Anatomic Study of the Abductor Pollicis Longus

A Source for Grafting Material of the Hand

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Abstract Interposition grafting material is used frequently to treat osteoarthritis of the base of the thumb or tendinous and ligamentous injuries of the hand. The observation of duplicated tendons in the first dorsal compartment of the hand prompted us to explore the possibility of using the accessory abductor pollicis longus (AAPL) tendon as grafting material. Based on dissections of 78 cadaveric upper limbs, we describe the number of tendons in the first dorsal compartment of the hand, the number of muscle bellies, their innervation, their insertion site, and the tendon dimensions to determine whether the AAPL can be considered a true tendon. The AAPL was present in 85% of the hands. Average length, width, and thickness (in millimeters) of the APL were of 69.3, 5.2, and 2.1, respectively. Average length, width, and thickness (in millimeters) of the AAPL were of 69.2, 3.3, and 1.6, respectively. No differences in dimension of the tendons were found between the APL and the AAPL. The dimensions of the tendinous portion of the AAPL are similar to those of the APL and can be considered a true tendon. When present, the AAPL is a suitable source of local grafting material.

Introduction

The need for interposition grafting material is frequent in the treatment of osteoarthritis of the base of the thumb [13, 17] or tendinous [6, 15, 22] and ligamentous injuries of the hand [10, 14]. The use of different tendons as grafting material is extensive in hand surgery. One of the most important principles of using a tendon unit as a graft is to avoid donor site morbidity. The extensor indicis proprius frequently is used for different conditions of the hand but reduces the strength of index extension of 38% and 49% of those of the normal finger, as reported in two studies [19, 23]. Harvesting the entire flexor carpi radialis (FCR) alters wrist kinematics [24]. One study comparing the long-term results of trapeziectomy and suspensionplasty for treatment of trapeziometacarpal (TMC) osteoarthritis using FCR and the abductor pollicis longus (APL) tendon, suggested using the APL tendon resulted in better grip strength and key and pinch grip [26].

The observation of duplicated tendons in the first dorsal compartment of the hand has prompted multiple studies to define the local anatomy [8, 12, 21] and to define its use as grafting material [3, 16, 25]. As reported by Lacey et al., Henle first described the presence of a duplicated APL tendon in 1871 [18]. Finkelstein has provided the most detailed anatomic description of the first dorsal compartment, showing the multiple anatomic insertion sites of the APL and its relation with De Quatrain's disease [12]. The terminology of tendon slip and accessory tendon remains equivocal. A recent study using the AAPL as grafting material for reconstruction after chronic extensor pollicis longus ruptures showed a functional ROM in all cases and a mean loss of 10° radial abduction [6]. Available studies, however, do not document tendon dimensions or the appropriateness for various grafting purposes.

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We therefore (1) determined the number of tendons and muscle bellies along with their innervation in the first dorsal compartment of the hand; (2) described their insertion site; (3) recorded the tendon dimensions; and (4) determined side-to-side differences in the APL and AAPL tendons. We presumed if the AAPL tendon could be considered a true tendon and not only an additional slip of the APL it could provide another source of tendon grafting material in hand surgery.

Materials and Methods

We dissected the distal upper limb in 39 white cadavers (78 upper limbs) provided by the Department of Anatomy of the Universidad Autonoma of Madrid; 22 were from females and 17 from males. Preparation of the cadavers included fixation with 10% formalin (equivalent to 37% performaldehyde) in a solution containing antimonium.

The dissection technique was briefly as follows. We used a dorsal forearm approach extending in a straight line from the interphalangeal joint of the thumb directed toward the lateral epicondyle. Subcutaneous tissue was dissected and retracted until the forearm fascia was seen. We incised the fascia and dissected it longitudinally from distal to proximal to expose the extensor retinaculum and the extensor muscles. The first dorsal compartment then was incised on its most radial aspect and the APL and the extensor pollicis brevis (EPB) were exposed. Additional tendons found radially to the APL were considered accessory tendons.

We recorded the presence of accessory tendons of the APL or EPB, the presence of independent septa for the APL or the EPB, and the anatomic insertion sites of both tendons and the dimensions of the APL and accessory tendons. A macroscopic dissection of the muscle bellies and their innervation was performed under wide-field low-power magnifying glasses. We used a calibrated caliper for all measurements. The diameter and width of the tendons were recorded at their insertion sites and the length was recorded from that point to the beginning of the muscle belly.

A descriptive analysis of the quantitative and qualitative data was performed. We determined differences in the dimensions of the tendon between the APL and AAPL using a two-tailed Student's *t*-test. With additional analysis we tried to determine differences in gender and side between the APL and the AAPL using the chi square test. We recorded data in an Excel spreadsheet (Microsoft, Redmond, WA) and performed statistical analysis using SPSS 9.0 (SPSS Inc, Chicago, IL).

Results

The APL tendon was present in all specimens. An AAPL tendon was found in 66 hands (85 %), 57 of which had one AAPL (73%), six hands had two AAPLs (8%), and three hands had three AAPLs (4%). In each of these cases, the accessory tendons were located radial to the APL tendon. This topographic distribution was maintained proximally toward the muscle belly (Fig. 1). Twelve hands had no AAPL tendon. Of these, four cadavers (eight hands) had no AAPL on either side and four had an AAPL on only one side. The presence of the AAPL tendon showed no side-to-side differences ($p = 0.545$). No accessory EPB tendons were encountered. An independent septum for the EPB was found in eight cases, and in all these cases, there was at least one AAPL tendon present. Conversely, no APL or AAPL tendons had an independent compartment. Two independent muscle bellies were found in 16 hands (20%) (Fig. 2); in these 16 specimens, a specific branch for the radial-sided muscle belly was present in 13 hands.

The APL inserted in the proximal first metacarpal on its volar aspect in all cases, except in one case in which it inserted in the thenar muscles. The observed AAPL insertion site was the trapezium in 31 hands (41%), the proximal volar aspect of the abductor pollicis brevis in 17 hands (22%), the proximal aspect of the opponens pollicis brevis in four hands (5%), a double insertion in the trapezium and the thenar muscles in 12 hands (15%) (Fig. 3), and the base of the first metacarpal in two hands (1%).

Mean length of the AAPL tendon averaged 69.2 mm, mean width averaged 3.3 mm, and mean thickness averaged 1.6 mm. The comparative APL tendon dimensions were 69.3 mm, 5.2 mm, and 2.1 mm, respectively. In the hands in which more than one AAPL was found, the subsequent accessory tendons were of decreasing dimensions (Tables 1–3).

Fig. 1 The insertion of the AAPL in the abductor pollicis brevis is shown. APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus; EPB = extensor pollicis brevis; EPL = extensor pollicis longus.

Fig. 2 Independent muscle bellies of the abductor pollicis longus and accessory abductor pollicis longus are seen. APL = abductor pollicis longus; AAPL = accessory abductor pollicis; EPB = extensor pollicis brevis.

Fig. 3 A double insertion of the accessory abductor pollicis longus in the trapezium and the thenar muscles can be seen in this specimen. APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus; EPB = extensor pollicis brevis; EPL = extensor pollicis longus.

Table 1. Comparative length measurements of APL, AAPL, and AAPL2 (in millimeters)

Length	APL	AAPL	AAPL2
Mean $\pm$ SD	69.3 $\pm$ 16.6	69.2 $\pm$ 20.9	56.1 $\pm$ 20.5
Minimum	29	4.9	24
Maximum	120	127	85

APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus.

Table 2. Comparative width measurements of APL, AAPL, and AAPL2 tendons (in millimeters)

Width	APL	AAPL	AAPL2
Mean $\pm$ SD	5.2 $\pm$ 4.7	3.3 $\pm$ 0.9	2 $\pm$ 0.9
Minimum	2.9	1	1
Maximum	9.5	6	3.8

APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus.

No differences with respect to side were found in tendon length, width and thickness for the APL ($p = 0.80$, $p = 0.5$ and $p = 0.23$, respectively) and the AAPL ($p = 0.9$,

Table 3. Comparative thickness measurements of APL, AAPL, and AAPL2 tendons (in millimeters)

Thickness	APL	AAPL	AAPL2
Mean $\pm$ SD	2.1 $\pm$ 0.5	1.6 $\pm$ 0.4	0.9 $\pm$ 0.3
Minimum	0.9	0.8	0.4
Maximum	3.9	2.5	1.5

APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus.

Table 4. Side-to-side differences in APL and AAPL tendon length (in millimeters)*

Length	APL	AAPL
Left	69.12 $\pm$ 16.73	69.30 $\pm$ 19.36
Right	70.08 $\pm$ 16.75	69.94 $\pm$ 22.86
	$p = 0.801$	$p = 0.9$

* Results are presented as mean result $\pm$ 2 SD; APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus.

Table 5. Side-to-side differences in APL and AAPL tendon width (in millimeters)*

Width	APL	AAPL
Left	5.58 $\pm$ 4.59	3.20 $\pm$ 0.97
Right	4.85 $\pm$ 1.1	3.40 $\pm$ 0.93
	$p = 0.5$	$p = 0.41$

* Results are presented as mean result $\pm$ 2 SD; APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus.

Table 6. Side-to-side differences in APL and AAPL tendon thickness (in millimeters)*

Thickness	APL	AAPL
Left	2.06 $\pm$ 0.5	1.62 $\pm$ 0.43
Right	2.21 $\pm$ 0.61	1.71 $\pm$ 0.43
	$p = 0.23$	$p = 0.39$

* Results are presented as mean result $\pm$ 2 SD; APL = abductor pollicis longus; AAPL = accessory abductor pollicis longus.

$p = 0.41$ and $p = 0.39$, respectively) (Tables 4–6). Comparative length between the APL and the AAPL found no differences ($p = 0.97$).

Discussion

Interposition grafting material frequently is used to treat various disorders or ligamentous injuries of the hand. Given reports of duplicated tendons in the first dorsal compartment of the hand, we explored the possibility of using the AAPL tendon as grafting material. Specifically we (1) described the number of tendons and muscle bellies and innervation in the first dorsal compartment of the hand, (2) described their insertion site, (3) recorded the tendon dimensions and (4) established side-to-side differences in the dimensions of the APL and AAPL.

Our study has several limitations. First, the specimens available for dissection were Caucasian, and direct extrapolation of the data presented in this study may not be applicable to other racial groups. In a study to determine the ethnic variability of palmaris longus agenesis, Sebastin et al. revealed a low prevalence of absence in Asian, black, and Native American populations and a much higher prevalence of absence in Caucasian populations [29]. Second, we used x2.5 loupe magnification to dissect and describe the innervation of the muscle and found a specific nervous branch in 80% of the cases in which there was an independent muscle belly. Dos Remedios et al. reported finding a specific nervous branch in all their cases using x4 loupe magnification [9]. Thus, the lower magnification might influence the rate at which innervation can be found.

An APL tendon duplicity has been widely documented appearing in 56% to 98.5% of hands [38]. In our study, it appeared in 85%, which is close to the results presented by other authors [20, 37] with 92% and 89%, respectively. When planning a reconstructive procedure of the hand, the use of preoperative ultrasound can provide useful information regarding the number of tendons and approximate dimensions.

In APL muscle dissection, we observed some AAPL tendons have their own muscle belly. It appears as an independent muscular entity, fusiform and proximal and radial to the proper APL muscle. van Oudenaarde and Oostendorp [35] and Zancolli and Cozzi [38] reported the existence of two muscular components, one deep and one superficial. The deep one is more proximal and has multiple insertion sites around the trapeziometacarpal joint. This distribution would match our AAPL muscle. The superficial portion is more distal and inserts at the base of the first metacarpal and would match what we considered the APL muscle. However, some authors consider the

differentiation of these muscles difficult even with the use of vascular studies [28].

In the majority of cases (13 of 16) in which an independent muscle belly for the AAPL appears, we identified two nerve branches: one descending long branch that enters the muscle in the ulnar and distal portion of the APL muscle and continues toward the EPB muscle and a shorter one that inserts in the more proximal and radial side of the APL muscle. There is some discrepancy in the literature regarding the number of forearms with two muscle bellies and forearms with two specific nervous branches. Two studies [9, 11] suggest a similar pattern of nervous distribution with an independent nervous branch for each muscle belly. Others, however, have found only one nervous branch [31, 33].

The distal insertion sites are in accordance with published data [2, 32, 38]. The insertion of the APL in the thenar muscle instead of the base of the first metacarpal is rare and we found it in one of 78 hands [27].

We found no difference in tendon dimensions between the APL and the AAPL. Others have reported the existence of multiple slips but have not analyzed the tendons' dimensions [8, 21]. Our findings favor the use of the term accessory tendon instead of tendon slips.

The dimensions of the AAPL are appropriate for its use as a graft donor in hand surgery. The recommended length of tendon used in TMC arthroplasty for treatment of osteoarthritis was 5 cm [1]. The average length of the AAPL in our cadaveric specimens was almost 7 cm, thus allowing the use of the AAPL for that specific technique. The use of the AAPL for extensor tendon reconstruction after chronic EPL ruptures also has been reported with good functional scores and patient satisfaction [6]. Loss of abduction with the use of the AAPL compares favorably to the use of the APL [6, 7]. The APL has been considered more relevant for thumb mobility and the AAPL was presumed more important for TMC stability. TMC stability is not compromised with the sacrifice of the AAPL tendon [5]. This may be the cause of the diminished morbidity with the use of the AAPL [34, 36]. Some authors have credited the APL with a complex function in movement of the thumb [4, 30]. However, others reported minimal functional impairment of the thumb with absence of the APL, probably owing to the coordinated action of the rest of the musculotendinous units acting in the thumb [5]. Additional studies are required to determine the morbidity of using the AAPL for grafting material procedures.

The absence of differences in tendon dimensions between the APL and the AAPL, along with the findings of a separate muscle belly and proper innervation, suggest the AAPL can be considered a true tendon and not just an extra slip of a present tendon. The information regarding tendon dimensions may prove useful to the surgeon performing reconstructive surgery of the hand.

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