Hand Tips & Tricks: Tendon Transfers for Posterior Interosseus Nerve Palsy: Principles and Technique

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Introduction

Tendon transfer relies on the redistribution of functional parts, which is a fundamental principle of reconstructive surgery. Damage to one of the three major nerves of the hand can cause significant disability in motor and sensory function. The decision to perform a tendon transfer relies on first ruling out the possibility of nerve recovery or nerve repair, as this may restore both motor and sensory function.Tendon transfers restore motor function, but they are unable to restore sensation. They involve the detachment of a donor tendon from its insertion and rerouting it to a new insertion distally.

Prior to pursuing tendon transfer for a patient, the surgeon should consider the principles of the technique. Adherence to these principles will not only ensure that preoperative planning has been performed properly, but it will also allow for more predictable outcomes. Below we will discuss the principles of the technique. This will be followed by the surgical options and technique for a posterior interosseous nerve (PIN) palsy.

Principles

Correction of Contracture

Nerve injury is often complicated by joint contracture, especially when the presentation is delayed. The utility of tendon transfer depreciates in the presence of joint stiffness, and one may not achieve a postoperative active range of motion that exceeds the preoperative passive range of motion. To that end, patient selection should be dictated by the presence of contracture, scarring and stiffness around a joint over which a tendon transfer is planned. Postoperatively, a protocol should be employed to keep the joint supple and prevent scarring that would portend contracture.

Tissue Equilibrium

Tendon transfers should not be done until the local tissue environment has been optimized to receive a tendon transfer. Factors that might be hostile to a successful tendon transfer such as soft tissue swelling, thickened scars, stiff joints and immature wounds, should be addressed ahead of time. Open wounds are a contraindication to tendon transfer, as they carry with them a risk of infection. In the event that soft tissue coverage with a flap or graft is required prior to tendon transfer, it should be performed well in advance so as not to jeopardize the viability of the soft tissue coverage with the tendon transfer.

Adequate Strength

The muscle selected to be transferred must have sufficient strength to perform its new role. The power of the muscle correlates with the cross-sectional area of the muscle. After transferring the muscle, the muscle typically loses one grade of strength on the Medical Research Council (MRC) grading system. Therefore, muscles should only be selected for transfer if they have similar, or preferably greater, power than the muscle they have been selected to replace.

Adequate Excursion

There exists variation in the distance traveled by tendons with movement.This distance traveled is known as excursion, and it is directly related to the amount of joint rotation. It is essential that the tendon harvested has sufficient excursion to replace that which is deficient. As a rule, there is 3 cm of excursion with wrist extensors and flexors, 5 cm of excursion with finger extensors, EPL and FPL, and 7 cm of excursion with finger flexors.A tendon with 5 cm of excursion cannot be expected to replace a tendon with 3 cm of excursion. The result of such an attempt would be a floppy and ineffectual transfer.

Straight Line of Pull

When a tendon is transferred, it should ideally run in a straight line to its new insertion. By maintaining this straight line of pull, one minimizes the resistance of surrounding soft tissue present and the force needed to overcome that resistance. If the tendon must run through a pulley from its origin to its insertion, the less change in direction that occurs at the pulley will produce less friction and adhesion formation on the tendon. There should never be more than one change in direction for a tendon.

Synergism

Muscles that work simultaneously to perform a movement are described as synergistic. Whenever possible, the donor muscle tendon unit should be synergistic to the muscle tendon

unit it has been selected to replace. The wrist flexors and finger extensors are an example of synergistic muscles. According to the principle of synergism, a wrist flexor may be utilized to replace a deficient finger extensor as it would require minimal effort to retrain the brain to have the donor perform this new function.

Expendable Donor

Transfer of a tendon should never result in a critical loss of function. Ideal candidates for harvest are those that perform a function that is performed by another tendon. This allows for preservation of the tendon's original action following transfer. To that end, no two tendons that perform the same function should be transferred simultaneously.

When adhered to, these principles fill an important role as a template for selection when planning a tendon transfer. Below we now cover the use of the tendon transfer for a palsy of the posterior interosseous nerve (PIN).

Tendon Transfer for PIN Palsy

Preoperative Assessment

Before a treatment plan is developed, a comprehensive physical exam, which focuses on wrist, hand and finger range of motion, as well as motor and sensory function of the radial, ulnar, and median nerves must be evaluated to identify any functional deficits. On exam patients may present with forearm extensor compartment atrophy in chronic cases. Weakness will be observed with extension of the thumb and fingers. Radiographs or advanced imaging may be obtained to evaluate possible etiologies such as fractures or tumors.

In regards to radial nerve deficits, one must distinguish a high radial nerve palsy from a low radial nerve palsy. Injuries proximal to the elbow result in a high radial nerve palsy, with loss of function of all wrist, thumb, and finger extensors as well as loss of sensation in the radial nerve distribution over the dorsal thumb and index finger. Injuries distal to the elbow result in a low radial nerve palsy, typically the posterior interosseous nerve. With an injury to the posterior interosseous nerve, patients will exhibit deficits in radial abduction and extension of the thumb as well as inability to extend the metacarpophalangeal (MCP) joints of the fingers. The function of the radial-sided wrist extensors is intact, so patients will maintain wrist extension with radial deviation as the extensor carpus ulnaris is no longer functioning to provide counterbalance. Sensation is usually maintained in low radial nerve palsy.

PIN Palsy Tendon Transfers

In low radial nerve injuries, as wrist extension is maintained with extensor carpi radialis longus (ECRL) and extensor carpi radialis brevis (ECRB), the goal is to restore finger extension at the metacarpophalangeal joints and thumb extension.

Finger Extension

Many tendon transfers exist for finger extension. Common transfers include flexor carpi radialis (FCR) to extensor digitorum communis (EDC), flexor carpi ulnaris (FCU) to EDC, or flexor digitorum superficialis of the long or ring finger (FDS III or IV) to EDC. Some authors advocate against the use of FCU as it is more difficult to harvest than FCR, is too strong with excursion too short, and results in loss of coupled wrist flexion and ulnar deviation, causing both weakness in grip strength and decreased function in tasks such as hammering. In transferring the FDS, the surgeon has the option of excising a large opening in the interosseous (IO) membrane to pass the tendons or routing the tendons around the radius and ulna. In passing through the IO membrane, there is the risk of adhesions and limited function of the transfer.

Thumb Extension

For thumb extension, the most common transfer is palmaris longus (PL) to extensor pollicis longus (EPL). In patients with an absent PL, FDS III or IV can be transferred to the EPL. The brachioradialis is another option but has limited excursion, and it can be difficult to reeducate the patient during rehabilitation.

Tensioning the tendon transfer is a subject of debate. Some authors propose tensioning the tendons until wrist flexion of 30° produces appropriate thumb and finger extension through the tenodesis effect. Other authors suggest that for the FCR to EDC transfer, the wrist be placed in neutral with the MCP joints in full extension and to tension the FCR to around 75% of its maximal tension. Optimally, tension must be tight enough to allow for full extension of thumb and fingers while allowing full flexion of the wrist and fingers. It is better to err being too tight rather than too loose as tendons tend to stretch over time and additional excursion can be regained with therapy. If it is too loose from the start, then the transfer will not function.

Author's Preferred Technique: FCR to EDC, PL to EPL

This operative technique is useful in the setting of a chronic posterior interosseous nerve palsy. Care must be taken to ensure that sufficient wrist extension is intact as an additional tendon transfer would be needed in this case.

Procedure

The patient is positioned supine on a regular operating table with the operative extremity placed on a hand table. A non-sterile, well-padded brachial tourniquet is placed and set to 250mmHg. The operative extremity is prepped and draped in the usual sterile fashion. The limb is then exsanguinated with a sterile esmarch and tourniquet inflated to 250mmHg.

The first incision is made volarly over the FCR tendon. The tendon is identified and the subsheath is released the length of the tendon to accommodate further excursion and allow a more direct line of pull. Without this release, the tendon often makes more of a right angle turn to be transferred dorsally. The wrist is then flexed and the FCR tendon is cut at the level of the trapezium.

Attention is then turned to dissection of the palmaris longus tendon, which will be found just ulnar to the FCR tendon. One

must be vigilant preoperatively to make sure the patient has a palmaris longus tendon, as there have been cases where the median nerve was mistakenly harvested. We typically mark the exact location of the tendon at the wrist crease in the preoperative holding area with the patient actively flexing the PL. Once the PL has been identified, the median nerve is then visualized and protected. The palmaris longus is freed from its surrounding sheath using tenotomy scissors and cut at its insertion into the palmar fascia. Typically, there is abundant length of tendon for this transfer and dissection into the palmar fascia is not necessary.

Dorsally, an incision is made just ulnar to Lister's tubercle to expose the recipient tendons. Dissection is taken down to the level of the fascia with subsequent release of the extensor retinaculum.The EPL tendon is transposed from its sheath and cut proximally at its musculotendinous junction.

Next, the EDC tendons are identified just ulnar to the EPL tendon in the 4th extensor compartment. The extensor retinaculum is released as there is no risk of bowstringing after tendon transfer given the volar pull of the FCR. Prior to cutting the tendons, the wrist is placed in neutral and all fingers are placed in full extension to set the tension of the 2^{nd}-5^{th} extensor tendons. In cases where there is not an EDC to the small finger, one can elect to use the extensor digiti minimi (EDM). Once the tension is set, all four slips are sutured together with 3-0 Ticron suture.The tendons are then cut just proximal to the suture.

After the donor and recipient tendons are exposed, a plane is developed to pass the tendons superficial to the radial artery and deep to the superficial branch of the radial nerve, making sure the tendon transfer does not compress the nerve.

FCR to EDC (Finger Extension)

The FCR tendon is passed from the volar wound to the dorsal wound. At this point, the wrist is placed in neutral and all digits are extended by placing towels beneath them and having an assistant ensure that they remain extended. Once positioned, the tendon transfer is initiated. Using a sharp Pulvertaft weaver, the FCR is passed through each of the four EDC tendons.After the first pass, one must check to make sure tension is adequate. If satisfied, 2 more passes through the tendon are performed and sutured into place with 3-0 Ticron (Figure 1).

PL to EPL (Thumb Extension)

The EPL is then passed from the dorsal wound to the volar wound. Again, the thumb is positioned in full extension with the wrist in neutral. A pulvertaft weave between EPL and PL is performed with tension checked after the first pass. Two additional passes are performed and the ends of each tendon are split and sutured so that they are flush on the sides of the other tendon. (Figure 2).

At this point, tension is checked by testing the tenodesis.The wrist is flexed and extended to ensure adequate excursion and full extension of the thumb and digits. If the transfer appears loose, it is better to revise now than a later date. Once this is satisfied, the tourniquet is released and hemostasis achieved.

Figure 1. FCR to EDC transfer. With a pulvertaft weave, FCR is passed through each of the four EDC tendons and sutured into place with 3-0 Ticron using the dorsal wound.

Figure 2. PL to EPL transfer. Picture of the volar wound demonstrating the Pulvertaft weave of the PL to EPL.

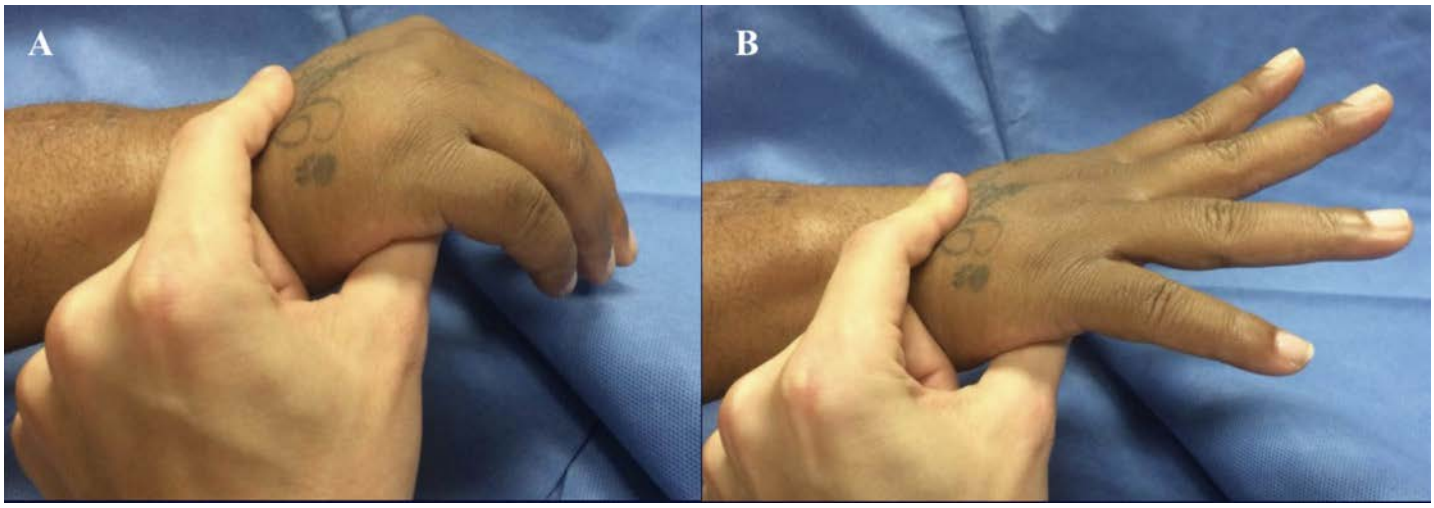

Figure 3. FCR to EDC transfer at the two month postoperative visit. **(A)** MCP joints resting in flexion. **(B)** The patient is able to achieve extension of the MCP joints while the wrist is held in slight extension.

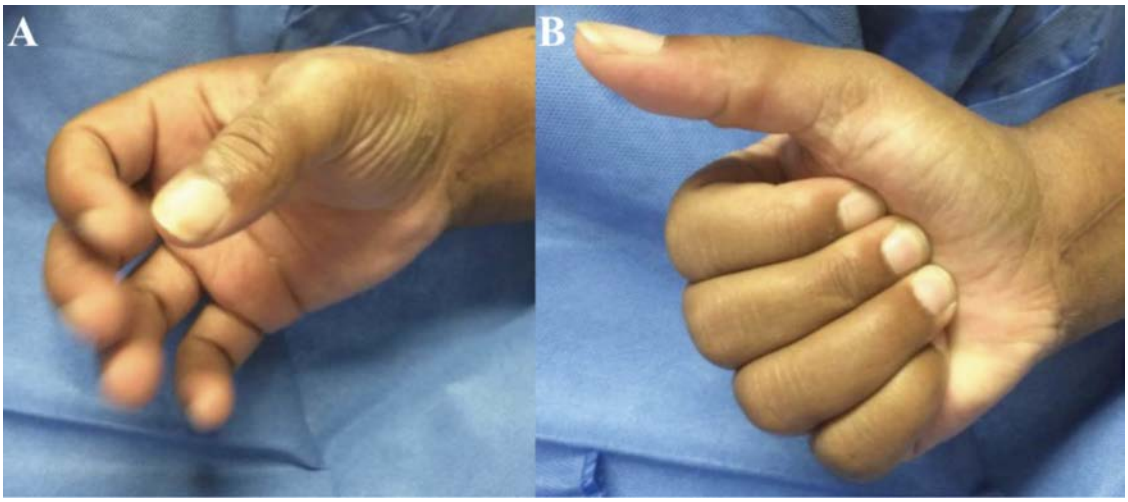

Figure 4. PL to EPL transfer at the two month postoperative visit. **(A)** Thumb IP joint resting in flexion. **(B)** Extension of thumb IP joint achieved through the PL to EPL transfer while the wrist is held in neutral.

The incision is closed in a layered fashion and a dry sterile dressing is placed. The operative extremity is splinted with the wrist in neutral to slight extension and the thumb and fingers extended so as to not place tension on the repair.

Postoperative Protocol

One to two weeks postoperatively the splint is taken down and the wound is examined. A short arm cast is applied with the wrist and thumb extended while the MCP joints are placed in slight flexion. Care is taken to pad all bony prominences. At six weeks, patients are fitted for a custom removable splint, and therapy is initiated. The splint is molded such that the fingers, thumb and wrist are placed in extension. The patient is instructed that they may flex the MCP joints while the interphalangeal (IP) joints are in extension. Similarly, they can flex the IP joints while the MP joints are in extension. At ten weeks postoperatively patients may be advanced to strengthening. (Figures 3 and 4)

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