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Radial nerve palsy corrected by brand's procedure: A case report

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Abstract
The radial nerve is one of the three important nerves of the upper limb which causes the wrist, fingers and thumb extension. Loss of radial nerve function in the hand creates a significant disability with difficulty in grasp and power grip. Injuries to the radial nerve can occur at any point along its anatomical route and the etiology could be either post-traumatic or post-surgical. After irreparable radial nerve injury, the only treatment available is tendon transfer other than arthrodesis. Tendon transfer is a treatment option to compensate for the loss of function of the wrist, fingers and thumb extensions of which the flexor carpi radialis (FCR) and flexor carpi ulnaris (FCU) are the most common used donor tendons. FCR tendon transfer provides better functional results than FCU tendon transfer. There is no standard procedure but the surgeon must tailor the tendon transfer procedure according to the patients needs.

Keywords: Radial nerve injury, loss of extension, tendon transfer, rehabilitation

Introduction
The radial nerve arises from the posterior cord of the brachial plexus [1]. The deficits following a radial nerve injury involve the wrist, finger, and thumb extensors. Radial nerve palsy are of two types, high and low. High palsy refers to a radial nerve injury that is proximal to the elbow and that results in deficits in wrist and digital extension. Low palsy refers to involvement of muscles that are innervated by the posterior interosseous nerve (PIN) with deficits in thumb and finger extension and sparing wrist extension. As the extensor carpi ulnaris (ECU) is denervated in a low palsy, wrist extension occurs in a dorsoradial direction [2]. In a high radial nerve palsy, aside from the obvious inability to extend the digits or wrist, poor grasp is a major functional complaint with a grip strength decreased by 77% [2]. The etiology of radial nerve injury in the brachium is usually direct or indirect trauma resulting in neuropraxia or axonotmesis and, rarely, neurotmesis [3]. In supracondylar fractures of the humerus in children, the radial nerve is the most commonly injured nerve [4, 5]. Posterior interosseous nerve (PIN) palsy can occur due to compression by a mass such as a ganglion cyst or synovitis that arises from the elbow joint [6, 7]. Nerve entrapment can occur in the radial tunnel in which the nerve passes under unyielding fascial structures, most commonly, the arcade of Frohse or bands within the supinator muscle [7]. Tendon transfer was first used by Nicoladoni in 1880 in Vienna, then Codovilla in 1899 [8, 9]. These procedures have to be adapted for each patient according to the remaining motor muscles [10]. Tendon transfers restore the function that has been lost and not the function of one paralyzed muscle [10]. They are indicated after 6-18 months of a nerve injury when no clinical and electrical reinnervation occurs following repair, or when nerve repair has failed or when the nerve is irreparable [10].

Case Report
53 year old female presented to our department with difficulty in using the right hand for the past 1 year. She gives a history of a road traffic accident 1 year ago when she sustained a fracture of the right arm for which she was operated immediately elsewhere. After the surgery, she was not able to raise her wrist or fingers. On examination, she had wasting of the extensor group of forearm muscles with absent wrist, fingers and thumb extension with sensory loss of

the right first web space. Nerve conduction study showed no activity of the right radial nerve. A diagnosis of right high radial nerve palsy was made. (Fig. 1) We planned for exploration and tendon transfer as the injury was more than 1 year duration. Under general anaesthesia, loupe magnification and tourniquet control, a longitudinal curvilinear volar and dorsal made and deepened in layers. The pronator teres (PT), Palmaris longus (PL) and flexor carpi radialis (FCR) tendons were identified from the volar incision. The extensor carpi radialis brevis (ECRB), extensor pollicis longus (EPL) and the extensor digitorum communis (EDC) tendons of all four fingers were identified in the dorsal incision. The following tendon transfers were done – PT to ECRB (end to side), FCR to EDC to all four fingers (end to side), and PL rerouted to EPL (end to end). (Fig. 2,3,4) The tendons were approximated by pulvertaft weave method with 3-0 nylon sutures with appropriate tension. Haemostasis secured and incisions closed in layers with 3-0 polyglactin and 3-0 nylon sutures. A volar POP slab was applied. Post-operative period was uneventful with POP slab removal after 3 weeks. Necessary physiotherapy was given and the patient regained good wrist, fingers and thumb extension in 3 months post-operatively. (Fig. 5)

Fig 1: Clinical photograph showing right wrist, fingers and thumb drop

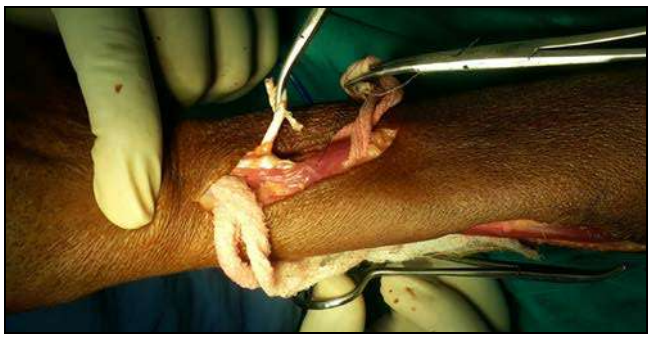

Fig 2: PT to ECRB transfer for wrist extension

Fig 3: EPL tendon rerouted to PL for thumb extension

Fig 4: FCR to EDC transfer for finger extension

Fig 5: Late post-operative picture showing good results

Discussion

A tendon transfer procedure relocates the insertion of a functioning muscle-tendon unit in order to restore lost movement and function at another site. The most common indication for upper extremity tendon transfer procedures is a peripheral nerve injury that has no potential to improve [11]. This includes nerve injuries that are physically irreparable such as root avulsions, nerve injuries that do not recover after direct nerve repair or grafting, or failed nerve transfers. In addition, tendon transfer procedures are often indicated when peripheral nerve injuries present late that muscle re-innervation is not possible due to motor end-plate fibrosis. The principles of tendon transfers are that the joints should be supple prior to transfer, soft tissue equilibrium must be maintained, there should be adequate excursion of the donor tendon with adequate strength, donor should be expendable with a straight line of pull, synergistic action and single function per transfer. The radial nerve arises from the posterior cord of the brachial plexus, passes through the triangular space and enters the spiral groove along with the profunda brachii artery where it gives off branches to the lateral and medial heads of the triceps and to the lower lateral brachial cutaneous nerve [1]. After piercing the lateral intermuscular septum, the radial nerve enters between the brachialis and brachioradialis muscles and near the level of the lateral epicondyle of the humerus, the nerve bifurcates into the superficial and deep branches [1]. The superficial branch of the radial nerve continues beneath the brachioradialis muscle and passes between the tendons of the brachioradialis and the ECRL about 9 cm proximal to the radial styloid and supplying them [12, 13]. Distally, it arborizes to provide sensory innervation to the dorsoradial aspect of the hand, thumb, index finger, the long and ring fingers. The deep branch or posterior interosseous nerve (PIN) passes beneath recurrent vessels from the radial artery and about 5 cm distal to the lateral humeral epicondyle, enters the supinator muscle underneath the arcade of Frohse. The arcade of Frohse is the proximal margin of the supinator which varies from a muscular to a tendinous quality and when fibrous in a third of patients, may compress the nerve [12, 14, 15]. The nerve winds around the neck of the radius between the two heads of the supinator innervating it by multiple branches. In 25% of cases, the nerve lies against the periosteum for about 3cm (bare area) when the forearm is supinated where it is more susceptible.

As the posterior interosseous nerve emerges from the distal margin of the supinator, it supplies the extensor carpi radialis brevis (ECRB), extensor digitorum communis (EDC), the extensor digiti minimi (EDM) and the extensor carpi ulnaris (ECU). The PIN continues distally between the extensor pollicis longus (EPL) and the abductor pollicis longus (APL) [15]. One branch exits the nerve to branch again to innervate the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) and another branch subdivides to supply the extensor indicis proprius (EIP) and the extensor pollicis longus (EPL), and the remainder of the nerve continues distally to the wrist joint [15]. Radial nerve palsy results in debilitating motor dysfunction of the hand. The patient loses the ability to extend the wrist, fingers and thumb, movements that are essential for functional grasp. In addition, the patient loses grip strength because he cannot stabilize the wrist during power grip. Fortunately, the loss of cutaneous sensibility in the radial nerve distribution is well tolerated. High radial nerve palsy is defined as an injury proximal to the elbow. Wrist, finger (MCPJ), and thumb extension, as well as thumb abduction are lost. Low radial nerve palsy, defined as an injury to the PIN, occurs distal to the elbow. Wrist extension is preserved because the more proximally innervated ECRL remains intact. If the PIN is injured proximally, ECU function may be lost, resulting in radial deviation with wrist extension. If the injury to the PIN is more distal, ECU function is preserved and wrist extension remains balanced. There are three main goals when treating radial nerve palsy. They include restoration of finger (MCPJ) extension, restoration of thumb extension, and in cases of high radial nerve palsy, restoration of wrist extension. The most accepted method for restoring wrist extension after high radial nerve injury is the pronator teres (PT) to ECRB transfer. If recovery of the radial nerve is not expected, the transfer should be performed in an end-to-end fashion creating a direct line of pull and a more efficient transfer. However, if the radial nerve has been repaired and ECRB reinnervation is expected in the future, the transfer should be performed in an end-to-side fashion. If performed early, this transfer acts as an internal splint that stabilizes the wrist while the nerve is recovering. The palmaris longus (PL) or the ring finger flexor digitorum superficialis (FDS) are often transferred to the EPL to restore thumb extension. When the PL is used as a motor, the EPL is usually rerouted volarly to meet the PL in a direct line of pull. This results in abduction of the thumb as well as IPJ extension. Three main patterns of tendon transfer procedures for radial nerve palsy are the FCR transfer (Brand), the FCU transfer (Jones), and the superficialis transfer (Boyes) [16-19]. All three transfers use the PT to ECRB transfer to restore wrist extension, but vary in the transfers used to restore finger and thumb extension. The FCR transfer involves an FCR to EDC transfer to restore finger extension and a PL to EPL transfer to restore thumb extension. The FCU transfer is identical except that the FCU is used to power the EDC instead of the FCR. In the superficialis transfer the ring finger FDS is transferred to the EPL and EIP to provide thumb and index finger extension. The middle finger FDS is used to power the EDC to all four fingers, restoring finger extension. In addition, the FCR can be transferred to the APL and EPB to restore independent planar abduction of the thumb [20]. The most important step in surgery having effect on the functional result, is adequate tendon suture tension in any of these three tendon transfers [21, 22]. All patients are given an above elbow plaster holding the wrist in 30-40 degrees of dorsiflexion, metacarpophalangeal and PIP joints in full extension, and the thumb in maximum radial abduction and extension.

Conclusion

Tendon transfers are a good option to correct the loss of function of the wrist, fingers and thumb extensions as a result of irreparable damage to the radial nerve. FCR tendon transfer provides better functional results than FCU tendon transfer in irreparable damage to the radial nerve. The duration from the time of injury to the tendon transfer surgery has no effect on the final functional outcome. There is no single tendon transfer procedure that can be recommended as a standard for any patient but the surgeon must tailor the procedure to the patient's needs.

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