also reported limited functional recovery of intrinsic muscles in their series. Vander wilder *et al.* (1992) reported a successful hand replantations at the level of the wrist joint with a recorded cold ischaemia time of 54 h, but intrinsic motor function was not detectable

at the sixth post-operative month. Vanstraelen *et al.* (1993) also reported poor recovery of intrinsic muscle function after wrist or distal forearm replantations.

Despite the fact that functional outcome of replanted hands will never equal that of normal healthy counterpart, replantation has major functional, cosmetic and psychological benefits. Our patients were very satisfied with their replanted hands, which have helped them to return to a better quality-of-life than they might otherwise have had.

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