

Original Research Article

Evaluation of split flexor carpi ulnaris tendon transfer for fingers and thumb extension, pronator teres transfer for wrist extension in high radial nerve palsy

Ananta K. Bhakta^{1*}, Pankoj K. Mondol², M. Ziaur Rahman³, M. Humayun Kabir¹,
Bappy K. Biswas¹, Syed M. Sahid¹, Sree A. Kumar¹, M. Rakiz Khan¹

¹Department of Orthopedic Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh

²Department of Ortho Onco Surgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh

³Department of Hand and Microsurgery, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh

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*Correspondence:

Dr. Ananta K. Bhakta,

E-mail: anantabhakta79@gmail.com

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ABSTRACT

Background: The radial nerve is the largest terminal branch of the brachial plexus. Loss of radial nerve function creates a significant disability in the hand. The grip is severely impaired following loss of radial nerve function as a result of loss of extension of wrist, metacarpophalangeal joints of fingers and interphalangeal joints of the thumb.

Methods: Prospective, quasi experimental study carried out for 3 years at National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR). Forty-eight patients of high radial nerve palsy were selected for tendon transfer (split FCU tendon to EDC and EPL) and PT transferred to ECRB.

Results: Mean age of the patients was 28.92 years (range 15-45 years), significantly higher in 26-35 years age group. There was preponderance of injury to the dominant right side (58.33%) than the non-dominant left side (41.67%). Motor vehicle accident (66.67%) was the common cause of injury followed by assault (33.33%). Out of 48 patients, 28 patients score 8-9 (excellent), 16 patients score 7 (good), 4 patients scores 5 (fair). So that, total 44 patients achieved satisfactory outcome (91.67%) and 4 patients achieved unsatisfactory outcome (8.33%). All patients can extend their wrist, fingers and thumb. Beyond this, all patients can flex their fingers up to mid palmar crease and thumb can be extended separately-independent of EDC function.

Conclusions: Transfer of split FCU tendon to EDC and EPL for fingers and thumb extension in irreparable and neglected long standing high radial nerve palsy results significant functional outcome.

Keywords: Radial nerve palsy, Split FCU tendon transfer, Pronator teres transfer, Finger extension, Wrist extension

INTRODUCTION

Hand is a highly specialized organ with grasping, pinching and hooking function, carried out by musculotendinous units. It can give information about the position, size and shape of an object by its highly developed sensory mechanism and described as third eye.¹ The radial nerve is

the largest terminal branch of the brachial plexus. Loss of radial nerve function creates a significant disability in the hand. The grip is severely impaired following loss of radial nerve function as a result of loss of extension of wrist, metacarpophalangeal joints of fingers and interphalangeal joints of the thumb. If radial nerve does not show neural recovery following conservative or surgical repair, tendon

transfer is considered as the standard treatment. Tendon transfer for radial nerve palsy has a 100 years history and any set of tendons that can be considered to be useful has been utilized for the purpose.² There are different levels for radial nerve injury. A very high level radial nerve injury occurs at the level of axilla resulting loss of elbow, wrist, fingers and thumb extension. A high level radial nerve palsy occurs due to injury at or just below the level of spiral groove of the humerus. Here, elbow function is intact but wrist drop is obvious associated with loss of fingers and thumb extension. A low level lesion occurs due to injury just below the elbow. Here elbow and wrist spared but fingers and thumb extension are lost.³ The radial nerve lies in close proximity to the humeral shaft throughout the arm. The nerve is vulnerable to injury at the junction of distal and middle third of humerus where it is tethered to the periosteum by lateral intermuscular septum.⁴ One of the main causes of high radial nerve lesion is the fracture of the humerus during reduction, osteosynthesis, application or removal of implants. If the neurological examination does not reveal any signs of reinnervation and if all signs of an irreversible lesions are present, a tendon transfer operation is justified. The goal of the tendon transfer is to provide wrist extension, fingers extension, thumb extension and abduction.⁵ Irreparable or neglected long standing radial nerve injury is treated with tendon transfers to restore wrist extension, fingers extension and thumb extension/radial abduction. Most surgeons transfer the pronator teres (PT) to extensor carpi radialis brevis (ECRB) to restore wrist extension.⁶ Restoration of fingers extension may be done by using the flexor carpi ulnaris (FCU) or flexor carpi radialis (FCR) or flexor digitorum superficialis (FDS).⁷⁻¹¹ To restore thumb extension/radial abduction most commonly used technique is the transfer of palmaris longus (PL) to the rerouted extensor pollicis longus (EPL).^{6,12,13} The important principle of the tendon transfer is that it should not hamper the existing function of the hand and should not create any significant deformity/disability with or without the return of nerve function.^{14,15}

Objectives

General objective

General objective of the study was evaluation of split flexor carpi ulnaris tendon transfer for fingers and thumb extension, pronator teres for wrist extension in high radial nerve palsy.

Specific objectives

Specific objectives of the study were: evaluation of range of fingers extension, evaluation of range of thumb extension, and evaluation of range of wrist extension.

METHODS

This was a prospective, quasi experimental study and was conducted in the National Institute of Traumatology and

Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh during the period from 01 January 2013 to 31 December 2015. Forty-eight patients of high radial nerve palsy were selected for tendon transfer (split FCU tendon to EDC and EPL) and PT transferred to ECRB. As NITOR is a specialized center for musculoskeletal system and lack of expertise in this speciality in the peripheral centers, many patients are referred to this institute, with a prolong gap since injury, when nerve repair is not feasible. The patients with irreparable or neglected long standing (>9 months) high radial nerve palsy diagnosed on the basis of presenting complaints, clinical examinations.

Enrolment criteria

Inclusion criteria

Patients with irreparable or neglected high variety radial nerve injury, duration of nerve injury for more than 9 months, supple joints of the affected limb, normal muscle power of FCU and PT (MRC-5), and well-motivated and well informed patients were included.

Exclusion criteria

Patients with stiff joints of the affected limb, sharp cut injury of the radial nerve less than 9 months, non-union in affected upper limb fracture, and other nerve, muscle and tendon injury in the affected limb were excluded.

Study procedure

A questionnaire prepared by the researcher considering key variables like age, sex, presenting complains, duration of injury, clinical findings, associated medical conditions, investigations, pre-operative findings and outcome of the surgery which was verified by the guide and the data collected by researcher himself. After enrolment according to the inclusion and exclusion criteria, an informed written consent form with easily understandable language and let the patients duly informed. All the patients were selected as study group for split FCU tendon transfer. A detail history and physical findings were noted according to structured questionnaire.

During postoperative management each patient evaluated by physical examination. For valid statistical analysis, outcome was re-grouped: excellent and good considered as satisfactory; fair and poor categories considered as unsatisfactory. Binczaz scale used for the overall assessment of tendon transfers for high radial nerve palsy.

Data collection

A preformat was prepared as per protocol and it was filled with information from history, clinical examination, investigations, pre-operative findings and postoperative follow up. The data was verified by the guide on discharge of the patient and subsequent follow-up visits.

Statistical analysis

Data were collected, compiled and tabulated according to key variables and functional assessment scoring. The analysis of different variable was done according to standard statistical analysis.

Ethical consideration

Ethical clearance was obtained from the authority prior to commencement of the study. All potential subjects were informed about the purpose of the study and that the information generated from the study would be utilized for the interest of the patients and research. They were also informed about their rights to withdraw themselves from the study at any time for any reason what so ever. The subjects who voluntarily consented to participate in the study were included in the sample.



Figure 1: Preoperative photograph.



Figure 2: Final postoperative photographs.

RESULTS

Table 1 shows that age of the patients in this series ranged from 15 to 45 years. Mean age was 28.92 ± 6.11 years. The age incidence was significantly higher in age group (26-35) years respectively.

Figure 3 shows that in this series, right sided radial nerve were injured in 28 (58.33%) patients and left sided in 20 (41.67%) patients.

Table 1: Age distribution of our study patients (n=48).

Age (years)	N	%
15-25	12	25.00
26-35	32	66.67
36-45	4	8.33
Total	48	100
Mean $\pm$ SD	28.92 $\pm$ 6.11	
Range	15-45	

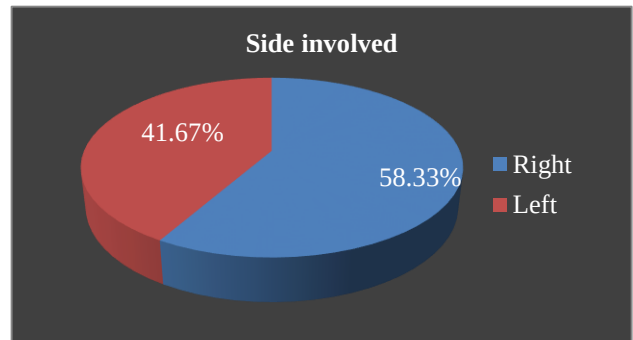


Figure 3: Side involved (n=48).

Table 2 shows that the causes of injury were higher in motor vehicle accident 32 (66.67%) cases and followed by assault were found in 16 (33.33%) cases.

Table 2: Mode of injury (n=48).

Mode	N	%
Motor vehicle accident	32	66.67
Assault	16	33.33
Total	48	100

Table 3 shows that out of 48 cases, 16 (33.33%) patients had associated fracture shaft of humerus and 32 (66.67%) patients had no other injury.

Table 3: Associated injuries (n=48).

Injuries	N	%
Fracture shaft of humerus	16	33.33
None	32	66.67
Total	48	100

Table 4 shows that tendon transfer was done in 32 (66.67%) patients within 9-12 months of injury and 16 (33.33%) patients within 13-15 months of injury.

Table 4: Time of tendon transfer (n=48).

Time (months)	N	%
9-12	32	66.67
13-15	16	33.33
Total	48	100

Table 5 shows that follow-up period ranged from 0 to 12 months. Out of 48 patients, 20 patients (41.67%) were followed up for 6-8 months and 28 patients (58.33%) for 9-12 months.

Table 5: Duration of follow-up (n=48).

Follow-up (months)	N	%
6-8	20	41.67
9-12	28	58.33
Total	48	100

Table 6 shows that 36 cases had no complications, 8 (16.67%) cases developed stiffness of wrist and 4 (8.33%) cases developed stitch infection. All complications subsided gradually with adequate physiotherapy, appropriate antibiotic and dressing.

Table 6: Incidence of complications (n=48).

Complications	N	%
None	36	75.00
Stiffness of wrist	8	16.67
Stitch infection	4	8.33
Total	48	100

Table 7 shows that functional outcome was satisfactory (excellent plus good) in 44 (91.67%) cases and unsatisfactory (fair plus poor) in 4 (8.33%) case.

Table 7: Final outcome (n=48).

Functional and clinical outcome	N	%
Satisfactory		
Excellent	28	58.33
Good	16	33.34
Unsatisfactory		
Fair	4	8.33
Poor	0	0
Total	48	100

DISCUSSION

Tendon transfer provides satisfactory return of function, patient satisfaction, and ability to return to gainful employment for patient with high radial nerve palsy. In cases of irreparable and long standing high radial nerve palsy, a tendon transfer is recommended as the method of choice.^{7,16}

Kruft evaluated the results after a 12 years follow-up of 43 patients underwent Merle d'Aubigne procedure. In this study, FCU is transferred to EDC and EPL, the ulnar stabilization stays intact and the FCU continues to work against radial deviation of the wrist.⁵ Application of FCU causes only minor balance problems because the muscle's location and its direction of pull remain almost unchanged. If a radial deviation occurs, this condition can be corrected

by physiotherapy. The patient has to learn to extend the wrist and to reach ulnar adduction simultaneously. In case of radial abduction after FCU transfer, an ECU therapy will provide a balanced wrist function and patient can perform daily life activities where ulnar stabilization/activation is required. 41 out of 43 patients (95%) expressed satisfactory outcome and 38 patients (88%) were able to work in their former job again. 32 patients (84%) complained of discomfort only during heaviest exertion. 26 patients (63%) could extend their fingers separately.

Qattan et al carried out a prospective study since 1994 over 15 patients (10 males and 5 females) of irreparable high radial nerve palsy treated with pronator teres to extensor carpi radialis brevis (for wrist extension) and a single tendon (flexor carpi radialis or ulnaris) transfer to restore fingers extension as well as thumb extension/radial abduction.¹⁷ The result of this transfer in 15 consecutive patients (mean age 28 years) were analyzed. At final follow-up (mean 30 months), all patients had reasonable wrist movement, finger extension and thumb extension/radial abduction. Extension deficit of metacarpophalangeal joints of the fingers did not exceed 7° and there were no extension deficits at the interphalangeal joint of the thumb. All patients were able to make a full fist with no deficits of finger. The overall results were rated excellent in all patients and good in the remaining three patients according to the Binczaz scale. More interesting was the ability of all patients to flex their fingers with only mild relaxation of the extended/abducted thumb.

In our study, total 48 patients were included in the study after fulfilling all the criteria for selection and were treated by tendon transfer. In this study, patients age ranged from 15 to 45 years, 66.67 percent of the patient was between the age group 26 to 35 years. This group represents the youngest age group having high activity for earning, needed early return to their job or activity. In this study, 28 cases (58.33%) were injured on right side and 20 cases (41.67%) were injured on left side. Most of them were in moderate to low-income group. Most of them were earning member of their family. None of them were athlete. 66.67% of the radial nerve palsy was due to motor vehicle accident.

I have used three incisions for isolation of donor and recipient tendons. I transferred PT to ECRB for wrist extension, FCU tendon splitted into two halves, one transferred to EDC for metacarpophalangeal joints extension and another transferred to EPL for thumb extension. Tensions of the tendon were maintained in such a way that wrist joint was at 30° of dorsiflexion and passive flexion of the fingers after suture had been inserted and on flexing the wrist there was extension of finger and thumb.

Postoperatively, 4 cases developed stitch infection treated with regular dressing and antibiotic, 8 cases developed

stiffness of wrist which were dealt in time. Finger movements return before the wrist movements.

In my series, minimum follow-up period was 6 months and maximum period was 12 months. During this follow-up period, I have given more emphasized on regular active and passive exercises of wrist, fingers and thumb. Adequate exercise, regular follow-up and cooperation of the patient is essential for expectation of better result.

Among 48 patients, ten patients can extend the wrist joint more than 29° and 8 patients can extend the wrist joint less than 29°. All patients can flex the wrist strongly to neutral position. Forty patients have no extension deficit, 8 patients developed 10° extension deficit at metacarpophalangeal joints. All patients can flex their fingers upto mid palmar crease. All the patients had weakness of thumb abduction at first and second follow-up. But after removal of cast, all of them starts adequate physiotherapy and regained the power of thumb abduction.

The grading of the results absolutely dependent on the range of movement of the wrist and metacarpophalangeal joints. In this series of 48 follow-up cases 40 cases achieved full range of motion of wrist and fingers at the last follow-up and 8 cases achieved some limitation of motion of wrist or metacarpophalangeal joints of fingers. The decrease in range of movement was of the fact that: preoperative stiffness of joint, ineffective maintenance of tension of tendons during operative procedure, irresponsive to the active and passive exercise of the joints, and long delay of tendon transfer causes disuse atrophy of muscle.

Considering all these criteria in mind, the result of our study has been charted out on the basis of permissible range of motion in the wrist, fingers and thumb. The subjective evaluation was obtained by questioning the patients as to their limitation in their occupation or activities of daily living an asking them to assess their functional result.

Our study's findings align with previous research on tendon transfers for radial nerve palsy. Hwang et al reported a high rate of functional recovery with FCU to EDC and PT to ECRB transfers, where most patients regained significant wrist and finger extension.¹⁸ Similarly, Seddon highlighted the effectiveness of tendon transfers in restoring hand function, with patients achieving satisfactory outcomes in terms of strength and range of motion.¹⁹

Zancolli and Mitre's comparative study found that FCU and PT tendon transfers provided reliable results, with most patients regaining functional use of their hands. They noted that factors such as preoperative joint stiffness and the timing of surgery impacted outcomes, consistent with our findings on the importance of timely intervention and postoperative rehabilitation.²⁰

In terms of complications, our study observed a 16.67% rate of wrist stiffness and an 8.33% rate of stitch infection. These rates are comparable to those reported by Camitz and Hovnanian, who also documented similar complication rates and emphasized the importance of postoperative care to minimize these issues.²¹

The overall assessment of functional outcome done by Bincaz scale. Out of 48 patients, 28 patients scored 8-9 (excellent), 16 patients scored 7 (good), 4 patients scored 5 (fair). So that. Total 44 patients developed satisfactory outcome (91.67%) and 4 patients developed unsatisfactory outcome (8.33%). Related study by Kruft obtained 95% satisfactory outcome and Qutan obtained excellent in 12 patients and good in the remaining 3 patients according to Bincaz scale. These satisfactory results of international studies support our study.^{5,17}

Limitations

The study was conducted with a small sample size. So the study findings may not be generalizable in large scale. Due to short study period, it was very difficult to obtain necessary data from the patient by follow up. Because sometimes patients may not be interested in follow up at a fixed interval. The study may face some lacking in statistical significance of its final outcome due to small sample size, strict inclusion and exclusion criteria.

CONCLUSION

Transfer of split FCU tendon to EDC and EPL for fingers and thumb extension in irreparable and neglected long standing high radial nerve palsy results significant functional outcome. Thumb can be extended separately independent of EDC function. Tendon transfer by two tendons in high radial nerve palsy is not only easier and safe procedure for surgeons but also cosmetic and convenient to patient.

Recommendations

The maximum duration of follow up is 12 months. So, further study should be contemplated taking long term evaluation into consideration. A long term randomized comparative study with a large series aiming the merits and demerits of split FCU tendon transfer with other standards sets of tendon transfer for fingers and thumb extension in high radial nerve palsy is recommended. Large scale studies with longer follow-up are essential requirement for an optimum outcome comparison. Though the study was very small but the results of the study can be utilized for further large study.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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