

Cadaveric Study of Extensor Retinaculum of the Wrist

Abstract

Introduction: The function of the wrist extensor retinaculum is to prevent the extensor tendon bowstringing. Because the retinaculum is damaged by hand trauma and surgical exposure during the wrist surgery, the knowledge of anatomy of the retinaculum helps surgeons to restore the normal function of the extensor retinaculum. **Material and Methods:** The morphological variation of the retinaculum and average length and width of both septal attachment of the retinaculum were examined using 50 fresh donor cadavers. **Results:** Our finding found that the extensor retinaculum was white thickening fascia which arranged in transverse direction across over the wrist extensor group. The original retinaculum was defined as the part inserted from the radius to the pisiform and triquetrum. The mean length was ranging 10–35 mm and the mean width of proximal and distal end was 62–93 mm and 64–89 mm, respectively. There were supplemental retinaculae where were located on the proximal and distal to the original retinaculum. These retinaculae were thinner and more translucent. We found four patterns of attachment sites of the proximal retinaculum and five patterns for the distal extensor retinaculum. In addition, the average septal attachment size was varied from 1.24 to 27.81 mm in length and width was 0.33–20.50 mm for the real retinaculum. We also found the 84% present of the septal attachment beside the 6th compartment in ulnar side. **Discussion and Conclusion:** The knowledge of anatomical characteristic of the extensor retinaculum includes morphology, dimensions, and septal attachment is benefit for surgery.

Keywords: Attachment, extensor retinaculum, extensor tendons, septum, wrist

Introduction

The wrist extensor retinaculum is a fibrous band over the dorsum of the wrist, and it extends fascial attachment to forms six compartments which contain extensor tendons to the hand. It holds the extensor tendons in place and prevents bowstringing during movement of the hand. The retinaculum was originally defined as the part inserted from the radius to the pisiform and triquetrum. In addition to the original retinaculum, there are supplemental retinaculae where are located on the proximal and distal aspect. These retinaculae are thinner and more translucent.^[1,2] The extensor retinaculum is damaged by hand trauma, and athletes with repetitive weight-bearing hyperextension activities are predisposed to wrist pain due to extensor retinaculum impingement.^[3] The retinaculum is once opened by detaching the septum during wrist surgeries such as synovectomy, repairment of ruptured extensor tendons,

and wrist arthroplasty.^[4-6] The retinaculum is divided into six compartments which consist of different extensor tendons, and there is anatomical variation of the septal attachment of the retinaculum.^[7] Thus, knowledge of anatomy of the retinaculum helps surgeons to restore normal function of the extensor retinaculum.

There have been revealed that rheumatoid arthritis affected to rupture of extensor tendons, particularly little and ring fingers. Common patients with rheumatoid arthritis had tenosynovitis sign that occurred approximately 50%–64%.^[4-6] The important problems of rheumatoid arthritis are extensor tendon ruptures and loss of wrist functions. The ruptured tendon may occur one or more tendons. Earlier studies^[8] investigated the ruptured wrist extensor tendons by using magnetic resonance imaging (MRI) in patients with rheumatoid arthritis. All 13 of 23 wrist found extensor tendon ruptures in the extensor indicis proprius, extensor digitorum communis of the index, middle, ring, and little fingers (EDC 2–5), and extensor digiti minimi (EDM) tendons. In addition,

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How to cite this article: Komutrattananont P, Gumpangseth T, Omokawa S, Mahakkanukrauh P. Cadaveric study of extensor retinaculum of the wrist. *J Anat Soc India* 2020;68:299-305.

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Article Info

Received: 23 June 2019

Accepted: 18 January 2020

Available online: 28 February 2020

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Access this article online

Website: www.jasi.org.in

DOI:
10.4103/JASI.JASI_84_19

Quick Response Code:



previous literature^[9] also examined tendon damage in rheumatoid arthritis by ultrasound scoring system. They focused on second to sixth compartments of the wrist and found the most often damage structure is extensor carpi ulnaris (ECU) tendon and EDM tendon, respectively. Thus, the study about the extensor tendons is crucial, especially the ECU, extensor digitorum, and EDM tendons.

A previous study reported^[10] the anatomy and mechanical property of the septal attachments on the radius and measured the dimension of attachment site to the radius, between 1st and 2nd, 2nd and 3rd, 3rd and 4th, and 4th and 5th compartments of the wrist. They found that the septal attachment between 1st and 2nd compartments had the largest dimension with the highest failure strength. These results of septal attachment on the radial aspect are useful for the treatment of patients who need carpal ligament reconstruction using the bone-retinaculum-bone segment from the radius. However, there is a lack of information regarding the anatomy of septal attachment at the ulnar aspect of extensor retinaculum (5th and 6th compartments, attachment to the triquetrum and the pisiform).

An MRI study^[11] investigating ECU tendinopathy at the wrist revealed that the tendinopathy occurred not only in the ECU groove (fibro-osseous tunnel) but also in the more distal extensor retinaculum area. Thus, knowledge of the anatomy of septal attachment at the ulnar aspect of extensor retinaculum (5th and 6th compartments, attachment to the triquetrum and the pisiform) is important to help to understand the pathomechanism of ECU tenosynovitis (tendinopathy).

The study by Palmar described that they found the second fascial component which extended from the ulna to radius in V-shaped fascia.^[2] Taleisnik *et al.* mentioned that there were three parts of the ulnar attachment site of extensor retinaculum which were fascia of flexor carpi ulnaris, pisiform, and fascia of hypothenar muscle.^[1] Based on the study of Taleisnik, we defined the extensor retinaculum into three types as follows: the original retinaculum, proximal retinaculum, and distal retinaculum [Figure 1].

Thus, the anatomical study involving the wrist includes the extensor retinaculum, attachment size, and the extensor tendons are crucial and clinically useful for the wrist surgeon. There is no detailed study is available regarding the location and dimension of the extensor retinaculum, attachment site, and variation of these structures. The purposes of this study are to investigate the general anatomy of the extensor retinaculum, variations of the extensor retinaculum, and to quantify the dimensions

of the extensor retinaculum, septal attachment of each compartment in human wrist.

Material and Methods

The study was obtained 50 fresh human wrists of 25 donor cadavers from anonymous to investigate the anatomy of the extensor retinaculum by gross dissection. The aged was ranged between 62 and 85 years with both sexes. For the extensor retinaculum, we used a probe (wire with a diameter of 0.5 mm) to detect the septal compartment and plotted the point with permanent pen on retinaculum by using the oblique fibers of the retinaculum to define the boundary of the retinaculum and measure the dimensions in each compartment of wrist defined as radius (1R), between 1st and 2nd compartments (1st-2nd), between 2nd and 3rd compartments (2-3), between 3rd and 4th compartments (3-4), between 4th and 5th compartments (4-5), between 5th and 6th compartments (5-6), radial to ECU tendon (6U), and attachment at pisiform. The septal attachment areas were measured at the radius (1R), between 1st and 2nd, 2nd and 3rd, 3rd and 4th, 4th and 5th, 5th and 6th, attachment at ulnar to ECU tendon (the triquetrum and pisiform).

The parameters were measured as follows: the length and width of the extensor retinaculum of each compartment, the length and width of the septal attachment site. The length was identified using the longitudinal axis of the bone and the width was measured along the transverse axis. These dimensions were analyzed using Vernier caliper, and each data were derived from the average value of three times measurements. The presence or absence of septal attachment at each intercompartmental area was recorded.

Results

Original retinaculum

The results showed the clearly white thick band of the extensor retinaculum. It obliquely extended from the radius to pisiform that not attached to the ulna and it was defined as the original retinaculum. The original retinaculum showed that the average length was ranged between 10.32 and 35.15 mm and the average width of the proximal and distal end was 62.10–93.40 mm and 63.86–89.37 mm, respectively. The dimensions (length and width) of the original retinaculum found a wide range of variation that demonstrated in Table 1.

Septal attachment of the original retinaculum

For the septal attachment size of the extensor retinaculum, found that the attachment at radius (1R) was 15.10 ± 3.61 mm

Table 1: Dimension of the original extensor retinaculum (n=50)

Structure	Mean length±SD (mm)	Mean width in proximal end±SD (mm)	Width in distal end±SD (mm)
Original retinaculum	18.65±4.20 (10.32-35.15)	79.61±6.26 (62.10-93.40)	74.61±6.11 (63.86-89.37)

SD: Standard deviation

in length and 2.29 ± 1.17 mm in width. For the septal area between 1st and 2nd compartments, the mean length and width were 16.80 ± 3.26 mm, 5.74 ± 2.16 mm, respectively. The septal area between 2nd and 3rd compartments was length 11.91 ± 3.53 and width 4.34 ± 1.53 mm. The mean length between 3rd and 4th compartments was 13.97 ± 3.21 mm and the width was 3.92 ± 1.56 mm. The septal area between 4th and 5th compartments was 16.31 ± 4.17 mm in length and in 6.42 ± 3.50 in width. Between the 5th and 6th compartments, the mean length was 14.43 ± 3.79 mm and mean width was 3.33 ± 1.47 mm. For the septal area where beside the 6th compartment in the ulnar aspect, the mean length was 10.64 ± 3.69 mm and mean width was 2.01 ± 0.97 mm. The mean length of the septal surface area in medial attachment was 13.21 ± 3.00 mm and the mean width was 4.61 ± 1.86 mm [Table 2].

Supplemental retinaculum

Moreover, there were additional retinaculum where located on the proximal and distal end to the real retinaculum and they were thinner and more translucent.

Proximal retinaculum

For the proximal retinaculum, the mean dimensions of the proximal retinaculum were 17.20 mm in length, and width in the proximal and distal end were 54.85 mm and 56.80 mm, respectively [Table 3]. We found four patterns of attachment sites shown in Table 4 that was divided into A-D. All patterns is originated form fascia of flexor carpi ulnaris muscle and attached to the different sites. In most cases, the proximal retinaculum usually extended from the fascia of flexor carpi ulnaris muscle and its ended between the 3rd and 2nd compartments in 54% (27 wrists). The proximal retinaculum was found in all cases.

Distal retinaculum

The distal extensor retinaculum frequency extended from the fascia of the hypothenar muscle to between 1st and

2nd compartments that found in 21 wrists (42%). In addition, we found five patterns of the distal extensor retinaculum shown in Table 5 that were divided into A-E. The attachment sites of proximal and distal are demonstrated in Figures 2a-d and 3a-e, respectively. The distal retinaculum was found in all cases. The mean dimensions of the distal retinaculum were 20.66 mm in length, and width in the proximal and distal end was 57.32 mm and 72.81 mm, respectively [Table 6].

In addition, we found the supratendinous and infratendinous portions of the extensor retinaculum that they cross over and under the extensor tendons. The infratendinous of the retinaculum was observed between the 5th and 6th compartments to the 3rd compartment. There was the overlapping of the extensor retinaculum (double layers) between the original and distal supplemental extensor retinaculum [Figure 4].

Discussion

The morphology of the extensor retinaculum in this study found the thick band as real retinaculum and the additional



Figure 1: The extensor retinaculum of wrist; original retinaculum, proximal retinaculum, and distal retinaculum

Table 2: Attachment site of extensor retinaculum (n=50)

Region of attachment	Mean length±SD (mm)	Mean width±SD (mm)
Medial attachment (pisiform and fibrous connective tissue)	13.21±3.00 (5.85-20.44)	4.61±1.86 (1.25-9.72)
Beside the 6 th compartment in ulnar aspect (triquetrum)*	10.64±3.69 (1.24-18.17)	2.01±0.97 (0.33-3.96)
Between 6 th and 5 th compartments (triquetrum and fibrous connective tissue)	14.43±3.79 (6.15-21.84)	3.33±1.47 (0.64-7.76)
Between 5 th and 4 th compartments	16.31±4.17 (5.59-27.81)	6.42±3.50 (1.71-20.50)
Between 4 th and 3 rd compartments (radius)	13.97±3.21 (7.17-18.64)	3.92±1.56 (1.05-7.44)
Between 3 rd and 2 nd compartments (radius)	11.91±3.53 (6.14-20.17)	4.34±1.53 (2.23-9.54)
Between 2 nd and 1 st compartments (radius)	16.80±3.26 (9.05-23.94)	5.74±2.16 (1.32-16.51)
Attachment at radius (1R)	15.10±3.61 (2.43-22.20)	2.29±1.17 (0.50-6.05)

*Absent 8 cases. SD: Standard deviation

Table 3: Dimension of the proximal retinaculum (n=50)

Structure	Mean length±SD (mm)	Mean width in proximal end±SD (mm)	Width in distal end±SD (mm)
Proximal retinaculum	17.20±4.63 (7.20-29.52)	54.85±12.91 (31.87-97.14)	56.80±12.22 (41.08-89.46)

SD: Standard deviation

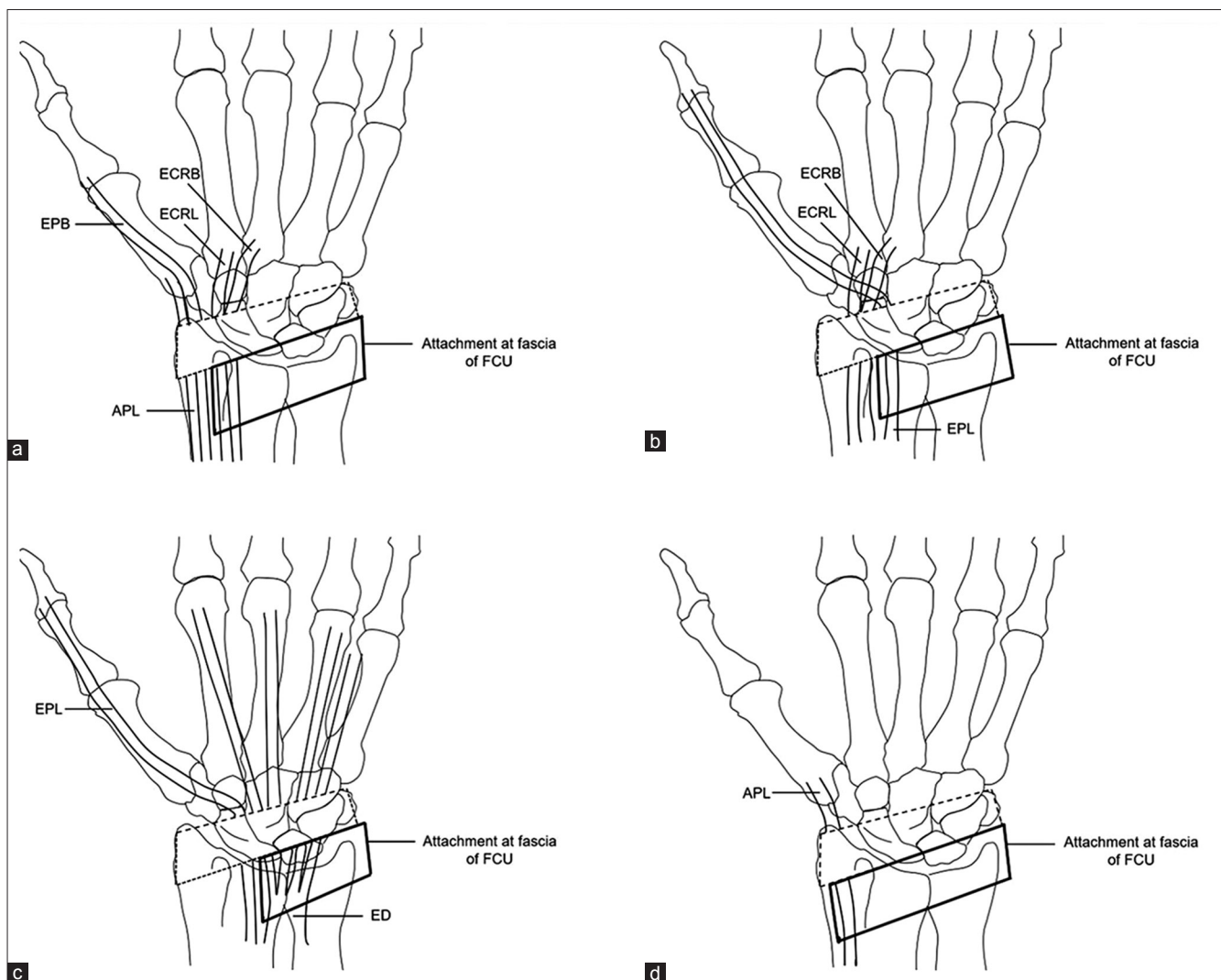


Figure 2: The attachment site patterns of the proximal extensor retinaculum as followed the Table 4. 2a; originate from fascia of FCU to between 2nd and 1st compartments, 2b; originate from fascia of FCU to between 3rd and 2nd compartments, 2c; originate from fascia of FCU to between 4th and 3rd compartments, 2d; originate from fascia of FCU to abductor pollicis longus to radius. FCU; flexor carpi ulnaris muscle

Table 4: Patterns of attachment site of proximal extensor retinaculum (n=50)

Attachment in ulnar side	Attachment in radial side	Number of cases, n (%)
Fascia of flexor carpi ulnaris muscle	Between 2 nd and 1 st compartments	2 (4)
Fascia of flexor carpi ulnaris muscle	Between 3 rd and 2 nd compartment	27 (54)
Fascia of flexor carpi ulnaris muscle	Between 4 th and 3 rd compartment	15 (30)
Fascia of flexor carpi ulnaris muscle	Abductor pollicis longus to radius	6 (12)

retinaculum defined as proximal and distal retinaculum that were consistent with the previous study.^[2] In most cases, the retinaculum extended obliquely and distally from the radial to the ulnar side, and it was rather wider. However, the length of the radial aspect was slightly wider than in the ulnar aspect. However, the dimension in length of the extensor retinaculum

Table 5: Patterns of attachment site of distal extensor retinaculum (n=50)

Attachment in ulnar side	Attachment in radial side	Number of cases, n (%)
Between 4 th and 5 th compartments	Flexor retinaculum which was located over the radial artery	4 (8)
Between 4 th and 5 th compartments	Abductor pollicis longus tendon to radius	16 (32)
Fascia of hypothenar muscle (ulnar to ECU)	Between 1 st and 2 nd compartments	21 (42)
Fascia of hypothenar muscle (ulnar to ECU)	Between 2 nd and 3 rd compartments	4 (8)
Fascia of hypothenar muscle (ulnar to ECU)	Between 3 rd and 4 th compartments	5 (10)

ECU: Extensor carpi ulnaris

in the previous literature was larger than this study. They found V-shaped of second fascial component which extended

Table 6: Dimension of the distal retinaculum (n=50)

Structure	Mean length±SD (mm)	Mean width in proximal end±SD (mm)	Width in distal end±SD (mm)
Distal retinaculum	20.66±8.74 (5.87-34.18)	57.32±10.29 (30.50-82.64)	72.81±21.49 (27.54-127.38)

SD: Standard deviation

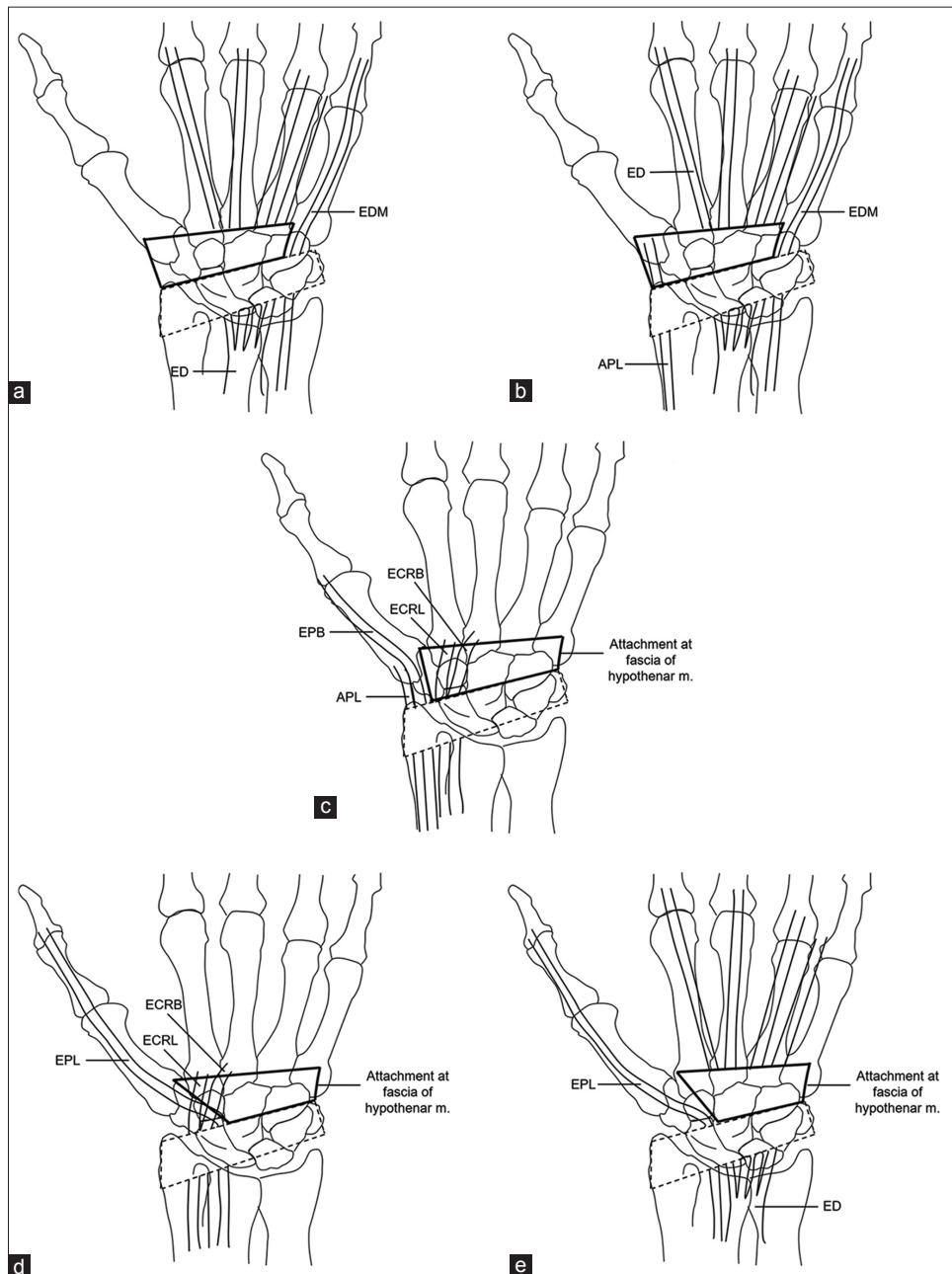


Figure 3: The attachment site patterns of the distal extensor retinaculum as followed the Table 5. 3a; originate between 4th and 5th compartments to flexor retinaculum which was located over the radial artery, 3b; originate between 4th and 5th compartments to abductor pollicis longus tendon to radius, 3c; originate fascia of hypothenar muscle to between 1st and 2nd compartments, 3d; originate fascia of hypothenar muscle to between 2nd and 3rd compartments, 3e; originate fascia of hypothenar muscle to between 3rd and 4th compartments

form the ulna to radius. In this study, we also measured the dimension of the second fascial components that divided into the supplement proximal and distal retinaculum. The study of Massaki found that the width of the extensor retinaculum in neutral position was 10.1–20.1 mm.^[12] Variation of measurement maybe effect to the result of this study such as

we cut the arm at the elbow joint and measured in forearm pronation that make easily hand rotation.

The septum attached not only radius and extend to dorsal site of the wrist, especially between 3rd and 4th compartments, between 4th and 5th compartments, and

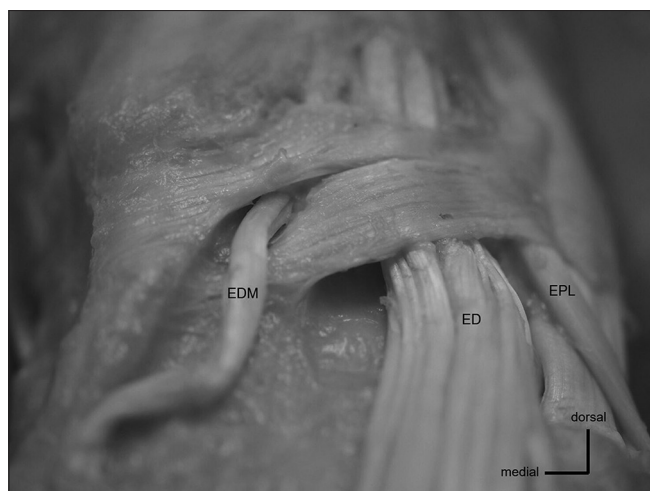


Figure 4: The supratendinous and infratendinous extensor retinaculum were observed between 5th and 6th compartments to 3rd compartment of the wrist. EDM; Extensor digiti minimi, ED; Extensor digitorum, EPL; Extensor pollicis longus

between 5th and 6th compartments had no attachment site to the radius. The previous studies^[1] found the different points of the attachment. They investigated the supratendinous and infratendinous portions of the extensor retinaculum. Supratendinous extensor retinaculum is a discontinuous fibrous layer. It was as thick the ulnar aspect of the distal forearm to the radiocarpal joint. Infratendinous of extensor retinaculum spreads from the radiocarpal joint to the carpometacarpal joint and discontinuous parallel fibers that narrow and short. They investigated retinaculum septa and compartment and found that the first septum attaches on the radius. The second attaches on the bony protuberance of the distal radius. The third septum device to the second and third components. It is periosteum in the distal radius. The fourth septum had well infratendinous retinaculum. It created a circular fibrous tube. The floor of the fifth compartment is infratendinous retinaculum and it had circular tube from the distal radius to the intercarpal joint level. The sixth septum attaches proximally to the dorsal-ulnar corner of the radius. The sixth compartment that ECU lying down inside. It added the infratendinous retinaculum and separated from the supratendinous retinaculum by loose tissue. The distal of ECU that retinaculum and ulnocarpal joint capsule attaches triquetrum. ECU compartment at ulnar wall is transverse fiber that medial wall support by linea jugata. It is longitudinal fibers and related to the tension in the extreme of supination. Another study^[2] revealed that the 4th compartment extended from the distal radius to dorsal capsular and the 5th compartment inserted at capsule of the distal radioulnar joint, the triangular fibrocartilage complex and the wrist capsule. An earlier study examined^[10] that the dimension of all septal attachment and showed same results with this study. They study the attachment site on radius by using caliper and three-dimensional digitizer and found the septum $\frac{1}{2}$ was the largest attachment in the width (width = 6.8, length = 21.4 mm). The largest area in

length was $\frac{2}{3}$ the septal attachment (length = 23.1 mm). They found a small area of fifth attachment to the dorsoulnar aspect on radius. There was no osseous insertion of the sixth septum and found only soft tissue attachment. In this study, we found the fifth septal attachment on the radius and found sixth septal attachment nearly located to the fifth septum. Moreover, Brody *et al.* reported that the distal portion of the extensor retinaculum is most important in preventing bowstringing tendon.^[13] This indicates that the information of extensor septum attachment at distal site to the radius may be more important for wrist biomechanics. We also studied the area on the ulnar side in this study that no have data on the ulna.

We studied the supplemental retinaculum which was located on proximal and distal to the original extensor retinaculum. In most cases, the proximal retinaculum originated from the fascia of flexor carpi ulnaris muscle to between the 2nd and 3rd compartments (54%). While the distal retinaculum had various different origin and insertion. The origin was regions between 4th and 5th compartments, and fascia of hypothenar muscle to the flexor retinaculum, which was located over the radial artery, abductor pollicis longus tendon to radius, between 1st and 2nd compartments, between 2nd and 3rd compartments, and between 3rd and 4th compartments. Mostly, the distal retinaculum extended from fascia of hypothenar muscle to area between 1st and 2nd compartments (42%). We found the overlapping structures between the original and distal supplemental extensor retinaculum, especially consistently found in the fourth compartment. There were found the supratendinous and infratendinous between the 3rd and 5th-6th compartments.

For clinical aspects, Santo *et al.* reported that ECU tenosynovitis may occur not only at the groove of ulnar head but also more distal site. In our study, there was septum surrounding ECU tendon located distal to ulnar head. This septum may be one of the causes for ECU tenosynovitis.^[11] Moreover, subluxation of the ECU tendon can occur in ulnar deviation and the supination and reconstruction of the retinaculum may be used to support the ECU tendon.^[14,15] Another study revealed the retinaculum impingement which is caused by repetitive dorsiflexion movements and may cause a chronic thickening of the extensor retinaculum in athletes.^[12] Studying the detailed anatomical characteristics of the extensor retinaculum, septal attachment is important. These supplemental extensor retinacula were not supported the whole compartment of the extensor tendons. Thus, this information is useful for wrist surgeries as ligament reconstruction. If impossible, the extensor retinaculum on the radiocarpal and ulnocarpal joints should be preserved for prevention the tendon bowstring.

Conclusion

The results of this study include morphology, dimensions, and septal attachment size of the extensor retinaculum

showed more variation. This knowledge might help the surgeons to appreciate and understand this anatomy for better any treatments of hand.

Acknowledgment

The authors would like to thank Excellence Center in Osteology Research and Training Center (ORTC) with partially supported by Chiang Mai University.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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