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Variations in the Extensor Tendons of the Hand and a Study of Extenor Digitorum Brevis Manus Muscle

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Abstract

Introduction: A detailed knowledge of the extensor tendons' anatomy is essentialfor understanding the consequences of tendon injuryat various levels. Extensor tendon injuries can cause serious functional impairment but have not received the attention in the literature as flexor tendon injuries.This study focuses on the variant pattern of the chief extensor tendons on the dorsum of hand. This study also throws light on the the relatively rare extensor digitorum brevis manus, a supernumerarymuscle in the fourth extensor compartment of thedorsum of the wrist. *Materials & Methods:* 25 upper limbs (13 right and 12 left) of adult cadavers of unknownage and sex, collected from the dissection room at the Anatomy Department, P.K. Das Institute of Medical Sciences, Vaniamkulam, Palakkad were examined to study the basic arrangement of the extensor tendons of the fingers and to determine the presence of variations of these tendons. *Results*: The number of ED tendons varied from 3 to 8. The incidence of 4 tendons (36%) was the commonest pattern observed in the present study, followed by 5 tendons for ED (20%) and 4 tendons for ED (16%). A single tendon for Extensor digitiminimi was observed in 23 limbs (92%), while the muscle was absent in 2 specimens (8%). The extensor indicis exhibited a single tendon in all the cases. The APL muscle and tendonwere found in all specimens. EPL & EPB were found in all specimens. Two accessory muscles were observed in the dorsum of the hand which were identified asextensordigitorum brevis manus. *Discussion*: The highest number of variations were observed for the tendons of Extensor Digitorum, the number of tendons ranging from 3 to 8. Extensor digitorum brevis manus muscle was observed in two specimens.The variations observed in the present work, could be due to the variable changes the extensor limb myotomespass through, during ontological development; regression, retention, or reappearance.

Keywords: Extensor; Pollicis; Digitorum; Digitiminimi; Indicis; Tendons; Anatomical; Variations; Digitorum Brevis Manus.

Introduction

Several anatomic structures contribute to the extensor mechanism, including the extrinsic muscles of the forearm, intrinsic muscles such as the interosseous and lumbricals, and fibrous structures. The synergisticcontraction of the extensor musculature along withthe long flexors is mandatory for an efficient grip ondifferent objects in daily life. Extensor compartment of the distal segment of the upperlimb is the back of the forearm and the hand. The muscles of this region can be classified into superficial and deep group and through their tendons they act upon the wrist joint and joints of the hand and extend the wrist and fingers. The extensor muscles are in the posterior (extensor–supinator) compartment of the forearm, and all are innervated by branches of the radial nerve.

The extensor tendons are held in place in the wrist region by the extensor retinaculum, which prevents bowstringing of the tendons when the hand is extended at the wrist joint. As the tendons pass over the dorsum of the wrist, they are provided with synovial tendon sheaths that reduce friction for the extensor tendons as they traverse the osseofibrous

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tunnels formed by the attachment of the extensor retinaculum to the distal radius and ulna.

The extensor muscles of the forearm are organized anatomically into superficial and deep layers.

Four of the superficial extensors (extensor carpi radialis brevis, extensor digitorum, extensor digitiminimi, and extensor carpi ulnaris) are attached proximally by a common extensor tendon to the lateral epicondyle. The proximal attachment of the other two muscles in the superficial group (brachioradialis and extensor carpi radialis longus) is to the lateral supra-epicondylar ridge of the humerus and adjacent lateral intermuscular septum.

The extensor carpi radialis longus is inserted into the lateral side of the base of the 2nd meta carpal bone and the extensor carpi radialis brevis is inserted into the dorsal aspect of the base of the second and third metacarpal bones.Extensor carpi ulnaris is inserted on the medial side of the base of the 5th metacarpal bone.

Extensor digitorum arises from the lateral epicondyle of the humerus via the common extensor tendon, the adjacent intermuscular septa and the antebrachial fascia. It divides distally into four tendons, which pass, in a common synovial sheath with the tendon of extensor indicis, through a tunnel under the extensor retinaculum. The tendons diverge on the dorsum of the hand, one to each finger. The tendon to the index finger is accompanied by extensor indicis, which lies ulnar (medial) to it. On the dorsum of the hand, adjacent tendons are linked by three variable intertendinous connections (juncturaetendinae), which are inclined distally and radially. The digital attachments enter a fibrous expansion on the dorsum of the proximal phalanges to which lumbrical, interosseous and digital extensor tendons all contribute.The common tendons of the index and little fingers are joined on their medial sides near the knuckles by the respective tendons of the extensor indicis and extensor digitiminimi.

Extensor digitiminimi is a slender muscle medial to, and usually connected with, extensor digitorum. It arises from the common extensor tendon by a thin tendinous slip and adjacent intermuscular septa. It frequently has an additional origin from the antebrachial fascia. Its long tendon slides in a separate compartment of the extensor retinaculum just behind the inferior radio-ulnar joint. Distal to the retinaculum, the tendon typically splits into two, and the lateral slip is joined by a tendon from extensor digitorum. All three tendons are attached to the dorsal digital expansion of the fifth digit, and there may be a slip to the fourth digit. Extensor digitiminimi is rarely absent, but sometimes it is fused with extensor digitorum.

Abductor pollicis longus arises from the posterior surface of the shaft of the ulna distal to anconeus, the adjoining interosseous membrane, and the middle third of the posterior surface of the radius distal to the attachment of supinator. It descends laterally, becoming superficial in the distal forearm, where it is visible as an oblique elevation. The muscle fibres end in a tendon just proximal to the wrist. The tendon runs in a groove on the lateral side of the distal end of the radius accompanied by the tendon of extensor pollicis brevis. It usually splits into two slips, one of which is attached to the radial side of the first metacarpal base, and the other is attached to the trapezium. Slips from the tendon may continue into opponenspollicis or abductor pollicis brevis. Occasionally the muscle itself may be wholly or partially divided.

Extensor pollicis longus is larger than extensor pollicis brevis, whose proximal attachment it partly covers. It arises from the lateral part of the middle third of the posterior surface of the shaft of the ulna below abductor pollicis longus, and the adjacent interosseous membrane. The tendon passes through a separate compartment of the extensor retinaculum in a narrow, oblique groove on the back of the distal end of the radius. It turns around a bony fulcrum, Lister's tubercle, which changes its line of pull from that of the forearm to that of the thumb, and is attached to the base of the distal phalanx of the thumb.

Extensor pollicis brevis arises from the posterior surface of the radius distal to abductor pollicis longus, and from the adjacent interosseous membrane. The tendon is inserted into the base of the proximal phalanx of the thumb, and commonly has an additional attachment to the base of the distal phalanx, usually through a fasciculus which joins the tendon of extensor pollicis longus. Extensor pollicis brevis may be absent or fused completely with abductor pollicis longus.

Extensor indicis is a narrow, elongated muscle which lies medial and parallel to extensor pollicis longus. It arises from the posterior surface of the ulna distal to extensor pollicis longus, and the adjacent interosseous membrane. Its tendon passes under the extensor retinaculum in a common compartment with the tendons of extensor digitorum. Opposite the head of the second metacarpal it joins the ulnar side of the tendon of extensor digitorum which serves the index finger.

Extensor indicis occasionally sends accessory slips to the extensor tendons of other digits. Rarely its tendon may be interrupted on the dorsum of the hand by an additional muscle belly (extensor indicis brevis manus). An extensor retinaculum, a fibrous band prevents bowstringing of tendon at the wrist levels and separates the tendons into 6 compartments. The first compartment contains the extensor pollicis brevis and the abductor pollicis longus; the second, the extensor carpi radialis longus and extensor carpi radialis brevis; the third, the extensor pollicis longus; the fourth, the four tendons of the extensor digitorum communis plus the extensor indicisproprius; the fifth, the extensor digitiminimi; and the sixth, the extensor carpi ulnaris.

Although extensor variations are common, mostof them are asymptomatic and accidently discoveredduring surgery. Extensor tendon injuries are more frequent than flexor tendon injuries and are very common (61%) as they are not protected as well as the flexor tendons due to their superficial location and lack of overlying subcutaneous tissue. Extensor tendon injuries can cause serious functional impairment but have not received the attention in the literature as flexor tendon injuries.

A detailed knowledge of the extensor tendons' anatomy is essential for understanding the consequences of tendon injuryat various levels. This tendon injury may be either dueto external trauma or spontaneous rupture as in patientswith rheumatoid arthritis and distal radioulnarjoint osteoarthritis.

Many researchers have used magnetic resonance imaging (MRI) to show the details of the musculo tendinous and retinacular structures of the extensorapparatus. They emphasized that understanding of the anatomy of the extensors of the hand and fingers and the acquaintance with their variations by the radiologist is mandatory for better assessment with MRI.

Therefore, the present research was performed to investigate the anatomy of the extensor tendons ofthe fingers, describe their sites of insertions and point out theirvariations. The results of this study might help the clinical radiologist and the surgeons to appreciate and understand these variations for better diagnosis, hand assessment, tendon repair and reconstruction.

Materials & Methods

This study was performed on a total of 25 upper limbs (13 right and 12 left) of adult cadavers of unknownage and sex, collected from the dissection room at the Anatomy Department, P. K. Das Institute of Medical Sciences, Vaniamkulam, Palakkad.

The procedure for this study didnot include any issue that required the approvalof the Ethics Committees of the institution. Upperlimbs of cadavers with obvious injury or scar from surgery were excluded. After the removal of skin and careful dissection of the superficial fascia on the dorsum of each hand, the muscles of the extensor compartments were dissected; the extensor retinaculum (ER) was defined.

The following six muscles were studied in detail.

1. Extensor Digitorum
2. Extensor DigitiMinimi
3. Extensor Indicis
4. Abductor Pollicis Longus
5. Extensor Pollicis Longus
6. Extensor Pollicis Brevis

The number of tendons for each of these muscles, proximal anddistal to the ER, was investigated. The ER was split verticallyto expose the underlying tendons. The tendons were traced to their insertions in the fingers. They were examined to study the basic arrangement of the extensor tendons of the fingers and to determine the presence of variations of these tendons. The incidence of variations in their numbers and sites of attachment were observed. Presence of any supernumerary muscles in the dorsum of hand was also looked for. Then they were photographed usinga digital camera. The obtained data were then tabulated and the percentages were calculated. A tendon was considered single, double or triplebased on the number of separable tendons originating from the muscle at the myotendinous junction.Tendon slips were defined as tendinous divisions distalto the origin of the tendon i.e. splitting of the tendoninto 2 or more separable smaller tendon slips.

Results

Extensor Digitorum (ED)

In 2 upper limb specimens (8%), 8 tendinous slips were observed for extensor digitorum. There was one slip each to little & ring fingers and 3 slips each to ring & middle fingers. (Figure 1).

In 4 specimens (16%), six tendinous slips were observed. There was one slip each to index & middle fingers and 3 slips to ring finger (Figure 2).

In 5 specimens (20%), five tendinous slips were observed. There was one slip each for index, middle & little finger and 2 slips for ring finger.

In 9 specimens (36%), four slips were observed, one for each of the medial four fingers.

In 5 specimens (20%), three slips were observed, one each for index, middle and ring fingers. There were no slips for little finger (Figure 3).

Extensor Digiti Minimi (EDM)

In 23 specimens (92%), a single tendon was observed to the little finger.

In 2 specimens (8%), extensor digitiminimi was absent.

Extensor Indicis (EI)

In all the 25 specimens, a single tendon was observed for extensor indicis, being inserted into the extensor expansion of index finger in all cases.

Abductor Pollicis Longus (APL)

In 22 specimens (88%), the muscle had a single belly & single tendon.

In 3 specimens (12%), the muscle had a single belly and 2 tendinous slips proximal & distal to extensor retinaculum (Figure 4).

Extensor Pollicis Longus (EPL)

In all 25 specimens, the muscle had only one tendinous slip.

Extensor Pollicis Brevis (EPB)

In all 25 specimens, the muscle had only one tendinous slip

In addition to the above observations, two accessory muscles were observed in the present study.

1. A small muscle arose from the lower 1/4th of the posterior surface of ulna. The muscle belly tapered off into a slender tendon, which was inserted into the extensor expansion of middle finger. This limb had only 3 slips for extensor digitorum (Figure 5).
2. An accessory muscle was observed on the dorsum of hand. This muscle originated from the distal most end of posterior surface of radius, medial to Lister's tubercle. 2 tendons arose from the muscle, one tendon joined the tendon of extensor indicis and the other tendon was inserted directly onto the extensor expansion of middle finger (Figure 6).

No separate nerves could be identified supplying the above two accessory muscles.

Discussion

In the present study, the number of ED tendons varied from 3 to 8. The incidence of 4 tendons (36%) was the commonest pattern observed in the present

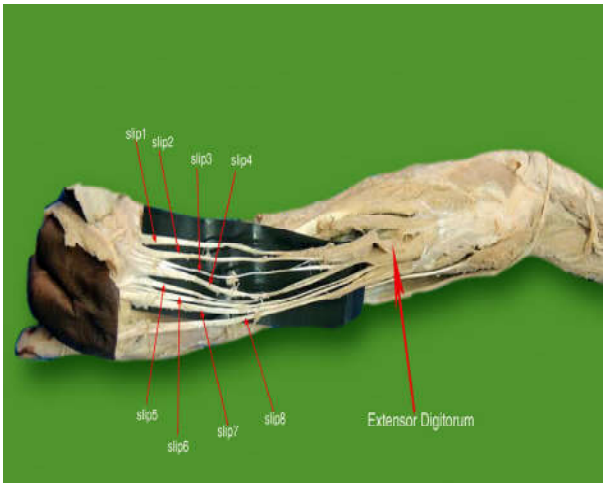

Fig. 1: Photograph showing extensor digitorum with 8 tendinous slips

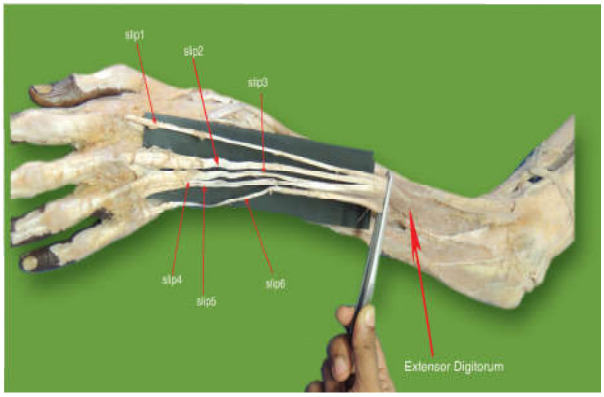

Fig. 2: Photograph showing extensor digitorum with 6 tendinous slips

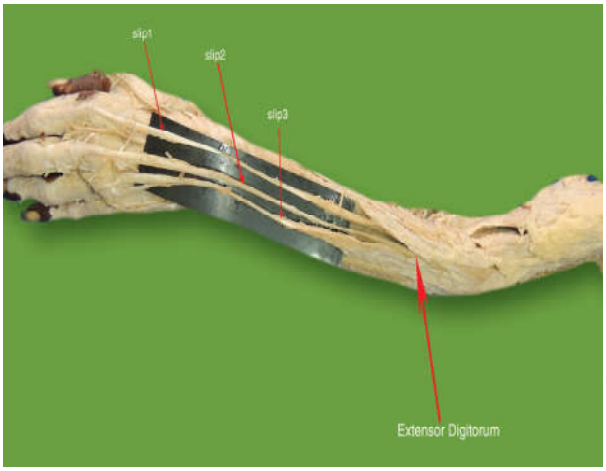

Fig. 3: Photograph showing extensor digitorum with 3 tendinous slips

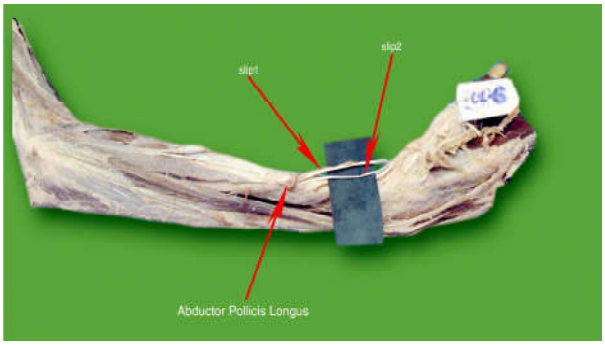

Fig. 4: Photograph showing abductor pollicis brevis with a single belly and 2 tendinous slips

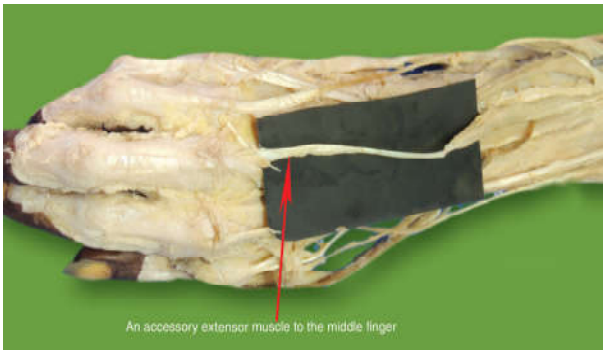

Fig. 5: Extensor digitorum brevis manus muscle arising from lower $1/4^{th}$ of posterior surface of ulna and inserting into extensor expansion of middle finger

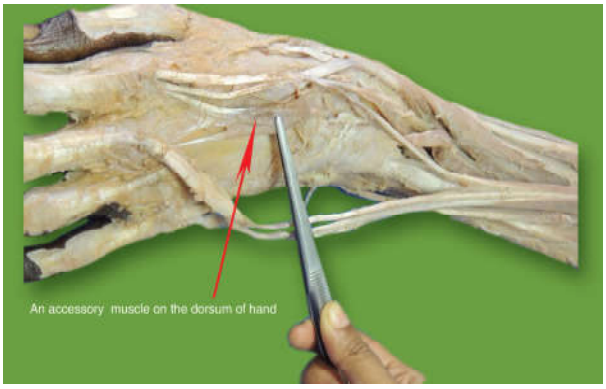

Fig. 6: Extensor digitorum brevis manus muscle arising from distal end of posterior surface of radius and dividing into 2 tendinous slips

study, followed by 5 tendons for ED (20%) and 4 tendons for ED (16%). This observation contrasts with the previous studies. G.A. Abdel-Hamid et al. [1] in his study of 95 specimens has reported the incidence of 6 tendons for ED (40%) being the commonest pattern, followed by 4 tendons (32.6%). El-Badawi MG et al. [2] in his study has reported the highest incidence of 4 tendons for ED, followed by 3 tendons. In the present study, the incidence of 8 tendons was observed in two of the hands(8%), the occurrence of which had not been reported in any previous studies to the best of our knowledge.

In the present study, a single tendon for Extensor digitiminimi was observed in 23 limbs (92%), while the muscle was absent in 2 specimens (8%). This finding is in concordance with the previous studies which had reported 92-95% incidence of a single tendon for EDM [1, 2, 3]. Very few previous studies had reported a complete absence of EDM, which was observed in 2 specimens in the present study.

In the present study, the extensor indicis exhibited a single tendon in all the cases. G.A. Abdel-Hamid et al. [1] had also reported a single tendon for EI in his study. Dass et al. [3] detected a single tendon of EI in 98% of specimens. However, some studies reported a lower incidence [2,4,5,6]. The EI permits independent extension of the index finger and is commonly used for tendon transfer [7, 8].

In the present study, the APL muscle and tendonwere found in all specimens. A single belly and a single tendon for this muscle was observed in 88% of the specimens, where as a single belly and duplicated tendons were seen in 12% of specimens.

In the present study, the EPL muscle and tendonwere found in all specimens. A single tendon was observed in all our specimens. Previous studies have reported a varying incidence regarding the tendons of EPL. G.A. Abdel-Hamid et al. [1] has reported single tendons in 67.4% of hands, whereas the duplicated ones were detected in 32.6% in the same study. Caetano MBF et al. [9] has reported a lower incidence of 8.3% of the duplicated tendons for EPL. Other researches [10, 11] noted the absence of this tendon without referring to its frequency.

In the present investigation, EPB was recorded in all the dissected limbs. EPB has been widely documented in 100% of specimens of the previous studies [12,13].G.A. Abdel-Hamid et al. [1] has reported incidence of EPB in 97.9% of cases. He has also reported absence of EPB in 2.1% cases, which is in concordance with the previous studies, which have reported similar percentages [14,15,16]. The sporadic absence of EPB could be explained because of its phylogenetically young structure [17].

Two accessory muscles were observed in the dorsum of the hand in the present study.

1. One of the muscles originated from the distal most end of posterior surface of radius, medial to Lister's tubercle. 2 tendons arose from the muscle, one tendon joined the tendon of extensor indicis and the other tendon was inserted directly onto the extensor expansion of middle finger.

2. A small muscle arose from the lower 1/4th of the posterior surface of ulna. The muscle belly tapered off into a slender tendon, which was inserted into the extensor expansion of middle finger. This limb had only 3 slips for extensor digitorum to the index, middle & ring fingers. So, there were 2 tendinous slips to the middle finger.

These variant muscles may be representing extensor digitorum brevis manus.

The extensor digitorum brevis manus, a supernumerarymuscle in the fourth extensor compartment of thedorsum of the wrist, is a relatively rare anomalous muscle. The extensor digitorumbrevis manus muscle (EDBM), an anatomic variant of theextensor muscle of the dorsum of the hand, is found inapproximately 2% to 3% of the population.The extensor digitorum brevis manus has also been called the "m. extensor anomalus" and "le muscle manieux" [18]. This muscle was first reported by Albinus in 1734. Since then, approximately 295 cases of extensor digitorumbrevis manus have been reported. Bunnel [19,20] and Souter [21] described that EDBM may represent a failure of proximal migration of ulnocarpal elements of the antebrachialmuscle mass in humans, which is found normally inamphibians.

This muscle generally consists of a single belly, but cases with two bellies with variable sizes alsohave been reported [23, 21]. EDBM is commonly said to arise from the dorsal carpal ligaments, the joint capsule, orthe carpal bone, particularly the scaphoid and the lunate[22]. However, other origins, including the distal radius,ulna, and metacarpals, have been reported [23].

Its insertion has been described as in the extensor hood of the index,middle, ring, or little finger, although multiple insertionsinto more than one finger has been reported [23, 24]. The most common insertion is said to be into the index finger,followed by the middle, and then the index and middle fingers [25]. The nerve supply and blood supply of EDBM has been confirmed to be from the posterior interosseousnerve and artery [25].

Extensor digitorum brevis manus should be included in the differential diagnosis of soft tissue masses on the dorsal aspect of the hand as it may mimic cystic, neoplastic, inflammatory, and infectious masses arising in the dorsumof the wrist. During clinical examination, the EDBM may be confused with abnormal processes such as ganglion, cysts, or soft tissue tumors thereby mimicking numerous abnormal entities which when misdiagnosed may lead to unnecessary surgery [25, 26]. Although usually asymptomatic, the patient may present with a painful dorsal wrist mass, particularly inindividuals performing repetitive movements of the wrist and hand [27].

The presence of these additional muscles in the fourth compartment of the extensor retinaculum, as in the present case, may lead to a condition called "fourth-compartment syndrome," which is manifested by chronic dorsal wrist pain of the fourth compartment. The increased pressure within this compartment may compress the posterior interosseous nerve directly or indirectly [28].

The variations observed in the present work, could be due to the variable changes the extensor limb myotomespass through, during ontological development; regression, retention, or reappearance as explained by Celik et al. [29] and Chevallier et al. [30]. Developmentally, in the forearm, the precursor extensor muscle mass differentiates into a radial portionwhich subsequently divides into superficial anddeep portions. The superficial portion differentiatesinto the ED, extensor carpi ulnaris, and Edm. The deep portion, gives rise to the abductor pollicis longus, extensorpollicis brevis, extensor pollicis longus and EI.

Conclusion

25 upper limbs were examined in the present study to observe the basic arrangement of the extensor tendons of the fingers and to determine the presence of variations of these tendons. Six extensor tendons on the dorsum of the hand were studied in detail. The highest number of variations were observed for the tendons of Extensor Digitorum, the number of tendons ranging from 3 to 8. To know the consequences of the injuries in forearm and hand at various levels. surgeons should be well versed in the extensor anatomy of forearm and hand. Extensor digitorum brevis manus muscle was observed in two specimens. This supernumerary muscle should be included in the differential diagnosis of soft tissue masses on the dorsalaspect of the hand as it may mimic cystic, neoplastic, inflammatory, and infectious masses arising in the dorsumof the wrist. This study will help the radiologists and surgeons to understand the variations for theirdiagnosis and performing hand surgery, especially tendon repair and reconstruction. So, clinicians andsurgeons should be advised to investigate each casethoroughly and individually, using recent techniques.

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