Functional Long-Term Outcome of Tendon Transfer for Late Radial Nerve Injury

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Abstract

Introduction Radial nerve palsy leads to an inability to extend the wrist, fingers, and thumb, which consequently causes decreased grip strength. Immediate and early presentations have multiple management modalities, including primary repair with or without internal splintage, as well as the option of nerve transfer. In contrast, for injuries with late presentation, tendon transfer remains the only effective management tool.

Objective This article assesses the outcome of tendon transfer in cases of radial nerve palsy with late presentation.

Materials and Methods This was a study performed in the department of burns, plastic, and maxillofacial surgery on patients who presented with late posttraumatic radial nerve palsy between March 2018 and March 2022. Restoration of wrist extension was achieved using transfer of the pronator teres to the extensor carpi radialis brevis. For finger extension, the flexor carpi radialis was transferred to the extensor digitorum communis, and the palmaris longus was transferred to the extensor pollicis longus to facilitate thumb extension.

Analysis Patients were followed up regularly every 4 weeks. Postoperatively, patients were scored for functional recovery using range of motion (ROM) assessment and grip strength as criteria, along with overall patient satisfaction with the results. The outcomes were evaluated using the Modified Mayo Wrist Score scale.

Results A total of 22 patients were studied, of which 15 had excellent results, 5 had good results, and 2 had fair results. Grip strength increased postoperatively, as did the ROM of the wrist and metacarpophalangeal joints.

Conclusion Tendon transfers remain the gold standard for managing late radial nerve palsy and are most commonly used in the upper extremity. The results are predictable and fairly consistent. Return to activity after surgery can be expected within 6 to 12 weeks, depending on the patient's tolerance.

Keywords
- late radial nerve palsy
- nerve injury
- tendon transfer

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Introduction

Radial nerve palsy leads to severe disability of the hand, which results in compromised extension of the wrist, fingers, and thumb, thereby significantly impairing daily functional capacity and overall quality of life.[1,2] There are various etiologies including iatrogenic injury, birth trauma, and oncologic resections.[3] Many different surgical interventions are available, each with specific advantages and limitations such as tendon transfer which utilizes a redundant donor muscle to substitute the function of the paralyzed muscles to restore gross movement. Other interventions include nerve grafting and nerve transfer. The recent technique of nerve transfer incorporates principles of both tendon transfer and nerve grafting by directly coapting a terminal motor nerve from an expendable muscle to the motor nerve of the paralyzed target muscle.[4] Selection of an optimal intervention depends on factors such as the time elapsed since injury, patient age, and desired functional outcomes, with each method providing distinct therapeutic benefits and limitations. Due to the specific timeline associated with each procedure, the patients coming with old radial nerve injury is amenable to only tendon transfers. For patients presenting earlier, tendon transfers can be planned based on the initial presentation.[5,6] It can be proposed in the initial few weeks, when suture repair or nerve grafting cannot be done or are not justified or if a very long nerve graft is required[7] where the results become unpredictable. When the nerve repair bed is of poor quality and/or if the subject is much older, than the tendon transfers can be done right away. It can also be done along with nerve surgery in cases of lesions of the posterior cord of the brachial plexus[8] and lesions of the plexus nerve roots, most often C7. Tendon transfer is considered secondarily when the patient presents late (ineffective motor recovery after 12–18 months of denervation[9]), and when there is incomplete or no recovery after nerve repair. Multiple combinations of tendon transfers have been described each with its own merits and demerits. The most widely used combination of transfers is pronator teres (PT) to extensor carpi radialis brevis (ECRB), flexor carpi ulnaris (FCU) or flexor carpi radialis (FCR) to extensor digitorum communis (EDC), and palmaris longus (PL) to rerouted extensor pollicis longus (EPL). Historically, Jones[10] used both FCR and FCU. Starr was the first to transfer FCR and PL, leaving FCU intact.[11] FCU is the strongest and a crucial wrist flexor. Transferring the FCU can lead to wrist radial deviation and decreased power grip. Brand's biomechanical studies also supported this concept demonstrating that the FCU is too strong and has insufficient excursion to be used as a donor tendon for finger extensors and being the prime ulnar stabilizer of the wrist, should not be sacrificed.[12] Hence, FCR transfer is being commonly practiced restoring finger extension in radial nerve palsy.

The aim of our study was to analyze the results of tendon transfer performed for radial nerve palsy who presented late to our department. We present a set of 22 patients, which were managed with tendon transfer to restore function of the wrist, finger, and thumb extension.

Materials and Methods

This is a study conducted on 22 patients presenting with isolated old radial nerve palsy to our department between March 2018 and March 2022. The number of male and female patients was 18 and 4, respectively.

Excluded from our study were the patients with brachial plexus injury or concomitant injury to the median or ulnar nerve and those with did not come for follow-up or dropped out.

The patients were thoroughly examined, preoperative photograph done after taking appropriate consent, and the findings recorded meticulously (►**Fig. 1A**). All patients had supple radiocarpal and metacarpophalangeal (MCP) joints. Preoperative range of motion (ROM) and grip strength were noted. Appropriate consent was taken and patient explained regarding the need for prolonged follow-up and postoperative splintage.

All the patients were operated using the same technique by the same specialist. For our patients, we have used the technique which involves transfer of PT to ECRB to provide wrist extension, for thumb extension PL was transferred to EPL, and FCR to EDC were transferred for finger extension. Postoperative management was same for all the patients. The patients were followed up for a period of 18 months.

Preoperative and postoperative ROM and grip strength were noted for all the patients at an interval of 4 weeks.

Operative Technique

The procedure was performed under general or regional anesthesia as indicated. Tourniquet was applied and limb exsanguinated for a bloodless field. The first incision was made on the volar-radial side of the middle forearm and was curved around the radial border near the PT tendon insertion and angled back toward the Lister tubercle on the back of the forearm. The tendon of PT, located on the palmar side of the incision, is followed to its attachment on the radius bone (►**Fig. 1B**). To facilitate the length of the PT tendon, it was elevated from its attachment along with a strip of periosteum. The PT muscle and tendon were then passed beneath the skin around the radial side of the forearm, over the brachioradialis (BR) and extensor carpi radialis longus (ECRL), and sutured to the ECRB just below its musculotendinous junction using the Pulvertaft method keeping the wrist in 40 degrees extension.

The EPL muscle was identified via a dorsal incision, cut at its musculotendinous junction. It is then removed from the Lister's canal and pulled out dorsal to the extensor retinaculum and is then rerouted to the volar aspect in the direction of the first metacarpal via the subcutaneous pocket. The PL tendon was identified at the wrist, released of its attachments dissecting it proximally to achieve a satisfactory excursion and straight line of pull, and then sutured to the EPL with the thumb in full extension and abduction (►**Fig. 1C**).

Through the radiovolar incision itself the tendon of FCR was identified, transected near the insertion, and freed up proximally up to the mid forearm level. It was then passed dorsally into the forearm using a tendon retriever through a

Fig. 1 (**A**) Preoperative picture with loss of wrist, fingers, and thumb extension in a patient with radial nerve palsy. (**B**) Palmaris longus, flexor carpi radialis, and pronator teres tendons dissected out and placed in their line of transfer. (**C**) All tendons sutured in place with wrist in extension. (**D**) Postoperative image with excellent finger extension at the metacarpophalangeal (MCP) joint and thumb extension. (**E**) Postoperative image with extension at wrist and MCP joint.

loose adequate subcutaneous pocket. The EDC was transected and brought out superficial to the extensor retinaculum and sutured to the FCR. The tendons are sutured with the wrist in around 40 degrees extension, the MCP joints in full extension with FCR at resting length, and the thumb in full extension.

Postoperative Management

Patients were immobilized with elbow pronated and flexed at 90 degrees, wrist kept at 40 degree of extension, and MCP joints and thumb in full extension for a duration of 4 weeks. Wrist extension splint was continued with 30 degrees of extension, active exercises are started at 3 to 4 weeks with finger extension and flexion movements. Wrist movements are started at 5 weeks. Strengthening exercises were introduced at 8 weeks onwards postoperatively and the splint is discontinued.

Assessment

Patients were followed up at 4 weekly interval, careful assessment was made of the range of active movement at the wrist and MCP joint. The functional results were charted using the Modified Mayo Wrist Score[13] (►**Table 1**).

Excellent: Scores between 91 and 100
Good: 80–90

Table 1 Modified Mayo Wrist Score for assessment of function following tendon transfer

Item	Points	Definition
Pain	25	No pain
	20	Mild, occasional
	15	Moderate (tolerable)
	0	Severe, intolerable
Return to sports (work) at 6 months	25	Return without protection
	20	Return with protection
	15	Restricted return to sports, only exercises
	0	Unable to return to sports
Range of motion	25	90–100%
	20	80–89%
	15	70–79%
	0	50–69%
Grip strength	25	90–100%
	15	80–89%
	10	70–79%
	0	50–69%

Fair: 65–79
Bad: less than 65

Grip strength was measured using a dynamometer and the values recorded during each follow-up. The grip strength was then compared with the opposite side and the function determined as the percentage of the grip strength of the opposite side.

Results

A total of 22 patients were included in our study, of which 18 were males and 4 females. The affected upper limb was right in 15 cases and involved the left in 7 patients. Mode of the injury was posttraumatic due to road traffic accidents with humerus fracture and associated injury in the arm seen in 18 cases and the rest had radial nerve palsy secondary to deep laceration.

The age group was between 18 and 45 years with the mean age of 22 years.

The mean wrist extension was around 44 degrees (30–60 degrees range) with PT to ECRB transfer.

For finger extension, the mean value when the wrist was put in extension was 9 degrees and with the wrist in neutral position was 12 degrees. For thumb extension, the first web space was measured in degrees and the mean value was found to be 65 degrees.

For all patients, grip strength was also measured on each follow-up visit. The mean grip strength in female patients was found to be 16.5 kg and 27 kg in male patients after 4 weeks. The grip strength was compared with the opposite hand and charted as the percentage grip strength of the opposite side.

The functional results were evaluated using the scoring system using Modified Mayo Wrist Score. For the 22 patients that were studied, 15 had excellent results, 5 good, and the rest had fair results. The grip strength was also found to have significantly improved from the preoperative state. On assessment, mean grip strength in male patients was found to be 12.5 kg preoperatively and 6 weeks later was found to be 27 kg. For the female patients, the mean value was found to be 8 kg preceding the surgery which improved to 16.5 kg in the follow-up visits (►**Figs. 1D, E** and **2A, B**).

Discussion

The radial nerve is frequently affected in upper extremity fractures, especially humerus fractures where the incidence reaches 12%.[14,15] The nerve can get injured at the middle/distal radius due to its position between two fibrous fixations anteriorly and is exposed to stretching or pulling damage.[16] At the proximal third, the radial nerve is at a risk of iatrogenic damage due to surgical access.[17] Based on the level of injury, it can be divided into high and low injuries depending on whether the level is proximal or distal to the emergence of the posterior interosseous nerve.[18] In high lesions, at the level of the humeral diaphyseal middle third, denervation of the BR muscle is also present. The most common clinical presentation of radial nerve palsies is characterized by complete paralysis with denervation of the extensor musculature with the characteristic "wrist-drop sign." The extension is maintained at the level of the interphalangeal joints, as the intrinsic musculature is innervated by the ulnar nerve.

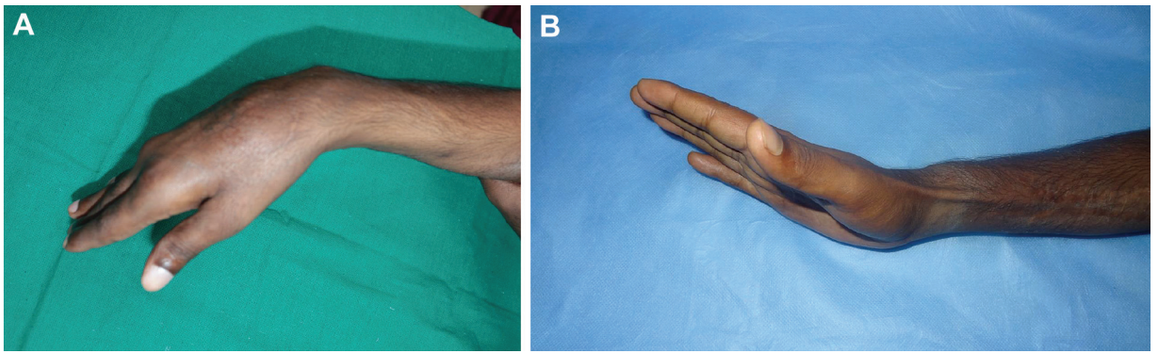

Fig. 2 (A) Preoperative. (B) Postoperative.

Loss of radial nerve function in the hand creates a profound disability. This is mainly due to loss of active wrist extension and the subsequent flexed position of the wrist, which does not allow a powerful grip.[5] Grasping objects also becomes difficult due loss of finger and thumb extension and restricted interosseous muscle function leading to loss of active finger abduction. Tendon transfers thus become one of the most important restorative surgeries for those with radial nerve palsy.

For a patient with radial nerve palsy the functions which need to be restored are (1) wrist extension, (2) finger (MCP joint) extension, and (3) a combination of thumb extension and abduction. All the extrinsic muscles which are innervated by the median and ulnar nerves can be used as donors for a patient with isolated radial nerve palsy. Among the myriad of options available for transfer, one or two combinations of transfers are mostly used by the majority of surgeons.

The sensory part of the radial nerve does not usually mandate repair since loss of sensibility in the territory supplied by it does not necessarily cause functional disability.

For restoration of function of radial nerve apart from tendon transfer, which has been used extensively for over a century now, nerve transfers are an alternative method. Usually expendable branches of median nerve are used with pure motor branch, close to the recipient motor end-plate. However, there are certain disadvantages such as long time to functional recovery as well as time-sensitive nature of the procedure due to the need to restore function before the motor end-plates degenerate. But the nerve transfers can only be done within a stipulated time after which the motor end-plates degenerate and the nerve transfers will have no use. For those presenting late with radial nerve palsies, tendon transfer thus is the procedure of choice.

These tendon transfers are therefore required to provide wrist extension, extension of the fingers at the MCP joints, and extension and radial abduction of the thumb. Tendon transfer can be performed as an "early" transfer simultaneously with repair of the radial nerve which acts as an "internal splint" for restoration of power grip by assisting wrist extension or as a delayed procedure when the reinnervation of the most proximal muscles, BR, and ECRL fails to occur within the stipulated time.[5,6] The more proximal the level of nerve injury, the less likely that the muscle reinnervation will occur before the degeneration of motor end-plates.

For late radial nerve palsy patients, tendon transfers are the procedure of choice and multiple combinations of tendons have been described. Return to activity after the procedure generally occurs at 6 to 12 weeks.

In a study done by Compton et al,[19] the strength regained after the tendon transfer produce for radial nerve, 99 out of 106 patients showed at least M3 motor function and 96 out of 106 achieved M4 wrist extension ranging between 0 to 70 degrees. Time taken to return to daily activities as shown in three studies in this systematic review was approximately 6 weeks.

Another study done by Bertelli[20] shows the recovery of around 40 degrees of ROM at wrist and 40% of grip strength compared with the opposite side despite not having a proper postprocedure hand therapy.

Ropars et al[21] evaluated 15 patients treated with tendon transfers and noted that 11 of the 15 patients reported excellent results, and 2 had good results. They transferred PT to the radial wrist extensors, FCR to EDC, PL to EPL, and abductor pollicis longus tenodesis. The same set of transfers was also recommended by Ishida and Ikuta[22] who assessed 21 patients with an average follow-up of 11.3 years. They reported an average grip strength of 63% of the contralateral side, average wrist extension of 54 degrees, and average finger extension of 5 degrees with the wrist in extension and reported that most patients were satisfied with their results.

Conclusion

Tendon transfer in radial nerve palsy is an important technique to restore wrist extension as well as finger and thumb extension. Nerve transfers are a good alternative but they cannot be done in patients presenting more than a year after injury. In cases which present early few systemic reviews, however, demonstrate that tendon transfers are more reliable and with guaranteed outcomes when compared with nerve transfers and nerve grafting, both of which have less predictable results. Tendon transfers for radial nerve palsy provide excellent and predictable long-term results with most patients describing the recovery as excellent to good. These transfers require sound knowledge of anatomy and a

multidisciplinary team approach with occupational therapists postoperatively to ensure the best results possible. The recovery period postoperatively is of around 2 months and thus gives patients a quicker return to work and faster integration into the society.

Conflict of Interest
None declared.

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