

High Radial Nerve Paralysis; Clinical Comparative Study between Single Tendon Transfer and Triple Tendons Transfer for Regain Wrist and Digital Functional Extension

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ABSTRACT

Background: High radial nerve paralysis is a very distressing hand condition among hand trauma patients, several methods have been used to restore the lost function in extension of the wrist and fingers.

Objectives: To compare between one of the classic methods used for tendon transfer in high radial nerve paralysis and new method which utilize single tendon instead of triple tendons.

Patients and Methods: Thirty patients with old post traumatic irreparable high radial nerve paralysis one year ago allocated into two groups the first one operated by the transfer of flexor carpi ulnaris to extensor digit minimi and extensor digitorum communis and extensor indicis proprius and extensor pollicis longus while the second group operated by triple Jones technique tendon transfer of pronator teres to extensor carpi radialis brevis and flexor carpi ulnaris to extensor digitorum communis and palmaris longus to extensor pollicis longus to restore wrist extension and fingers extension including thumb.

Results: Results was assessed using bincas scoring system which was described to assess results of radial nerve paralysis tendon transfer, by comparing the results of both groups we found that there is no significant difference between the two groups unless we found that group one has short operation time and early return to work than group two.

Conclusion: Tendon transfer in patients with high radial nerve paralysis gives high results in the form of functional extension and patient satisfaction; in addition, after one year follow-up single tendon transfer gives higher results in the form of utilizing less donor muscles, shorter operation time and early return to work.

Key Words: Radial nerve paralysis – Tendon transfer – Traumatic – Flexor carpi ulnaris.

INTRODUCTION

Peripheral nerves of the upper limb represent the extension of the brain, so regarding the hand surgery prospective, poor functional outcome after peripheral nerve lesions leads to disappointing

expectations either to patient or surgeon [1]. Wrist extension mainly done by radial nerve in its proximal pathway and fingers extensors also supplied by its posterior interosseous branch [2]. Patients with radial nerve paralysis suffer from loss of active fingers and wrist extension in which this loss has great affection on patients grasping and power grip affecting their daily activities and work [3]. More than fifty methods have been used and described in tendon transfer for patients with radial nerve paralysis, each method have its advantages and disadvantages and its indication. The most important principle is to choose which tendon to transfer and when to transfer and where you do the transfer [4]. The main aim of this study is to compare between Jones technique used for tendon transfer which uses three donor tendons in patients with high radial nerve paralysis and new method which utilize single tendon instead of triple tendons.

PATIENTS AND METHODS

This prospective randomized double blinded study was performed in Plastic and Reconstructive Surgery Department in Mansoura and Aswan University Hospitals. It was done on a convenient sample of a randomly selected 30 patients with post traumatic radial nerve paralysis ranging from 18 to 52 years, between August 2014 and March 2017. Two groups of adult patients of both sexes were scheduled for tendon transfer surgery in this period. First group has operated for single tendon transfer and the other group for triple tendon transfer surgery.

Inclusion criteria:

Radial nerve injury was to be completely cut without any previous attempts to repair or failed repair over one year and this failure is confirmed

by nerve conduction study in the repaired nerve. The study was approved in Ethics Committee Research of our institution and all patients were completed an informed consent form.

Exclusion criteria:

Those who were unwilling to accept risks, had stiffness or severe limitation of movement of the hand, subjected to other nerve repair related procedure in a period less than one year at time of presentation, similar procedures had been performed previously, associated with trauma to the ulnar or the median nerve of the same limb or the power of the flexor carpi ulnaris less than 4/5 on muscle scoring system and with compromising systemic conditions e.g. rheumatoid arthritis, diabetes mellitus or other debilitating chronic diseases are excluded. These patients have been randomly allocated into two equal groups.

Operative technique: For both groups regional anesthesia was done nearly to all patients except general anesthesia was done only for irritable and non-tolerable patient and failed regional block. Supine position, with the affected upper limb abducted on arm table with tourniquet applied. The operative site was sterilized using povidone iodine 10%.

For Group I; single tendon (FCU) transfer: This procedure includes only two incisions; the first incision is directed longitudinally over the FCU in the volar distal ulnar half of the forearm. The FCU tendon is transected just proximal to the pisiform and freed up as far proximally. The second incision is a dorsal longitudinal incision 5 to 7cm long in the center of the distal forearm and directed toward Lister's tubercle to expose the extensor digitorum communis, extensor indices proprius, extensor digiti minimi, and extensor pollicis longus and release of the proximal extensor retinaculum to permit excursion after transfer. A tendon passer or large clamp is then passed from the dorsal wound subcutaneously around the ulnar border of the forearm, and the tendon of the FCU is pulled into the dorsal wound. The FCU tendon is cut longitudinally into two equal segments radial and ulnar segments, a slit was done in every extensor tendon starting from the tendons of the little finger and passes obliquely upward to the next tendon till that of the index finger. The ulnar part of the FCU will be passed through the EDM, EDC and EIP tendons distally as possible and turn the distal end on EIP. It will be sutured to each, end to end separately using a Pulvertaft weave with 3-0 or 4-0 nonabsorbable braided sutures. The EPL tendon was cut at the musculo-tendinous part; then the radial part

of the flexor carpi ulnaris will be transferred along incision in extensor pollicis longus tendon and after that we should do the repair with full extension of the thumb by end to end technique. Locate the point of insertion into each slip that recreates the normal finger cascade. The final transfer tension is set with the metacarpophalangeal joints in full extension while the wrist is in 30 degrees of extension ensuring that the tension in the thumb and index metacarpal are parallel. Tension will be adjusted until wrist flexion of 30 degrees produces adequate thumb and finger extension (Figs. A,B,C).

Operative technique for Group II; triple tendon transfer (PT, FCU, and PL): This procedure was performed through three incisions, the first incision is like first incision in the first group but its distal end is "J" shaped, with the transverse extension being long enough to reach the PL tendon. The FCU tendon is transected just proximal to the pisiform and. Freed up proximally as the incision will allow. The PL will be released from its insertion to facilitate harvest toward the EPL tendon. The second incision like group one to expose the extensor digitorum communis, extensor indices proprius, extensor digiti minimi and extensor pollicis longus. While the third incision is a longitudinal incision was made over the middle third of the radial aspect of the forearm and radius. The insertion of pronator teres at the middle of the lateral surface of the shaft of radius was identified and the tendon was separated with a strip of periosteum to augment its coaptation to the ECRB tendon. The wrist extension transfer is performed first step in the transfer. Identify the ECRB then divide it at the musculotendinous junction. The PT is then rerouted superficial to the radial artery and the ECRL and deliver it dorsally, deep to the brachioradialis and suture it to the ECRB (Fig. F). Maximum tension is put on with the wrist in 45 degrees of extension, or suturing the PT into the ECRB without tension, with the wrist held in 60 degrees of extension. FCU then sutured to EDM, EDC and EIP, and then develop a subcutaneous tunnel to the dorsal thumb below the cutaneous nerve. The EPL tendon was cut at the musculo-tendinous part released from the third compartment and delivered through the tunnel to the volar incision and perform the transfer in a more volar location, and then sutured end to end to the PL tendon (Fig. D,E). Tension will be adjusted until wrist flexion of 30 degrees produces adequate thumb and finger extension (Fig. G). At the end of the operation, deflation of the tourniquet was done and achieving good hemostasis and the skin was sutured using 3/0 moncryl sutures or staples. The wrist has been immobilized in forty degree of extension, ten

degree of metacarpophalangeal joint hyperextension and maximal extension and abduction of the thumb in by a forearm splint. Finally the distal interphalangeal and proximal interphalangeal joints should be free.

Post-operative management program for both groups: All patients were discharged from the hospital on the day following the operation and the Sutures were removed after 15 days and the slab was removed after 4-6 weeks. Afterwards, the patients started a physiotherapy program for reeducation of the muscle. A dynamic splint may be applied so that finger extension may begin at 1

week postoperative (Fig. H,I). Follow-up has taken place weekly for the first 2 months after removal of the cast and then monthly up to 6 months.

Results have been assessed using the method described by (Bincaz et al., 2002) (Table 1). [5] According to this scoring system, the wrist extension, metacarpophalangeal joint extension, first web space opening and patient satisfaction have been considered by points from 0 to 3. Results have been judged to be excellent with a score above, or equal to 8 points, good with a score of 6 or 7 points, fair with 4 or 5 points and bad with 3 or less points.

Table (1A,B): Bincaz scoring system for assessment of results [5].

Number of scoring points	(3)	(2)	(1)	(0)
• Extension of the wrist		>29	0:29	<0
• Metacarpophalangeal joint extension		Complete	Extension loss <10	Extension loss >10
• First web space opening		>39	30:39	<30
• Patient satisfaction	Excellent (no difficulty to perform work)	Good (mild difficulty to perform work)	Fair (moderate difficulty to perform work)	Poor (sever difficulty to perform work or unable)

Results	Number of points
Excellent	8
Good	7 or 6
Fair	5 or 4
Bad	3 or less

RESULTS

Data was collected and analyzed using SPSS (Statistical Package for Social Sciences) Version 15. Qualitative data was presented as number and percent. Comparison between groups was done by Chi-Square test. Quantitative data was presented as mean $\pm$ SD. Student *t*-test was used to compare between two groups. $p < 0.05$ was considered to be statistically significant (Table 2).

This study included 30 patients. The mean age of the patients in group 1 is 35.07 ± 11.23 and group 2 is 34.87 ± 10.32 years. 12 males and 3 females in group 1 and 11 males and 4 females in group 2. 12 patients were right handed and 3 were left handed in group 1 and 13 patients were right handed and 2 were left handed in group 2. In the right hand 6 patients had injury and in the left hand 9

patients had injury in group 1 and in the right hand 5 patients had injury and in the left hand 10 patients had injury in group 2.

The wounds healed with first intention with no problems except 1 case in group 1 and 2 cases in group 2 and treated with frequent dressing and healed by secondary intention with no major complications. Re-education started 25-30 days' postoperative. The patient returned to work in first group after 4.27 ± 1.16 months and in second group after 5.27 ± 1.16 months.

In group 1 (Figs. of group 1 A,B,C) nine patients showed excellent results and 4 patient showed very good results and 2 patients show fair results and in group 2 (Figs. of group 2 D,E,F) eight patients showed excellent results and 6 patients showed

very good results and 1 patient show fair results. Regarding the results of operations, the mean result is 7.27 ± 1.10 in group 1 and is 7.20 ± 1.01 in group 2 so there is no significant difference between the results of operations in the two groups but, regarding the time of operation the mean time of operation in group 1 is 91.00 ± 11.98 minutes and $160.00 \pm$

19.36 minutes in group 2 and about patient return to work, in group 1 the mean time for patient return to work is 4.27 ± 1.16 months and in group 2 is 5.27 ± 1.16 months so, we found that there is significant difference between the two groups in the time of operation and time needed to return to work.

Table (2): Data and analysis of both groups' data.

	Group No. 1 (N=15)		Group No.2 (N=15)		<i>t</i>	<i>p</i>
Patients age	35.07±11.23		34.87±10.32		0.051	0.960
Operation time	91.00±11.98		160.00±19.36		11.735	<0.001*
Result of operation	7.27±1.10		7.20±1.01		0.173	0.864
Follow-up time	10.67±3.29		11.40±4.00		0.549	0.587
Return to work time	4.27±1.16		5.27±1.16		2.355	0.026*

	Group No. 1 (N=15)		Group No.2 (N=15)		χ^2	<i>p</i>
	No	%	No	%		
<i>Sex:</i>						
Male	12	80	11	73.3	0.186	0.666
Female	3	20	4	26.7		
<i>Hand dominance:</i>						
RT	12	80	13	86.7	0.240	0.624
LT	3	20	2	13.3		
<i>Injured hand:</i>						
RT	6	40	5	33.3	0.144	0.705
LT	9	60	10	66.7		
<i>Wrist extension:</i>						
0-29	8	53.3	5	33.3	1.222	0.269
>29	7	46.7	10	66.7		
<i>MCP extension:</i>						
Extension deficit <10	3	20	7	46.7	2.40	0.121
Complete	12	80	8	53.3		
<i>Web space opening:</i>						
30-39	7	46.7	9	60	0.536	0.464
>39	8	53.3	6	40		
<i>Patient satisfaction:</i>						
Fair	2	13.3	0	0	2.40	0.301
Good	4	26.7	6	40		
Excellent	9	60	9	60		
Complication	1	6.7	2	13.3	0.370	0.543

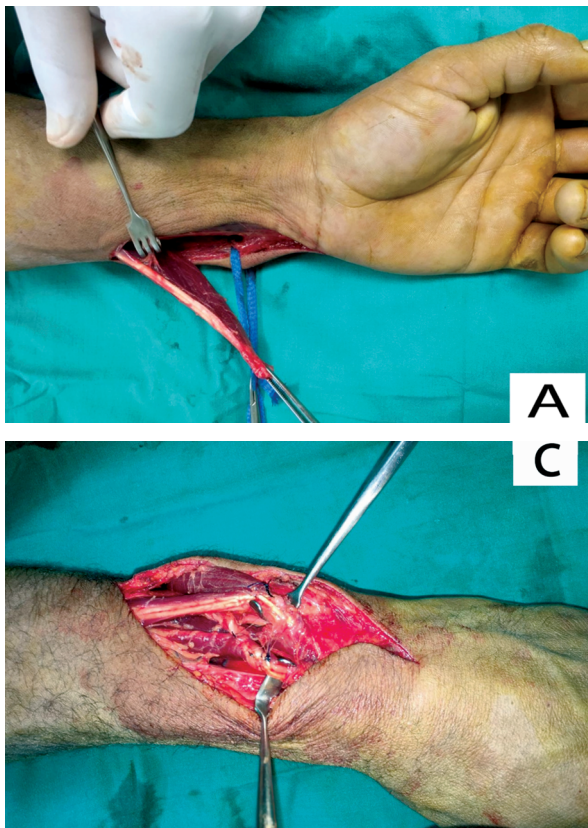


Fig. 1: (A,B,C) Harvesting and transfer of FCU muscle in group one.



Fig. 1: (D,E) Harvesting and transfer of PL, FCU muscle in group two.



Fig. 1: (F) Harvesting and transfer of PT muscle in group two.



Fig. 1: (G) Testing of repair in both groups intraoperative.

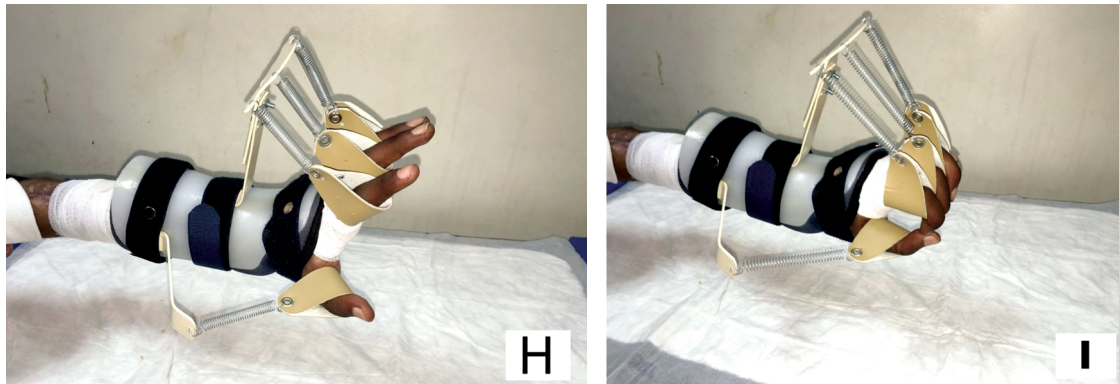


Fig. 1: (H,I) Post-operative dynamic splint in extension and flexion.

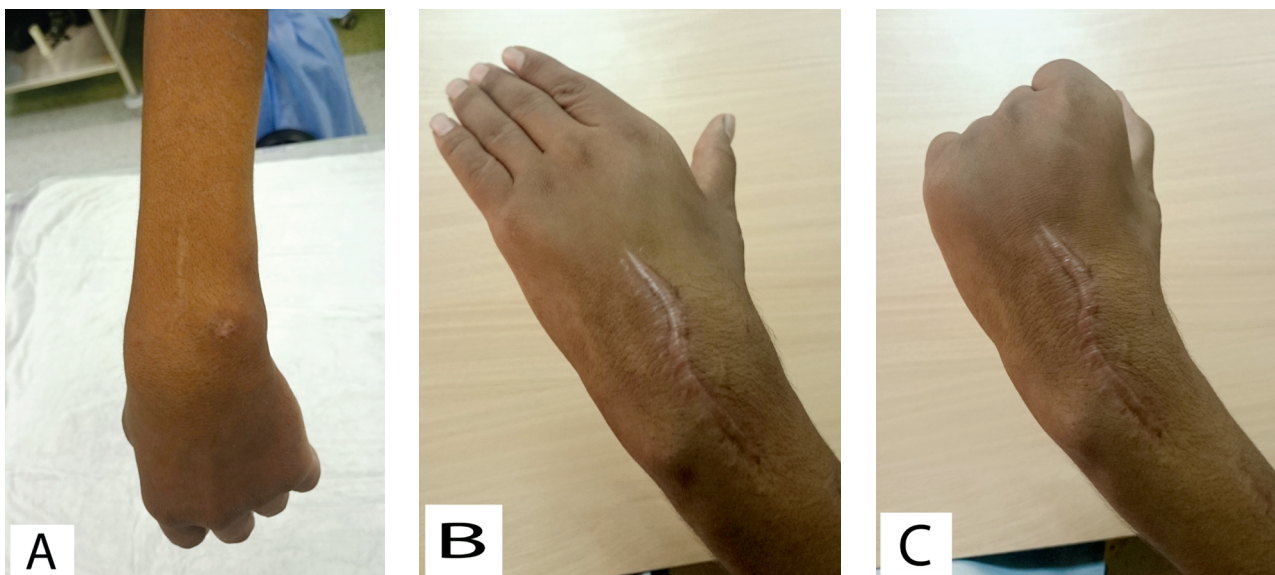


Fig. 2: (A,B,C) Group 1: (A) Pre-operative. Fig. (B,C) Post-operative.



Fig. 2: (D,E,F) Group 2: (D) Pre-operative.
Fig. (E,F) Post-operative.

DISCUSSION

Most authors believe that tendon transfers will result in good outcomes in cases of radial nerve palsy with irreparable damage or reconstruction failure [6,7]. Sunderland recommended that one year is enough to go on tendon transfer if nerve recovery has not happened in this time [8]. Nowadays, there is no agreement on the ideal technique in tendon transfer although nearly all of them give high results [6,9,10].

The site of radial nerve damage as well as the anatomy and general performance of the patient mainly determines the best available transfer method [4]. Regaining grip strength, wrist and digital extension is the main aim of tendon transfer surgery. Classically as mentioned early by Jones [11], triple tendon (PT, FCU, PL) transfer surgery described early to regain extension of the wrist and digits including thumb extension. A new simple procedure represented in transfer of a single tendon of flexor carpi ulnaris which seems to be technically simple and giving good cosmeses and is of appropriate utility especially in polytraumatized and scarring limbs after crushing trauma and tissue loss when fewer options for donor muscle is present [10]. The beginning of using FCU alone is described by Beasley who believes that it is a simple one muscle procedure (FCU) for transfer in low radial nerve palsies which provides excellent functional restoration of digital extension. Here, wrist ulnar deviation is not lost because the FCU is brought around the medial side of the wrist in the way for insertion [12].

But another option to use FCU described by (Gousheh and Arasteh 2006) [10] who done acute early flexor carpi ulnaris tendon transfer to extensor digitorum communis, extensor indicis proprius, extensor digiti minimi and extensor pollicis longus at the session of nerve repair in a group of cases. The author's intention for this transfer is for using it as internal splint during nerve regeneration period. Fortunately, they found good outcome in the early period after operation and the cases is returned work early than expected before nerve healing and regeneration had happened. By comparing these results with the classic one procedure in irreparable nerve lesions they found no significant difference which makes them describe this simple technique.

Recently Yavari, et al., [4] and Sankaran, et al., [13] use single FCU transfer in patients with high radial paralysis with satisfactory high results. Yavari, et al., [4] stated that flexor carpi ulnaris

muscle is a big muscle to be used in regaining the four fingers extension only in triple tendon transfer technique unless it is used alone its power is distributed along the wrist and fingers. Additionally, the muscle excursion improved after working on many recipient joints. The passive extension tenodesis action of the wrist in this transfer is enough to make the flexors muscles of the fingers recover strength of the grip; also there is no any disability or loss in independent thumb position.

There is old doubt about loss of wrist flexion and special hand movement (throwing and hammering) which depends on FCU but Raskin [14] concluded that flexor carpi ulnaris transfer is not different from flexor carpi radialis transfer and also he found that flexor digitorum superficialis acts as a stabilizer for wrist and ulna when flexor carpi ulnaris is not present so he stated that this option of transfer is a good quiet solution.

In the view of the previous mentioned opinions, it was the aim of this study to give an idea about the methods for tendon transfer done for the high radial nerve paralysis of the upper limb and comparing between two methods the old classic one who offered early by Jones [11] which utilizes 3 tendons to restore lost function in these patient and the other new one that utilize single tendon only to restore the lost function in these patients and its effect on the time needed by patient to return to his work and satisfaction after such procedures.

In these cases of radial nerve palsy; thirty patients were operated upon and they were randomly allocated into two groups. All of them had a traumatic high radial nerve paralysis above elbow with history of trauma one year ago after failure of immediate nerve repair procedures or conservative management. First group created from 15 cases that were operated by transfer of flexor carpi ulnaris to extensor digitorum communis, extensor indicis proprius, extensor digiti minimi and extensor pollicis longus. Second group, tendon transfer was done for the other 15 cases in the form of flexor carpi ulnaris transfer to extensor digitorum communis and palmaris longus transfer to extensor pollicis longus and pronator teres transfer to extensor carpi radialis brevis.

Accordingly, the findings of the present experience showed that there was no significant difference between the results of single tendon and triple tendon transfer surgery unless time of operation and time needed to return to work so that single

tendon transfer could restore fingers and wrist extension as well as thumb extension and abduction so that there is no need to transfer more tendons in such surgeries and to waste and damage three tendons in tendon transfer surgeries on patients with high radial nerve palsy because a single tendon transfer surgery may help in regain the lost function and it has the major advantages of being very simple procedure, short operation time, nearly no complication because it needs only 2 incisions and so decreased number of post-operative scars unlike classic one which needs three incisions.

Transfer of single flexor carpi ulnaris muscle has great benefits like less morbidity on the patient because it utilizes only one muscle tendon unit in addition it gives less disfigurement and distortion especially in young patients and females. Also it may play an appropriate role in multi-injured war population and poly-traumatized limb patients.

So the only contraindication to use this procedure is the state of the donor muscle and its power and excursion which should be in its maximal state 5/5 on the scoring system and if it is not so, we should use another procedure or combining other donors with it.

Conclusion:

Recent reports recommend the use of single FCU to restore functional extension of wrist, fingers and thumb, this study showed that; there is no significant difference between the two methods in range of motion and extension for joints of metacarpophalanges, thumb and wrist, patient satisfaction and the whole results. The time of operation is shorter, the patient returned to work early so there was no need to harvest three tendons in tendon transfer surgeries on patients with radial nerve palsy.

It is notable to mention that further studies in near future should be directed to long term follow-up of these patients at least for 5 years and documentation of their life style change after operations and put a suitable questionnaire to be filled pre and post-operatively and compare the grip strength in these patients pre and post-operative and also compare results with normal hand pre and post-operatively. This could be considered as an introduction for more detailed studies for this simple method of tendon transfer in this type of nerve

injury and at different times of high radial nerve paralysis to get a more precise comparison and results.

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