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Brachioradialis to Extensor Carpi Ulnaris Transfer – An Additional Transfer to Prevent Radial Deviation Deformity of the Wrist following Tendon Transfers for Posterior Interosseous Nerve Palsy

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The usual recommendation in posterior interosseous nerve (PIN) palsy is to use the flexor carpi radialis instead of the flexor carpi ulnaris (FCU) for restoration of digital extension. The use of FCU takes away the only remaining ulnar deviator of the wrist. Although, preserving the FCU prevents severe radial deviation deformity, we found that some patients still develop a radial deviation deformity, especially during wrist extension. We have used a brachioradialis (BR) to extensor carpi ulnaris (ECU) transfer to prevent the development of a radial deviation deformity and find that it restores the normal radio-ulnar balance of the wrist by providing a dynamic ulnar stabiliser. It is a simple addition to the standard two tendon transfers for PIN palsy with minimal donor morbidity. We have used this triple transfer for PIN palsy in seven patients with satisfactory results and no complications.

Level of Evidence: Level V (Therapeutic)

Keywords: *Triple tendon transfer, Radial nerve palsy, Posterior interosseous nerve palsy, Radial deviation deformity, Brachioradialis*

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INTRODUCTION

The usual recommendation in posterior interosseous nerve (PIN) palsy is to use the flexor carpi radialis (FCR) instead of the flexor carpi ulnaris (FCU) for restoration of digital extension. The use of FCU takes away the only remaining ulnar deviator of the wrist. Although, preserving the FCU prevents severe radial deviation deformity, we found that some patients still develop a radial deviation deformity, especially during wrist extension. Radial deviation is more pronounced when the patient attempts to perform wrist flexion and extension with flexed fingers (clenched fist), as with the fingers flexed strongly, the FCU is relaxed resulting in more radial deviation when ECU is not present. This deformity becomes a problem for some patients, and they often ask for the possibility of correction, even if it is not functionally disabling (Fig. 1). Existing tendon transfer options do not address the radial deviation deformity seen in these patients, focusing only on restoring finger and thumb extension.

An active transfer to ECU would effectively balance the wrist and correct the radial deviation deformity. The brachioradialis (BR) is available for transfer in patients with PIN palsy because it is innervated by the radial nerve at a higher level. We have used transferred the BR to the ECU to prevent the development of a radial deviation deformity and have used it in addition to the standard transfers to restore extension of the fingers and the thumb. Our set of transfers could be called 'Triple Tendon Transfer for PIN paralysis' in which the FCR is transferred to the extensor digitorum communis (EDC) to restore finger extension; the palmaris longus (PL) to the extensor pollicis longus (EPL) to restore thumb extension; and BR is transferred to ECU to correct the deformity of radial deviation and restore active ulnar deviation. This transfer rebalances the wrist by providing an active ulnar deviator on the extensor side and corrects the radial deviation deformity in these patients. There is no deficit of donor muscle, and it is a simple adjunct to the conventional tendon transfers performed for PIN palsy.

SURGICAL TECHNIQUE

The standard approach for harvesting the PL, FCR and exposing the EDC and EPL is done. The ECU is identified as the most ulnar of the extensor tendons and it is dissected off its fascial attachments. The extensor retinaculum overlying the ECU is not disrupted. The BR tendon is identified at the radial border of the distal third of the forearm and traced to its insertion into the lateral aspect of the radial styloid process. BR is scraped from its bony attachment to obtain its full length to allow easy reach to the ECU. BR is now mobilised to the proximal third of the forearm to have a good excursion and allow its transfer to ECU in a straight line (Fig. 2A,B). The FCR and PL are tunnelled subcutaneously along the radial border to the dorsal incision to reach the tendons of EDC approximately one centimetre proximal to the extensor retinaculum and the rerouted EPL tendon, respectively. The 'standard' transfer for finger and thumb extension is performed first, and then the BR to ECU transfer is added to restore ulnar deviation of the wrist. The transfer is tensioned with the elbow fully extended, wrist held in neutral position in respect to flexion-extension and 20º of ulnar deviation. The ECU is pulled proximally and the brachioradialis pulled distally to its maximum, and the transfer is completed with a Pulvertaft weave using 3-0 Prolene sutures. Tensioning of the transfer should still allow passive movement of the wrist to its central position with the wrist neutral and radial deviation with the wrist extended. All wounds are closed with subcuticular sutures after haemostasis has been achieved.

The hand is splinted in a volar below elbow plaster of Paris slab with the wrist in 30° extension, neutral with respect to ulnar/radial deviation; the metacarpophalangeal joints in 45° flexion and the interphalangeal joints in full extension. The slab is converted to a cast on the third post-operative day and maintained for 4 weeks. After 4 weeks, the cast is converted to a splint and rehabilitation begins. To train the BR to ECU transfer, the patient is asked to hold the wrist in ulnar deviation while performing resisted elbow flexion in a mid-prone position of the forearm. The patient is asked to do these exercises 3–5 times daily. Eight weeks after surgery, the splint is removed and the patient is allowed to use the hand for daily activities and gradually increase their activities.

DISCUSSION

We performed this surgery in seven patients with PIN palsy. Good extension of the fingers and thumb was achieved in all patients. None of the patients exhibited radial deviation of the wrist after BR to ECU transfer, which was frequently observed in patients who had undergone the usual double tendon transfer for digital extension only. All patients were satisfied with the outcome and returned to their normal activities. They were all able to perform active radial and ulnar deviation of the wrist (Fig. **3**). All patients had full range of flexion and extension of the wrist with preserved 'dart-throwing'

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Fig. 1. Persistent radial deviation deformity of the right wrist at 3 years follow-up in a patient who underwent tendon transfer for finger and thumb extension without addressing the radial deviation; the deformity was more obvious while making tight fist.

motion. We felt that the outcomes were better in the group with the addition of the BR to ECU to transfer compared to patients in whom the standard double transfer was performed.

We now perform the BR to ECU transfer in all patients with PIN palsy that elect tendon transfer to restore digital extension. Before a patient can be considered for this tendon transfer, the fingers and wrist must have full passive motion and there must be no joint stiffness. In two of our patients, PIN palsy resulted from surgical intervention for Monteggia fracture dislocation, and in the other five it was due to trauma to the proximal forearm. The mean age at presentation was 28 years (range: 8–54 years). None of these patients were candidates for nerve transfer surgery due to late presentation.

The brachioradialis meets all the criteria laid out by Brand to be a potential donor for correction of wrist radial deviation.[1] The muscle has adequate muscle strength and excursion, with a straight line of pull after transfer to ECU.[1,2] BR is an expendable donor and is always available in patients with PIN paralysis. Smith noted that BR has limited excursion due to its broad insertion into the radial styloid and antebrachial fascia.[3] However, the excursion can be increased by two to three centimetres by releasing the fascial attachments.[3] Several subsequent studies have confirmed that the excursion of BR increases significantly after proximal mobilisation, so it can be considered a useful donor.[4–7] Kozin and Bednar found in their in vivo study that the excursion of BR averages 61 mm after the release of the fascial connections and muscle mobilisation.[5]

Different techniques have been described in literature for correction of the radial deviation deformity following tendon transfers in patients with PIN or radial nerve palsy.

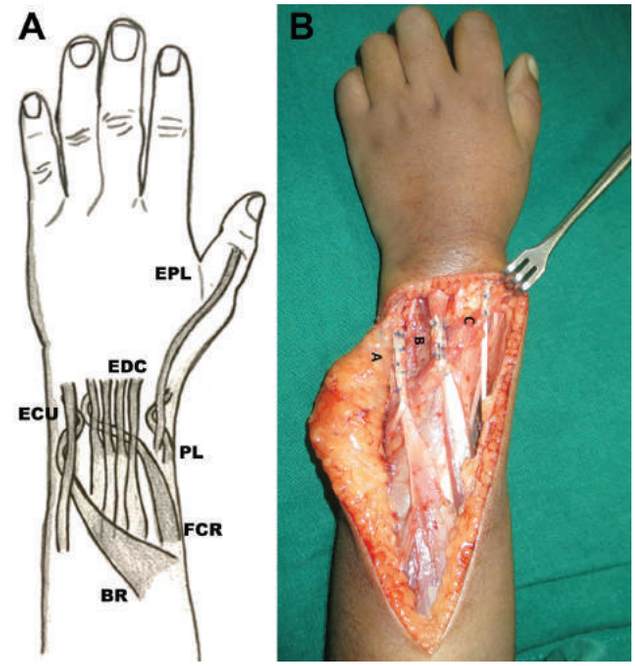

Fig. 2.
A. Schematic representation of the triple tendon transfer – brachioradialis (BR) to extensor carpi ulnaris (ECU); flexor carpi radialis (FCR) to extensor digitorum communis (EDC) and palmaris longus (PL) to the extensor pollicis longus (EPL)
B. Intra-operative photograph showing the triple transfer – A. BR to ECU; B. FCR to EDC and C. PL to EPL

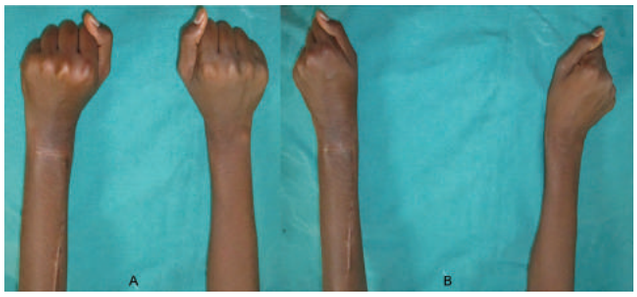

Fig. 3. Post-operative photograph at 6 months from surgery showing correction of the deformity **(A)** and active ulnar deviation in extension at the wrist **(B)**.

Smith described suturing the distal extensor carpi radialis brevis to the ECRL with adequate tension.[3] Tubiana et al. divided the ECRL tendon at its insertion, rerouted it into the fourth extensor compartment, and fixed it to the ulnar aspect of the base of the third metacarpal, medial to the insertion of the ECRB.[8] Others have suggested suturing the ECRL tendon to the ECU/ECRB to effectively increase relative ulnar deviation during wrist extension, restore balance and maximise power grip.[9] Another solution described was to suture the FCU to ECU, making the FCU a pure ulnar deviator of the wrist.[10] However, none of these methods are able to provide active ulnar deviation with extension of the wrist. This is an important consideration in writing and other activities involving 'reversed dart-throwing' motion.

More emphasis was placed on the mechanics of the wrist during 'dart throwing'. However, activities such as writing require a 'reverse dart-throwing' motion that requires active ulnar extension of the wrist. The transfer described here provides an active ulnar deviator and extensor that could restore the reverse dart-throwing motion and provide dynamic balance in the wrist. A longer surgical scar could be considered a limitation of our transfer. However, the dynamic balance achieved by providing an active ulnar deviator would outweigh this disadvantage. The 'Triple Tendon Transfer for PIN palsy' requires the simple addition of a BR to ECU transfer to the conventional tendon transfers used in patients with PIN paralysis. This effectively corrects the radial deviation that occurs in these patients and provides an active ulnar balancing force. This procedure is simple and reliable and is reported for wider application.

DECLARATIONS

Conflict of Interest: The authors do NOT have any potential conflicts of interest with respect to this manuscript.

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Ethical Approval: Not applicable for surgical techniques.

Informed Consent: Written informed consents were obtained in all patients before the surgery. There is no information (names, initials, hospital identification numbers or photographs) in the submitted manuscript that can be used to identify patients.

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