Accessory Tendons and Anatomical Variations of the Dorsal Compartments of the Wrist: A Descriptive Cadaveric Study

El Bileğinin Dorsal Kompartmanlarının Aksesuar Tendonları ve Anatomik Varyasyonları: Kadavra Çalışması

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ABSTRACT

Objective: Detailed anatomical knowledge of the accessory tendons of the dorsal compartments of the wrist is crucial for understanding the effects of tendon injury due to external trauma or rupture. This study was performed to investigate the variations of the extensor compartments of the wrist and a relation between the thickness of extensor digiti minimi (EDM) and abductor pollicis longus (APL) tendons and accessory extensor digiti quinti proprius (EDQP) slip to the little finger.
Methods: Fourteen fixed wrists of adult cadavers were dissected. The tendon variations in the extensor compartments of the wrist and their abnormal insertion sites were recorded, and the number, length, width, and type of accessory tendons were also recorded.
Results: A double tendon of the extensor digiti minimi was detected in one female cadaver out of the 14 fixed cadavers. Ulnar and radial tendons of the EDM were detected in the right wrist of one female cadaver. The radial tendon was accepted as an accessory EDQP but did not join the extensor digitorum (ED), and the ulnar tendon was normal. Four out of fourteen wrists (28.5%) had APL tendon variations. The lateral was accepted as the main APL and the medial as the accessory tendon. A thin accessory tendon was detected from the extensor carpi ulnaris (ECU) at the ulnar styloid process.
Conclusion: Tendon variations of the dorsal compartments of the wrist and the relationship between the ED slip and accessory tendons should be considered when planning surgical treatment. The presence of accessory tendons might assist in finding alternative tendon sources for tendon grafts.

Keywords: Variation, accessory tendon, extensor digiti minimi, extensor carpi ulnaris, abductor pollicis longus, wrist

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ÖZET

Amaç: Dış travma veya yırtığa bağlı tendon hasarının etkilerini anlamak için el bileği'nin dorsal kompartmanları'nın aksesuar tendonlarının detaylı anatomik bilgisi çok önemlidir. Bu çalışma, el bileği'nin ekstansor kompartmanları'nın varyasyonlarını, ve m. ekstansor digiti minimi (EDM) ve m. abductor pollicis longus (APL) tendonlarının kalınlığı ve aksesuar m. ekstansor digiti quinti proprius (EDQP) tendonu arasındaki ilişkiyi araştırmak için yapıldı.
Yöntemler: Ondört fikse edilmiş erişkin kadavra el bileği diseke edildi. Elin ekstansor kompartmanlarındaki tendon varyasyonları ve anormal sonlanma yerleri kaydedildi ve ayrıca aksesuar tendonların sayısı, uzunluğu, genişliği ve tipi de kaydedildi.
Bulgular: Ondört fikse kadavradan bir kadın kadavra el bileğinde çift EDM tendonu tespit edildi. Sağ el bileğinde EDM'nin ulnar ve radial tendonları tespit edildi. Radial tendon, aksesuar m. ekstansor digiti quinti proprius (EDQP) olarak kabul edildi, ancak m. ekstansor digitorum tendonuna (ED) katılmadı ve ulnar tendon normaldi. Ondört el bileği'nin dördünde (% 28.5) m. abductor pollicis longus'un (APL) tendon varyasyonları vardı. Lateral APL primer ve medial olan aksesuar tendon olarak kabul edildi. Processus styloideus ulnae seviyesinde m. ekstansor carpi ulnaris'ten (ECU) ayrılan ince bir aksesuar tendon tespit edildi.
Sonuç: Cerrahi tedavi planlanırken el bileği'nin dorsal kompartmanlarındaki tendon varyasyonları ve ED'den ayrılan tendon slipleri ile aksesuar tendonlar arasındaki ilişki dikkate alınmalıdır. Aksesuar tendonların varlığı, tendon greftleri için alternatif tendon kaynakları bulmaya yardımcı olabilir.

Anahtar Sözcükler: Varyasyon, aksesuar tendon, m. ekstansor digiti minimi, m. ekstansor carpi ulnaris, m. abductor pollicis longus, el bileği

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INTRODUCTION

Detailed anatomical knowledge of the accessory tendons of the dorsal compartments is crucial for understanding the effects of tendon injury due to the external trauma or rupture (1). Many of them have asymptomatic, but they can be a cause of compressive neuropathy or a palpable soft tissue mass (2). Detection can be complicated because the muscles have the same strength and vision as the nearby muscles, but being aware of spaces where muscles should not insert gives a clue as to the accessory tendons typically (3). The accessory muscles and tendons are commonly detected incidentally during anatomical dissection or in surgery (3).

Treatment of De Quervain's disease or arthritis of carpometacarpal joint comprises of anatomical variations in the abductor pollicis longus (APL), and extensor pollicis brevis (EPB) muscles lie over the lateral radius called as the 1st dorsal compartment of the wrist (4). The APL and EPB lie in the deep layer of the forearm (5,6). The APL is usually dividing into two slips, one insert into the base of the first metacarpal; the other extends to the trapezium, and abducts and extends the thumb at the carpometacarpal joint. The EPB insert into the dorsal surface of the base of the proximal phalanx of the thumb and extends the thumb at the metacarpophalangeal joint. The main symptom of the first dorsal compartment is pain over the radial styloid process, and treatment includes avoiding repetitive movements of the thumb, splinting, and corticosteroid injections into the first extensor compartment (5, 6).

The 2nd compartment, including the extensor carpi radialis longus (ECRL) and extensor carpi radialis brevis (ECRB), can be detected on the dorsal side of the wrist when the fist is clenched and relaxed position. The 3rd dorsal compartment, including extensor pollicis longus (EPL), lies the lateral and medial sides of the Lister's tubercle, and the tendon of EPL defines the ulnar border of the anatomical snuffbox. The EPL lies posterior surface of the base of the distal phalanx of the thumb, and reaches the pollex at the carpometacarpal and interphalangeal joints, and partly adducts first metacarpal (6). The dysfunction or accessory tendons of the third compartment lead to distal intersection syndrome, followed by EPL tenosynovitis (6).

The 4th compartment comprising the extensor digitorum (ED) and extensor indicis (EI) lies within the ulnar head and EPL (6). The extensor indicis (EI) muscle is an accessory extensor of the 2nd digit and inserted into the extensor hood of the second digit. The ED or extensor digitorum communis, passes beneath the sagittal line of the metacarpophalangeal joint the tendon divides into three 'slips' consisting of two lateral slips and a middle slip. The lateral slips move both sides of the proximal interphalangeal joints to then unite with the intrinsic muscles of the wrist to form a conjoint tendon that inserts at the base of the distal phalanx. The central slip inserts at the dorsal base of the middle phalanx (6).

The tendons are protected by a synovial sheath during their passage via osteofibrous compartments on the dorsal side of the wrist. The presence of an accessory tendon or variation in the fifth and sixth dorsal compartments of the wrist might cause extensor tendinitis, hypertrophy, tenosynovitis, spontaneous rupture, Vaughn-Jackson syndromes or joint subluxation by limiting functions of extensor digiti minimi (EDM) and extensor carpi ulnaris (ECU). The tendon of EDM for the 5th digit passed under the extensor retinaculum via the 5th extensor compartment of the wrist and inserted into the expansion of a little finger. The ECU lies in the 6th extensor compartment of the wrist with its subsheath as it passes through at the level of the ulna, and inserted into the dorsal base of 5th metacarpal. The presence of the accessory tendons or compression of the ECU leads to tendinosis or tenosynovitis of upper limb or subsheath injury (7).

compartment syndrome exists where increased pressure in an osseofibrous compartments lead to decreased perfusion of the contents due to the trauma, external pressure, burns, arterial injury, or post-ischemic swelling (6). The increasing pressure is provoked by the passive extension of the digits, reduced sensation, or paraesthesiae in the affected side of the wrist (6). Since the finger flexes, the extensor tendons support the process by relaxing and providing the extensor compartments to slip distally on the dorsal side of the phalanges (6).

Furthermore, the understanding of anatomical variations of extensor tendon can assist in finding alternative tendon sources in tendon grafts. The presence of the accessory tendons might be asymptomatic, and patients can live without knowing of its existence. It may be of some clinical significance, as it can cause compressive symptoms or appear like a mass (8). Symptoms of its existence include pain or swelling of the dorsal aspect of the wrist, and the symptoms are remarkable after minor injury or trauma and confused by clinicians as ganglion cysts or soft tissue tumors (9, 10). Tendon variations should be considered when planning the surgical treatment, therefore this study aimed to analyze the anatomic variations of the dorsal compartments of the wrist and to evaluate their clinical importance.

MATERIALS and METHODS

This study was conducted at the Department of Anatomy, Faculty of Medicine, Bahçeşehir University. Fourteen fixed cadaver wrists were examined. The study was approved by the ethics committee of Bahçeşehir University, Istanbul, Turkey. After the removal of the skin and the superficial fascia, the dorsal compartments of the wrist were dissected, and wrists with injury were excluded from the study. The number of tendons, insertion site, course, length, width, and incidence of the accessory tendons of the dorsal compartments were investigated. The tendons of APL, EPL, and EPB were measured via length, width, and their relationship (Fig 1, Fig 3). The presence of an accessory tendon separated from ECU and EDM, which was examined via length, width, location, and distribution (Fig 2). The photographs that belong to the accessory tendons of the dorsal side of the wrists were taken as defined by Barut and Ertilav (11) (Canon EOS 70 D), and all measurements were done by 150 mm LCD Digital Vernier Dial Micro caliper (Mitutoyo, Japan).

RESULTS

Abductor pollicis longus (APL)

Four out of 14 wrists (28.5%) had APL tendon variations. The lateral was accepted as the main APL and medial as the accessory tendon (Fig 1). There were differences in the course of APL tendon. The lateral APL (0.2-0.3±0.07mm; 6.5±0.5 cm) inserted at the base of first metacarpal bone, medial APL tendon (0.5±0.07 mm; 6±0.4 cm) inserted in the trapezius. Lateral and medial APL were 0.3-0.4±0.07 mm 5.5±0.5 cm and 0.5±0.07 mm; 5.4±0.4 cm. The medial tendons of APL were regarded as accessory slips and were frequently inserted into the base of the first metacarpal bone (Fig 3). The other insertion site of accessory slips were extended to trapezium, abductor pollicis brevis, thenar fascia, the capsule of the first carpometacarpal joint, and opponens pollicis.

Extensor pollicis brevis (EPB)

The EPB had a single tendon in all fixed cadavers (Fig 1). The EPB was inserted into the base of the distal phalanx (6.7%). The width and lengths of EPB were 0.3±0.14 mm, 4.5±1.5 cm, respectively. Its tendon was inserted into the extensor expansion of the thumb at the base of distal phalanges (Fig 3). The mean width and length of EPB was 0.5±0.14 mm, 7.5±0.5 cm, respectively, in other cadavers.

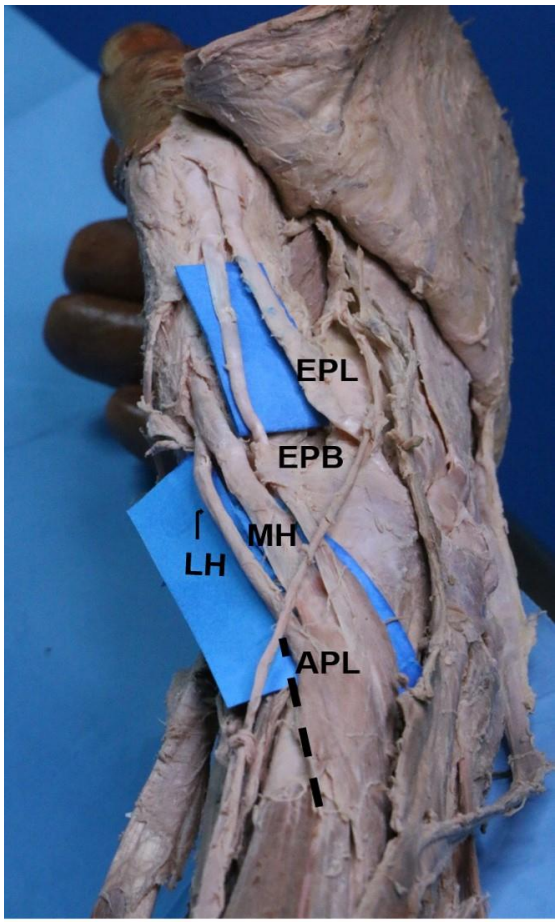

Figure 1: Right wrist of the female cadaver. Insertion of APL slips. The lateral head of abductor pollicis longus (primary) in a cadaveric wrist inserted into the base of the first metacarpal bone and medial head of APL (accessory) inserted into the trapezium. **APL:** Abductor Pollicis Longus**; MH**: Medial Head (accessory); **LH**: Lateral Head (main); **EPB**: Extensor Pollicis Brevis; **ER**: Extensor Retinaculum; **RA**: Radial Artery; **AS** Anatomical Snuffbox; **EPL**: Extensor Pollicis Longus

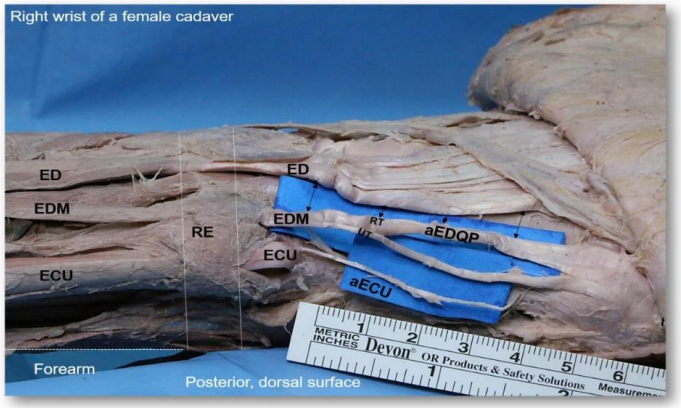

Figure 2: The right wrist of the female cadaver with accessory tendons. **ED**: Extensor Digitorum; **EDM**: Extensor Digiti Minimi; **ECU**: Extensor Carpi Ulnaris, **aEDQP**: Accessory Extensor Digiti Quinti Proprius; **UT**: Ulnar Tendon; **RE**: Retinaculum Extensorum; **RT**: Radial tendon

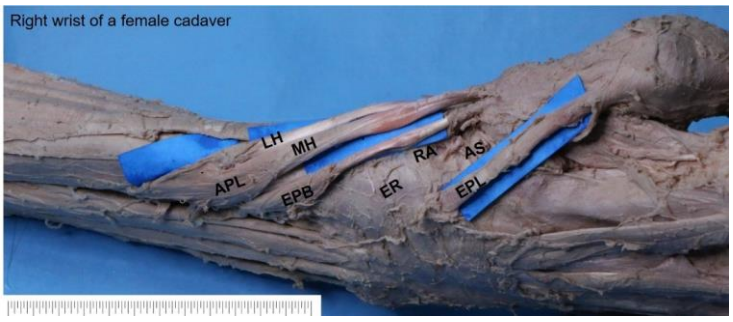

Figure 3: The dorsolateral aspect of right wrist showing tendons of extensor pollicis longus (EPL), abductor pollicis longus (APL), and extensor pollicis brevis (EPB) A right wrist with a single tendon of EPL, single tendon of EPB and the double tendons of abductor pollicis longus (APL) (LH & MH). EPB inserted in the base of the proximal phalanx (PP) of the thumb. **APL:** Abductor Pollicis Longus**; MH**: Medial Head (accessory); **LH**: Lateral Head (main); **EPB**: Extensor Pollicis Brevis; **ER**: Extensor Retinaculum; **RA**: Radial Artery; **AS** Anatomical Snuffbox; **EPL**: Extensor Pollicis Longus

Extensor pollicis longus (EPL)

The EPL was detected in all dissected wrist. Single tendons were recorded in all fixed cadavers. Duplicated EPL tendons were not observed. In 67.2% of wrist, the tendon of EPL was inserted into the extensor expansion of distal phalanx (Fig 1, Fig 3). The mean width and lengths of EPL were 0.6±0.07 mm, 5.7±0.3 cm, respectively. EPL was 0.6±0.07 mm ve 6.2±0.3 cm, respectively, in other cadavers. The tendon of EPL was inserted into the extensor expansion of proximal and distal phalanx in 93.5% (Fig 3).

Extensor indicis proprius (EI)

The extensor indicis proprius had a single tendon in all fixed cadavers. In all specimens, the EI tendon was inserted into the extensor expansion medially to the EDI tendon.

Extensor digitorum (ED)

The ED divides into the four tendons, and had no accessory slip to the fingers; it gave off a single tendon to the index, middle, and ring fingers (Fig 2). The tendon of ED is along with the EI, which lies medial to EI, and the extensor tendon to the little finger extends laterally to the EDM. The tendon of the ED inserted into the dorsal expansion of the middle and distal phalanges of the digits 2-5.

Extensor digiti minimi (EDM, extensor digiti quinti proprius)

The double tendon of EDM was detected in one female cadaver wrist out of 14 fixed wrists (Fig 2). In the majority of the cadavers, double tendons lie distal to the extensor retinaculum (Fig 2). The tendon extends as a single tendon in 92.8% of specimens, doubled in 7.2%. These tendons were inserted into the extensor expansion of the little finger except in one right wrist of the cadaver (Fig 2). The ulnar and radial tendons of EDM were detected in the right wrist of a female cadaver. The radial tendon was accepted as an accessory extensor digiti quinti proprius (EDQP) did not join extensor digitorum, while the ulnar tendon was normal. The radial tendon was 0.2 ± 0.14mm (width) and 6.2 ± 0.17cm (length), the ulnar tendon was 0.4 ± 0.14mm (width) and 6.4 ± 0.17cm (length).

Extensor carpi ulnaris (ECU)

A thin accessory tendon was separated from ECU at the ulnar styloid process. The accessory tendon of ECU was 0.1 ± 0.14 mm (width), 6.4 - 6.5 ± 0.12 cm (length), and inserted in the base of fifth metacarpal bone instead of medial tubercle of the fifth metacarpal bone.

DISCUSSION

The existence of accessory tendons of the dorsal compartments have been reported by many authors (5,12). It originates at the joint capsule lies beneath the extensor retinaculum, and inserts into the extensor expansion of fingers (12). Xu H *et al.* (13) reported that the proximal part and distal tendon of EPB were absent. The abductor pollicis longus (APL) tendon had more than one slips, and one of them inserted into the base of the proximal phalanx.

Another slip of APL lies in the septum alongside the EPB tendon for 4 mm and terminated base of the 1st phalanx with the APL tendon. Lee Z *et al.* (5) stated that the presence of a septum dividing the first dorsal compartment was examined in eighteen cadaver studies for a total of 1857 wrists and seven case series with 470 patients with De Quervain's tenosynovitis. Of the average wrists, 57% had a single compartment compared to 41% of patients with De Quervain's tenosynovitis. Seven cadaver studies differentiated between the complete and incomplete septum and demonstrated that 59% of wrists with a septum present had an incomplete septum. Rousset P et al. (14) indicated that the presence of multiple slips instead of a single APL tendon, and a vertical septum splitting the first dorsal compartment into two certain subcompartments, while the tendon of APL lies in its tunnel. The frequency of several insertion sites of the APL was as follow; the base of the 1st metacarpal bone (80-92%), anterior surface (20%) and anterolateral surface (80%) of the base of metacarpal bone, carpometacarpal joint (1,39%), the capsule of carpometacarpal joint (30%), trapezium (56-80 %), opponens pollicis (3,49-20 %), abductor pollicis brevis (12,59-60 %) and thenar fascia (40%). In the present study, double tendons of APL were observed in 28.5% of wrist, whereas the single tendons were detected in 71.5% of cadavers (Fig 1).

Furthermore, the lateral APL tendon (0.2-0.3±0.07mm; 6.5±0.5 cm) inserted at the base of first metacarpal bone, medial APL tendon (0.5±0.07mm; 6±0.4cm) inserted in the trapezius (Fig 1). This might be the reason for the failure of the proximal migration of deep precursor mass of extensor muscles that further forms the APL, EPB, EPL and EI. The superficial and radial layers of the dorsal compartments are phylogenetically stable, but the deep layer is known to be highly unstable and is undergoing evolutionary changes.

bdel-Hamed G et al. (15) reported that 67.4% single and the 32.6% duplicated tendons of EPL were detected in the dorsal wrist of cadavers. They stated that the tendon of EPL inserted into the extensor expansion of both phalanges in 94.7% and 5.3% of distal phalanges. In the present study, EPL inserted into the extensor expansion of proximal and distal phalanx (Fig 1). Abdel-Hamed G et al. (15) reported the 97.9% of EPB was recorded. It either had a single tendon in 87.4% or duplicated ones in 10.5%. The tendon of EPB inserted into the base of the proximal phalanges in 55.8% and the extensor expansion of the base of distal phalanges in 3.2% or both phalanges in 41%. The EPB tendon inserted into the base of the distal phalanx was also described in the literature with an incidence of 6.8%. Similarly, in the present study, the EPB inserted into the extensor expansion of the thumb at the base of the distal phalanges in 6.7% of cadavers (**Fig 3**).

Abdel-Hamed G *et al.* (15) reported the EI exhibited a single tendon in all cases. Also, Dass et al. (8) detected a single tendon of EI in 98% of specimens. Suwannakhan *et al.* (16) stated that the single tendon of EI does not usually insert into the medial side of the ED, and it can be easily overlooked, that can potentially lead to false identification. However, we detected a single tendon for EI in our 14 fixed cadavers, and tendons insert into the medial side of the ED. Ling J et al. (17) claimed a single tendon of EDM at the origin, then splits into the radial and ulnar slips and inserted into the dorsal aponeurosis of the little finger. Ling J. et al. (17) reported that the tendon of EDM slips lies proximal to the extensor retinaculum. The radial division inserted into the extensor aponeurosis of the middle and ring finger. Two slips of ulnar division inserting into the dorsal aponeurosis of the little finger and one slip inserted into the 4th junctura tendinum. Abdel-Hamed G et al. (15) reported a single tendon of EDM was detected proximal to the extensor retinaculum. Several authors stated the single EDM tendons lie proximal to the extensor retinaculum in 92–95% (15, 18, 19). However, double tendons of EDM were recorded in 75.8% and triple tendons of EDM in 15.8% distal to the extensor retinaculum (18, 20-22). The tendon of EDM is rarely absent, and sometimes it is fused with ED (6). Peker T et al. (23) reported that the EDM divided into ulnar and radial branches while passing via the fifth osteofibrous tunnel and that the ulnar branch inserted within the dorsal aponeurosis of the fifth finger but the radial branch inserted into the dorsal aponeurosis of the fourth finger. They stated that the length of the tendon of the EDM was 7.8 cm, and that the ED and the radial branch of the EDM inserted into the same region (23). The tendon of this muscle is usually divided, 74% according to the data reported in the literature (18-23). As seen in Fig. 2, the findings of this study revealed that the EDM could also be bifurcated and split at the lower edge of the extensor retinaculum. Ulnar and radial tendons of the EDM were detected in the right wrist of a female cadaver. The radial tendon was accepted as an accessory extensor digiti quinti proprius (EDQP) did not join extensor digitorum, while the ulnar tendon was normal. The radial tendon was 0.2 ± 0.14mm and 6.2 ± 0.17cm, the ulnar tendon was 0.4 ± 0.14 mm and 6.4 ± 0.17 cm.

The extensor expansion of the 5th digit and joined by a slip from ED at the metacarpophalangeal joint. A slip does not join the extensor expansion of the dorsal base of the proximal phalanx of digit V on the radial side and to ED. The accessory tendon might limit the extention of little finger, or partial extension of the wrist (6). This might be reason for a relation between the thickness of EDM tendon and ED slip to the little finger.

The incidence of the accessory tendon that leaves the ECU was 10 to 34% (24, 25). Pınar Y et al. (26) detected the accessory tendon slips, which were separated from the ECU in 3 wrist (5.6%), two on the left, and one on the right side (1.4 ± 0.01 mm). The accessory tendons were lies on the ulnar side and inserted into the head of the 5th metacarpal (Type C). Nakashima T et al. (24) reported that accessory tendon slips (34.2%) separated from the ECU in the 240 upper limbs. The slip inserted into the proximal of the 5th metacarpal bone (Type A) was 29.6%, the central tendon (29.6%), the midportion (Type B) (2.5%), and the head distally (Type C) were 1.7%. Kaplan and Spinner (27) also claimed as an accessory EDM arising from ECU. In the present study, tendon slips were similar to Type C according to the classification system of Nakashima (**Fig 2**)**.**The average width of the slips as 1.53 ± 0.37 mm, Barfred and Adamsen (28), as 1 mm. In our study, it was determined as 1.4 ± 0.01 mm. Barfred and Adamsen (28) first described the clinical significance of the tendon slip, leaving the ECU and reported that such a slip could cause functional impairment in the wrist and fifth finger. Peker T et al.(23) also stated that a thin tendon arising from the ECU inserted into the dorsal aponeurosis of the fifth finger. In our study, a thin accessory tendon was separated from ECU at the ulnar styloid process, and the accessory ECU was 0.1 ± 0.14 mm, 6.4 - 6.5 ± 0.12 cm, and inserted in the base of the fifth metacarpal instead of medial tubercle of the fifth metacarpal bone. This might be the reason for the failure of the proximal migration of ulnocarpal elements of the antebrachial mass (29) since the superficial layer of precursor mass of extensors are differentiated into the ECU, ED, and EDM (16). An accessory tendon is of clinical importance as it can weaken the movement of the wrist and fifth finger. Feeling pain in the ulnar side of the wrist during supination and pronation may indicate an accessory tendon. Furthermore, such an accessory can be used for tendon transfer in hand surgery and can be preferred for repairing tendon injuries in distal and proximal interphalangeal joints (30, 31).

The accessory tendon might lead to tenosynovitis by limiting the function of the extensor muscles of the dorsal compartments of the wrist. Therefore, tendon repair, functional tendon graft, or anatomical variation of the dorsal compartments should be considered in reconstructive surgery.

CONCLUSION

The presence of the accessory tendon in the dorsal compartments of the wrist might assist in finding alternative tendon sources in tendon grafts and preferred options for repairing tendon injuries. Furthermore, tendon variations should be considered when planning the surgical treatment.

Conflict of interest

No conflict of interest was declared by the authors.

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