

# Autologous Tendon Grafts Used in Upper Limb Surgery

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## ABSTRACT

Tendon autografts play an important role in upper limb reconstruction and a working knowledge of tendon autograft options is essential for the surgeon. Although palmaris longus is often the first choice, other options like plantaris, extensor Hallucis longus, flexor carpi radialis are readily available. Advantages of autografts include easy availability, satisfactory biomechanical properties and the human body tends to accept its own tendons than from a donor. This review highlights the various options available and their anatomical and surgical considerations in procuring grafts for upper limb reconstructive work.

**Keywords:** Autologous Tendon Graft; Palmaris Longus; Plantaris; Extensor Digitorum Longus; Extensor Hallucis Longus; Flexor Carpi Radialis; Hamstrings

## 1. Introduction

Autologous tendon grafting forms an integral part of reconstructive upper limb surgery. It is utilised in restoration of tendon length, joint stability, motion and ultimately function of the limb. Allografts have been used with limited success as irradiation prior to use may result in their loss of biomechanical properties [1,2]. Moreover, potential risks of disease transmission, limited availability and additional costs have prevented its widespread use [3-5]. Synthetic materials such as nylon, carbon fibres and silicone have also been employed but they can cause an inflammatory reaction or an antigenic response leading to failure at fixation sites and deficiencies in long-term biocompatibility [3,4]. The decision in choosing a specific tendon autograft involves consideration of the anatomy of the tendon, dispensability and potential morbidity of harvesting the graft as well as the demands of the surgical reconstruction. In this article, we review the anatomy and clinical applications of tendon autografts commonly used in upper limb surgery.

## 2. Palmaris Longus (PL)

PL arises from the medial epicondyle of the distal humerus and adjacent intermuscular septa and lies ulnar to the flexor carpi radialis. The tendon then passes palmar to the flexor retinaculum [6] and flattens into a sheet before being incorporated into the palmar aponeurosis. The vas-

cular supply is from the anterior ulnar recurrent artery and it is innervated by the median nerve with root values of C7 and 8. It serves as an anchor for the skin and fascia of the hand and resists horizontal shearing forces in a distal direction [6]. The tendon can be identified clinically by opposing the thumb to the little finger with the wrist flexed against resistance. PL is absent in about 15% of the population [7,8]. Its absence is more common among Caucasian and Turkish populations [9]. It has also been noted that right-sided absence was more common in left-handed persons while left-sided absence was more common in right-handed persons [10]. The tendon can be harvested without risk of compromising function of the hand and wrist.

In order to harvest the tendon, a small transverse incision is made just proximal to the wrist crease to identify the distal end of the tendon. It is then retracted firmly to create tenting of the overlying skin. At the desired length, a stab incision is made right over the tendon to disconnect it proximally. The tendon is then pulled through before division at the distal end. Alternatively, a tendon stripper may be used to facilitate harvesting through a single transverse incision at the wrist crease. Firm traction is maintained on the tendon while the stripper is advanced in a back and forth rotatory fashion. The instrument is aimed at the medial epicondyle of the humerus [11]. Complications of harvesting PL include damage to the median nerve, palmar cutaneous branch of the me-

dian nerve, medial cutaneous nerve of the forearm, adjacent tendons and flexion contracture at the wrist [12].

The tendon is usually long enough for a graft of about 15 cm [13]. Occasionally there may be a double tendon or multiple insertions [13]. PL is valuable for palm-to-fingertip tendon reconstructions as it is in the same field of surgery and is easily accessible. It has also been used in a variety of reconstructions, including A2 pulley, triceps, distal biceps and collateral ligaments of the elbow and metacarpophalangeal joints [14-16].

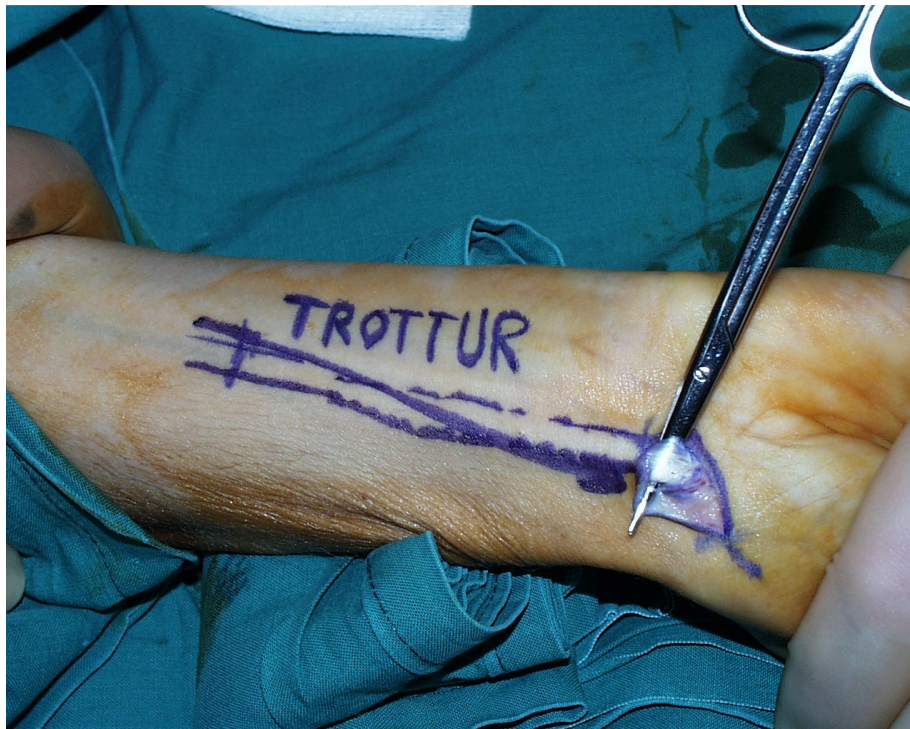
### 2.1. Flexor Carpi Radialis (FCR)

The muscle originates from the medial epicondyle through the common flexor tendon. It runs over a groove on the trapezium and the long tendon inserts into the base of the second and third metacarpal. In the distal portion of the tendon the radial artery lies between the FCR and the brachioradialis. It is innervated by the median nerve [17]. To harvest the tendon a 1 cm incision is made on the radial aspect of the wrist crease (**Figure 1**). The paratenon is incised. A tendon stripper is then passed along the proximal length of the tendon. The maximum width of the tendon harvested is usually a third of its maximum thickness. At the proximal end of the tendon a stab incision is made into 30% to 40% thickness of the tendon although some surgeons use the entire FCR without any significant problems with wrist function. It is then folded on to the stripper. The stripper is then re-

tracted reminding oneself that the tendon rotates over the top from the ulnar to radial direction (TROTTUR). About 10 cm long graft can be generally harvested (**Figure 2**). Due precautions are taken to avoid injuring the median nerve and radial artery. The graft has been used in trapeziometacarpal arthroplasty and volar beak ligament reconstruction [18].

### 2.2. Plantaris

Plantaris is present in over 90% of individuals [13]. It takes origin from the lateral supracondylar line of femur and the oblique popliteal ligament. The tendon then crosses obliquely between gastrocnemius and soleus and then, runs along the medial border of the tendoachilles [6]. It either inserts into the calcaneum or fuses with the tendoachilles. There are numerous variations in the long axis and insertion of the muscle [19]. It is supplied by the lateral sural, popliteal and additionally from the lateral superior genicular artery. It is innervated by the tibial nerve [6]. When present it can serve up to three palm-to-fingertip grafts or one long forearm-to-fingertip graft [14] and as such it is popular for forearm-to-fingertip reconstruction or when multiple or long grafts are needed [14]. In order to harvest the tendon, a longitudinal incision is made just posterior to the medial malleolus. The tendon is identified, tagged and divided. The tendon stripper is aimed at the lateral aspect of the knee joint. Its attachments to the triceps surae may make it difficult to



**Figure 1.** Incision to harvest the flexor carpi radialis.



**Figure 2. Length of tendon harvested.**

harvest in one length. Brand reported only a single case of lower extremity pain following 100 free plantaris tendon harvesting [15]. However compartment syndrome that was caused by a small arterial vessel laceration at the musculotendinous junction had been reported [14].

Plantaris is often used when the PL is absent [16]. Yamazaki *et al* reported satisfactory results from one-stage flexor tendon grafting in paediatric patients using plantaris tendon [20]. Indications for its use are similar to PL [16,21-24]. Ligamentous stabilisation of distal radioulnar joint has been described using the Plantaris [24].

### **2.3. Extensor Digitorum Longus (EDL)**

The EDL arises from the lateral condyle of the tibia, proximal three-quarters of the medial surface of the fibula, interosseous membrane and the deep fascia. It then divides into four slips to insert into the lesser toes. At the metacarpophalangeal joints MTPJ the tendons to the second, third and fourth toes are joined on the lateral side by a tendon slip of extensor digitorum brevis EDB [6]. The dorsal digital expansion thus formed also receives contribution from the lumbrical and interossei. The expansion narrows and divides into three slips which insert into the base of the middle and distal phalanges. It is innervated by the deep peroneal nerve which runs obliquely posterior to its upper half. The blood supply is derived from the anterior tibial artery and perforating

branch of the peroneal artery [6]. In the foot, it is supplied by the anterior lateral malleolar artery, lateral tarsal, metatarsal plantar and digital arteries. The EDL is harvested with an incision at the level of the metatarsophalangeal joint. A tendon stripper is used to facilitate harvest. Additional incisions are made over the extensor retinaculum and at the level of disconnection of the tendon proximally. Dissection is often required proximally to identify the tendon end.

Toe extensors have been utilised in reconstructions of elbow ligaments [21,25] and flexor tendon [26] particularly when longer grafts are needed in forearm to fingertip reconstruction.

A table can summarize all the information (**Table 1**).

### **2.4. Gracilis and Semitendinosus**

The semitendinosus and gracilis take origin from the ischial tuberosity and pubic symphysis respectively. They insert, along with the sartorius tendon, as the pes anserinus at the anteromedial tibia. An accessory insertion of semitendinosus is seen in 77% of knees [27]. At least seven different anatomical variations of the pes anserinus have been described in a cadaveric study who also noted at least one to be present in 48% of specimen [28]. The common insertion of these 3 tendons is located an average of 19 mm distal and 22.5 mm medial to the apex of the tibial tubercle [29]. The gracilis and semitendinosus tendons are located deep to the sartorius and over the

**Table 1. Various autografts: Anatomy, indications and structures at risk.**

Muscle	Location	Indication	Structure at Risk	Length	Width
Palmaris Longus	Midline of the wrist	Palm to finger tip surgery	Median Nerve Branches of medial cutaneous nerve of forearm.	16 cm	3 mm
Plantaris	Medial border of the tendoachilles	Palm-to-fingertip grafts; Forearm-to-fingertip graft	Artery at musculotendinous junction.	35 cm	2 mm
Extensor Hallucis Longus	Between the tibialis anterior (TA) and extensor digitorum longus.	Flexor tendon, elbow collateral ligament and extensor reconstruction	Anterior tibial vessels	35 cm	2.5 mm
EDL	dorsal digital expansion	Palm-to-fingertip graft	Anterior tibial artery	35 cm	2.5 mm

superficial medial collateral ligament [27]. The gracilis and semitendinosus tendons become distinct structures at 18 mm proximal and posteromedial to their combined insertion site [27]. The gracilis and hamstring tendons may be harvested through a vertical, transverse, or oblique incision centered about 4 cm medial to, and just distal to, the tibial tubercle [29]. A rough guide would be 3 fingerbreadths distal to the medial joint line. The subcutaneous tissue is divided in the line of the incision.

The gracilis is round whereas the semitendinosus is flatter [29]. In the upper limb they are used in reconstruction of chronic tears of distal biceps, triceps tear, medial and lateral ligament complexes in the elbow and anterior shoulder stabilization [18,30-32]. Complications of using this graft include injuries to branches of the saphenous nerve, donor site pain, medial collateral ligament injury, premature graft amputation, and temporary hamstring weakness [29].

### 2.5. Toe Flexors

Flexor tendons of the toes are less frequently used as graft compared to the other options already discussed, partly because of the dissection required for harvest. Recent studies have shown that toe flexor grafts heal with few adhesions but they are associated with small risk of injury to neurovascular structures [14].

### 3. Conclusion

A working knowledge of the various tendon autograft options should be part of the armamentarium of a reconstructive upper limb surgeon. A cadaveric study by Jakubietz *et al.* suggested that PL and plantaris despite being present may not be adequate for grafting hence underlining the importance of identifying alternative donor sites before embarking on surgery [33]. Other tendons which are less frequently harvested, but nonetheless are valuable, include the extensor digiti minimi and extensor carpi radialis longus. The authors prefer utilising a local graft, when available, hence limiting the surgery to a

single limb. If that is not possible, the contralateral upper limb will be considered before grafts from the lower limb are employed.

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