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Techniques in Hand & Upper Extremity Surgery

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Abstract

The use of tendon transfer to restore functions of extremities was initially recognised in the 19th century, and its advancement was further amplified by the polio epidemic towards the turn of that century. Tendon transfer surgery extended to the use for traumatic reconstructive surgery during World War I, with key surgical pioneers, including Mayer, Sterling Bunnell, Guy Pulvertaft and Joseph Boyes. In 1921, Robert Jones first described the transfer of pronator teres (PT) to the wrist extensors for irreparable radial nerve paralysis in infantile hemiplegia. Although, a detailed description of its indication and surgical outcomes were not published until 1959 and 1970 by Stelling and Meyer, and Keats, respectively. Pronator teres is often the tendon of choice for reconstructing wrist extensors, and used in a multiple of pathologies, including radial nerve palsy, cerebral palsy, and tetraplegia. Reconstruction of finger extensors are less straightforward and options include flexor carpi radialis (FCR), flexor carpi ulnaris (FCU), and flexor digitorum superficialis (FDS). Our article describes the techniques and outcomes of 25 patients that undergone pronator teres transfer. A good understanding of the pronator teres anatomical location and potential variations, aids efficient harvesting and limits unnecessary tissue dissection. Pronator teres tendon harvest is best performed through a systematic and anatomic approach.

Keywords

Anatomy, Pronator Teres, Dissection, Tendon Transfer

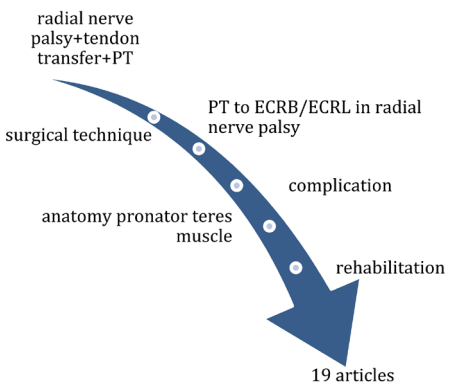
1. Introduction

During the 19th century, surgeon first recognised that transferring tendons could restore certain functional deficit in extremities, and its advancement was further amplified by the polio epidemic in Europe at the turn of that century, which saw a significant raise in patients suffering from limb paralysis. Key surgical pioneers, such as Leo Mayer, Sterling Bunnell, Guy Pulvertaft and Joseph Boyes, expanded tendon transfer sur-

gery, not only to those with paralysis from polio and cerebral palsy, but those with significant traumatic limb injuries endured during World War I [1] [2] [3] [4].

In 1921, Robert Jones described the first pronator teres (PT) transfer to wrist extensors for irreparable radial nerve paralysis in infantile hemiplegia, although a detailed description of indication and outcomes were not published until later by Stelling and Meyer in 1959, and by Keats in 1970. Pronator teres tendontransfer is most often used for wrist extensor reconstruction, commonly using the tendon of extensor carpi radialis brevis (ECRB) as attachment, and for patients with radial nerve palsy, cerebral palsy, or tetraplegia, [5]-[10]. The indication is currently limited to selected cases but offers great functional benefits. It not only improves wrist extension, but grip strength and dexterity, as well as reduction in power of pronation, which is particular useful in cases of muscular spasms. The choice of a transfer tendon for reconstruction of finger extension, is not as straightforward, and the flexor carpi radialis (FCR), the flexor carpi ulnaris (FCU), and the flexor digitorum superficialis (FDS) are all possible donors.

In radial nerve injury the greatest functional loss is grip weakness, an early PT to ECRB transfer (along with nerve repair) is recommended to eliminate the need for an external splint, as it acts as a dynamic splint during nerve regeneration. Authors have highlighted that this type of tendon transfer does not interfere with the recovery of radial nerve injury and supported this approach. The Merle d'Aubigné procedure isone of the technique used for the treatment of irreversible radial palsy, and describes the transfer of PT to ECRB and extensor carpi radialis longus (ECRL), FCU to the extensor pollicis longus (EPL) and extensor digitorum communis (EDC), palmaris longus (PL) to extensor pollicis brevis (EPB) and abductor pollicislongus (APL) [11]. Riordan's tendon transfer simplifies the process by means of the following transfers: PT to ECRB, FCU to EDC, and PL to EPL [12]. Tendon transfer procedure describes the transposition of volar tendons to the dorsal aspect through subcutaneous tunnels, which principally deviates the vector of pull on the extensors from the biomechanical and physiological points of view. We reviewed the literature in English without filter using search engines: Google scholar, CINAHL, and Pub Med, and used search terms: radial nerve palsy, tendon transfer, and pronator teres. 74 articles were identified and 19 were deemed relevant focusing Pronator Teres transfer technique on radial nerve palsy.



2. Anatomy

The word pronator comes from the Latin *pronus* and translate to "inclined forward or lying face downward", which describes the action of pronator teres on the forearm. The Latin term *teres* means "round or cylindrical shaped" or "long and round", which describes the shape of the muscle. PT is located on the volar aspect of the forearm, and functions to rotate the forearm palm-down (pronation) with pronator quadratus (PQ). The muscle originates from two heads (humeral and ulnar) and attaches onto the lateral aspect of the radius. The humeral head is larger and shallower, and begins above the medial epicondyle, at the medial supracondylar ridge with the other common flexor tendons. The ulnar head originates below the elbow on the medial aspect of the coronoid process of the ulna. The two heads come together, cross the forearm diagonally, and insert halfway down the lateral surface of the radius via a tendon.

A rare variant of a high-humeral origin had been reported by some authors, arising from an existing supracondylar process of the humerus and a fibrous band extending between the supracondylar process and the medial epicondyle—the ligament of Struthers. This variation often coexists with a variation of the musculocutaneous nerve [13]. According to anatomical studies PT is innervated by the median nerve with two nerve branches [14] [15]. The degree of reserved PT function if one head is removed is uncertain with no published supportive studies, thus PT had been not recommended for use in functional flap transfer [16].

3. Surgical Technique

Patient position is supine with arm tourniquet inflated up to physiological pressure around 80 - 100 mmHg. Local an aesthesia marcaine 0.25% with 1:200.000 adrenaline is infiltrated around skin incision. The PT tendon is approached through a straight skin incision on the upper lateral aspect of the forearm, and its attachment to the radial shaft could be traced underneath the brachioradialis (BR) muscle from the volar aspect. An amount of radial periosteum is usually raised with the PT tendon.

Pronator Teres to ECRB and ERCL

From the dorsal aspect of the BR, the ECRB and ERCL tendons are identified. The fascia surrounding the PT is released and if necessary proximal origin "z" cut is used to improve the line of pull and muscle excursion. The detached PT tendon is brought through a tunnel under the sheath of the brachioradialis muscle to the dorsal aspect, and tightly weaved (Pulvertaft) onto the ECRB and ECRL tendons in a combined manner with the wrist in maximal extension, using non-absorbable polyester sutures. The upper limb is immobilised for 3 weeks to allow the tendon transfer site to heal, followed by active rehabilitation to improve movement and gliding of the transfer. Cognitive rehabilitation is started after 6 weeks to recover stimulus-response curves and proper excitability of cortical and subcortical inputs.

4. Side Effects and Complication of Pronator Teres Transfer

It is reasonable to expecta weakened wrist extension and reduced range of wrist flexion in patients who had PT to ECRBL transfer. No studies had reported forearm pronation weakness after PT transfer, as pronator quadratus and oppositional supinator compensates for the absence of PT function. Rarer complications include dehiscence of dorsal forearm wound, which can heal secondarily without intervention. Aggressive traction to the nerve can lead to altered sensibility and dysesthesias of radial nerve distribution, and proximal release of the fascia surrounding the muscle can cause iatrogenic damage to the radial artery [10]. Incorrect tension, adhesion formation, and extensive dissection, are all potential complications. Ossification of the periosteum strip is rare, and presents as new bone formation on the tendineous connection that would require a second procedure to remove.

5. Conclusion

The use of PT tendon transfer to restore wrist extensor function is well recognised, and most commonly performed by transferring the PT onto the ERCB tendon. The fibre lengths and muscle shape of the two muscles are nearly identical, which suggests comparable power capacity and lengthening ability, suitable to inter-exchanging [17]. Aside from wrist extensors, PT is used for numerous other tendon transfer surgery, as a donor. The transfer of forearm pronator teres tendon to wrist extensors had shown good incorporation, as pronation is synergistic with wrist extension [18]. Good anatomical understanding of the PT location is essential to expedite the procedure and limit unnecessary tissue dissection. The harvest of the PT tendon is best performed through a systematic and anatomic approach. There is an inherit risk of new bone formation if a periosteum strip is retained during PT harvest, thus it is not necessary or advised if proximal elongation is performed. Contraindications for a PT transfer include partial or complete denervation of the muscle itself.

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Abbreviations

Pronator Teres—PT;

Flexor Carpi Radialis—FCR;

Flexor Carpi Ulnaris—FCU;

Flexor Digitorum Superficialis—FDS.