

# **Diplomarbeit**

**The course of the extensor pollicis longus tendon considering  
the different functional positions of the wrist and the first ray - an  
anatomical study**

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## List of Abbreviations

EPL	Extensor pollicis longus
ECRL	Extensor carpi radialis longus
ECRB	Extensor carpi radialis brevis
RP	Reference point

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## Zusammenfassung

### *Einleitung:*

Die Strecksehnen der Radiokarpalregion sind wichtige Landmarken bei chirurgischen Eingriffen. Eine besondere Rolle spielt der Verlauf der Extensor pollicis longus (EPL) Sehne, die radial-distal um das Tuberculum Lister herum verläuft. Die EPL Sehne zeigt eine hohe Variabilität in Bezug auf Bewegungsumfang, anatomische Variationen und Verlauf. Ziel der folgenden anatomischen Untersuchung war es, den Verlauf der EPL Sehne, die Lagebeziehung zu benachbarten Strukturen unter Berücksichtigung verschiedener Funktionsstellungen und die daraus resultierende klinische Relevanz darzustellen.

### *Material und Methoden:*

Für diese Studie wurden zwanzig obere Extremitäten von zehn erwachsenen menschlichen Kadavern verwendet, die nach der Methode von Thiel einbalsamiert worden waren. In einer ersten Studienreihe wurden die funktionellen Positionen definiert, welche zu einer größtmöglichen Bewegungsausdehnung der EPL Sehne führen. Hierfür wurde die Distanz zwischen dem Zentrum des ersten Carpometacarpalgelenks (Referenzpunkt [RP] 1) und dem Zentrum der EPL Sehne, sowie das Intervall zwischen der Spitze des Processus styloideus radii (Referenzpunkt [RP] 2) und dem Zentrum der EPL Sehne vermessen. In einer zweiten Untersuchungsreihe wurde zusätzlich der Winkel, in dem die EPL-Sehne das Tuberculum Lister umschlingt und über dem Extensor carpi radialis longus und brevis (ECRL und ECRB) verläuft, erfasst und in allen Funktionsstellungen gemessen. In der dritten Untersuchungsreihe wurde zusätzlich das Gleiten der EPL Sehne nach distal bestimmt.

### *Ergebnisse:*

Bewegungsumfang: Für das Handgelenk in Extension und Daumen in Opposition lagen die Werte für RP 1 bei 19,62 mm und für RP 2 bei 20,55 mm. Im Rahmen der Flexion im Handgelenk kombiniert mit Daumenextension lag der Wert für RP 1 im Mittel bei 15,14 mm und für RP 2 bei 10,55 mm. Bei flektiertem Handgelenk und Daumenopposition lagen die Mittelwerte bei 13,79 mm (RP 1) und 10,33 mm (RP 2). Die Werte für das Handgelenk in Radialduktion und Daumen in Extension betragen 15,90 mm für RP 1 und 14,94 mm für RP 2. Für das Handgelenk in Ulnarduktion und Daumen in Adduktion lag der Wert für RP 1 bei 14,64 mm und für RP 2 bei 17,12 mm.

Der Winkel um das Tuberculum Lister: Der größtmögliche Winkel wurde für das Handgelenk in Extension und Daumen in Abduktion (Mittelwert: 46°) und das Handgelenk in Radialduktion und Daumen in Abduktionsstellung (55°) erreicht. Der kleinstmögliche Winkel wurde für das Handgelenk in Ulnarduktions- und Daumen in Adduktionsstellung (13,5°) und für das Handgelenk in Ulnarduktions- und Daumenoppositionsstellung (14°) evaluiert.

Sehnengleiten: Die Werte für das Handgelenk in Neutralstellung und Daumen in Oppositionsstellung zeigten eine distale Sehnenbewegung von 10,41 mm. Die Werte für das Handgelenk in Extension und Daumen in Oppositionsstellung zeigten einen Mittelwert von 10,64 mm und für das Handgelenk in Radialduktion und Daumen in Oppositionsstellung betrug der Mittelwert 10,41 mm. Die Werte für das Handgelenk in Flexion und Daumen in Extension lagen bei -6,34 mm und für das Handgelenk in Ulnarduktion und Daumen in Extension lag der Mittelwert bei -7,71 mm (negative Werte repräsentieren ein Sehnengleiten nach proximal).

### *Schlussfolgerung:*

Zusammenfassend ist die Kenntnis des anatomischen Verlaufs der Extensor pollicis longus Sehne und des möglichen Bewegungsausmaßes und der daraus resultierenden Lageveränderung eine wesentliche Grundlage in der Diagnostik und auch operativen Behandlung von Patienten und Patientinnen mit Beschwerden/Verletzungen im dorsoradialen Handgelenksbereich.

## Abstract

### *Introduction:*

The extensor tendons of the radiocarpal region are important landmarks during surgical procedures. The course of the extensor pollicis longus (EPL) tendon, which courses around the Lister tubercle in a radial-distal direction, plays a special role. The EPL tendon shows a high variability in terms of range of motion, anatomical variations and course. This variability is of high importance during clinical practice. The aim of the following anatomical study was to evaluate the course of the extensor pollicis longus tendon and its positional relationship to adjacent structures, taking various functional positions and the resulting clinical relevance into account.

### *Material and Methods:*

Twenty upper extremities from ten adult human cadavers embalmed with Thiel's method were used for this study. In a first study series, the functional positions which lead to the greatest possible extension of movement of the EPL tendon were defined. Here, the distance between the center of the first carpometacarpal joint (reference point [RP] 1) and the center of the EPL tendon and the interval from the tip of the radial styloid process (reference point [RP] 2) to the EPL tendon center were evaluated. In a second study series, the angle at which the EPL tendon wraps around Lister's tubercle and courses across the extensor carpi radialis longus and brevis (ECRL and ECRB) was recorded and defined in all functional positions. In the third study series, the slippage of the EPL tendon was determined.

### *Results:*

Range of movement: For the wrist in extension and thumb in opposition, the value for RP 1 was 19.62 mm and for RP 2 20.55 mm. With the wrist in flexion and

thumb in extension, the mean distances to RP 1 and 2 were 15.14 mm and 10.55 mm, respectively. For the wrist in flexion and thumb in opposition, the values were 13.79 mm (RP 1) and 10.33 mm (RP 2). The values for the wrist in radialduction and thumb in extension were 15.90 mm for RP 1 and 14.94 mm for RP 2. For the wrist in ulnar induction and thumb in adduction the values were 14.64 mm for RP 1 and 17.12 mm for RP 2.

Angle around Lister's tubercle: The largest possible angle was achieved for the wrist in extension and thumb in abduction (mean:  $46^{\circ}$ ) and the wrist in radialduction and thumb in abduction ( $55^{\circ}$ ). The smallest possible angle was achieved with the wrist in ulnaruction and thumb in adduction ( $13.5^{\circ}$ ) and the wrist in ulnaruction and thumb in opposition ( $14^{\circ}$ ).

Tendon gliding: The value for the wrist in neutral position and thumb in opposition showed a distal tendon movement of 10.41 mm. The value for the wrist in extension and thumb in opposition showed a mean of 10.64 mm. For the wrist in radialduction and thumb in opposition the mean value was 10.41 mm. With the wrist in flexion and thumb in extension, the mean was -6.34 mm and for the wrist in ulnaruction and thumb in extension the mean value was -7.71 mm (negative values represent tendon gliding in a proximal direction).

### *Conclusion:*

In summary, knowledge of the anatomical course of the extensor pollicis longus tendon and the possible extent of movement and resulting change in position is therefore an essential basis during diagnostics and surgical treatment of patients with complaints/injuries in the dorsoradial wrist region.

## Introduction

The extensor tendons of the radiocarpal region are important landmarks during various surgical procedures. The course of the extensor pollicis longus tendon, which runs around the Lister tubercle in a radial-distal direction, plays a special role.

While the tendons of the other forearm muscles show an almost straight course along the forearm to distal, the long thumb extensor tendon bends at an angle of 30-40° from the median to radial-distal and hereby crosses the underlying tendons of the extensor carpi radialis longus and brevis.<sup>1</sup>

A further interesting fact is that the position to adjacent structures and bony landmarks changes during the different functional positions of the hand (wrist and thumb ray). This is of great importance during clinical and imaging diagnostics of chronic complaints of the radiocarpal region as well as during surgical treatments.

Knowledge of the anatomy and the course of the tendon is clinically important in assessing the possible proximity and positional relationship to inserted implants. Extensor pollicis longus rupture is a known complication after distal radius fractures.<sup>2</sup> The treatment (conservative, surgical) of distal radius fractures can also lead to percutaneous rupture of the extensor pollicis longus tendon<sup>3</sup> (e.g. insertion of Kirschner wires during the treatment of radius fractures or carpal injuries, intramedullary marrow wiring of forearm fractures in children [here the implant entry point is initially located near the Lister tubercle], irritation of tendons in dorsally protruding implants after treatment of radius fractures via a volar approach). Furthermore, tendon rupture is a clinical consequence of rheumatoid arthritis. With approximately 6 %, rupture of the EPL tendon is rare but clinically important.<sup>4</sup> Surgical reconstruction is performed using extensor indicis proprius transfer.<sup>5</sup>

Standard dorsal, dorsoradial and volar approaches are used for the surgical treatment of fractures of the distal radius.<sup>6</sup> Simple or combined accesses are used depending on the type of the fracture, the planned surgical procedure and the osteosynthesis material.

As the palpable Lister and the course of the tendon across the radiocarpal joint, with adjacent palpable soft spot, represent surgical landmarks during joint puncture, wrist arthroscopy and surgical accesses to the distal radius and carpus, possible anatomical variations and changes in the position of the tendon due to different functional positions of the radiocarpal joint and the thumb are relevant for daily clinical practice.<sup>7,8</sup>

Furthermore, the course of the tendon in relation to bony landmarks in sectional imaging is important. In addition, during surgical wound treatment with suspected injury to nerves and tendons, the functional position of the hand at the time of the accident must always be taken into account and surgical exploration must pay attention to this.

The aim of the following anatomical study was to evaluate the course of the extensor pollicis longus tendon, its positional relationship to adjacent structures, taking into account various functional positions and the resulting clinical relevance.

## I. Anatomical background

### ***1.1 Bony landmarks of the wrist***

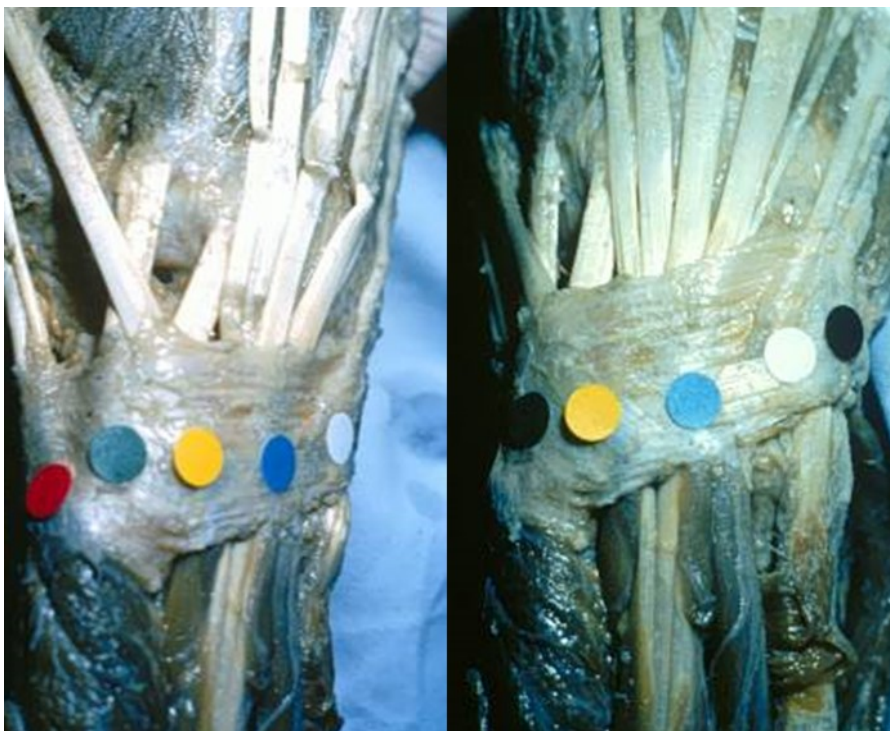
The bony landmarks are usually localizable by palpation. They are the radial styloid process, which is the most lateral and distal extension of the radius, the ulnar styloid process, the most medial and distal extension of the ulna and Lister's tubercle, which is a prominent cusp separating the tendons of the extensor carpi radialis brevis and the extensor pollicis longus. In addition, the dorsal base of the second metacarpal bone and the pisiform bone are of interest. Furthermore, the tubercle of the scaphoid, which is particularly palpable during radialduction, represents one of these landmarks.<sup>9</sup>

### ***1.2 Extensor retinaculum***

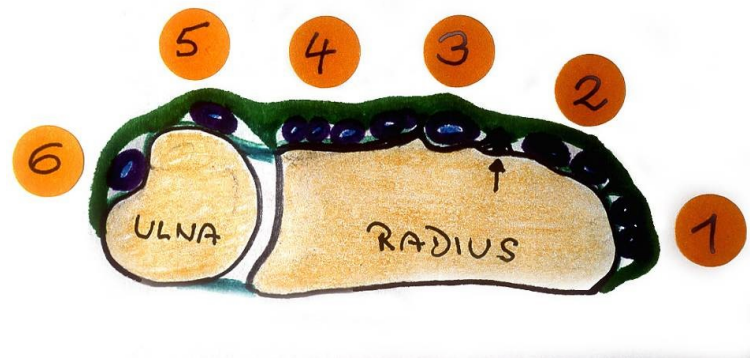
This is a diagonally running, approximately 1.5 cm wide, fibrous band (Fig. 1), from which rough septa are drawn into the depth. It is divided into the six extensor tendon compartments (Fig. 2). It consists of two fiber reins, which course from the radial edge of the distal radius epiphysis to the opposite side, fetter the tendon sheath of the extensor carpi ulnaris to the ulna and extend distally from the ulnar styloid process around the medial edge of the carpus to the pisiform bone. The extensor retinaculum restrains the tendons and guides them in the correct position across the wrist.<sup>2</sup>



**Fig. 1** Anatomical dissection of the distal radius from the dorsal side with numbered representation of the six extensor tendon compartments



**Fig. 2** Anatomical dissection of the distal radius from the dorsal side showing the extensor retinaculum and the six extensor tendon compartments



**Fig. 3** Anatomical cross-section of the distal radioulnar joint showing the tendons of the individual extensor tendon compartments

### ***1.3 Muscles***

#### **1.3.1 Extensor pollicis longus muscle**

It originates proximally from the dorsal surface of the ulna and from the interosseous membrane of the forearm. Its tendon courses alone through the third compartment beneath the extensor retinaculum. It merges with the tendon of the extensor pollicis brevis muscle and is attached to the base of the distal phalanx of the thumb. <sup>9</sup>



**Fig. 4** Course of the EPL muscle

### **I.3.2 Extensor pollicis brevis muscle**

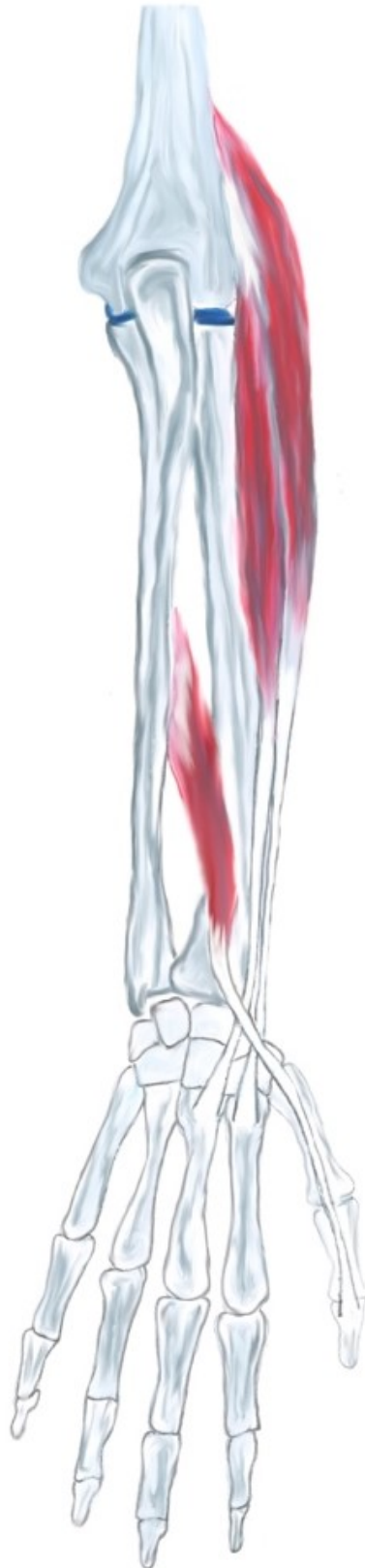
This muscle originates more distally from the posterior surface of the radius and from the interosseous membrane. Together with the abductor pollicis longus muscle, its tendon courses through the first compartment beneath the extensor retinaculum and attaches to the base of the proximal phalanx of the thumb by fusing with the tendon of the long thumb extensor.<sup>9</sup>

### **I.3.3 Extensor carpi radialis longus muscle**

It originates covered by the brachioradialis muscle, from the radial edge of the humerus and from the lateral intermuscular septum of the upper arm down to the radial humeral epicondyle. Together with the extensor carpi radialis brevis, its tendon runs through the second compartment of the extensor retinaculum and attaches to the base of the second metacarpal bone.<sup>9</sup>

### **I.3.4 Extensor carpi radialis brevis muscle**

It originates from the radial humeral epicondyle, from the annular ligament of the radius and from the collateral radial ligament. The muscle courses together with the extensor carpi radialis longus through the second compartment of the extensor retinaculum and attaches to the base of the third metacarpal bone.<sup>9</sup>



**Fig. 5** Course of the EPL muscle superficial to the extensor carpi radialis longus and brevis

## **I.4 Nerves**

### **I.4.1 Superficial branch of the radial nerve**

The radial nerve divides into a superficial (sensory) and a deep (motor) branch at the height of the humeroradial joint space. The superficial branch courses underneath the brachioradialis muscle along the forearm and to the dorsal side of the hand at the distal third of the radius.<sup>3</sup>



**Fig. 6** Anatomical dissection showing the course of the superficial branch of the radial nerve

As a sensory terminal branch, the superficial branch of the radial nerve (Fig. 6) must be spared during subcutaneous dissection of the approaches.

## ***1.5 Joints***

### **1.5.1 Distal radioulnar joint**

It is a pivot joint and formed by the distal ends of the radius, the ulna and the articular surface of the ulnocarpal disc. The flaccid joint capsule attaches to the cartilaginous edges and the articular disc forming a recess fold (sacciform recess) proximally between the radius and the ulna.<sup>9</sup>

### **1.5.2 Radiocarpal joint**

It is an ellipsoid articulation. On the lateral side, the radiocarpal joint is built by the scaphoid bone, the radius and the lunate bone. On the medial side, it is formed by the lunate bone, the triquetrum bone and the ulnocarpal disc.<sup>9</sup>

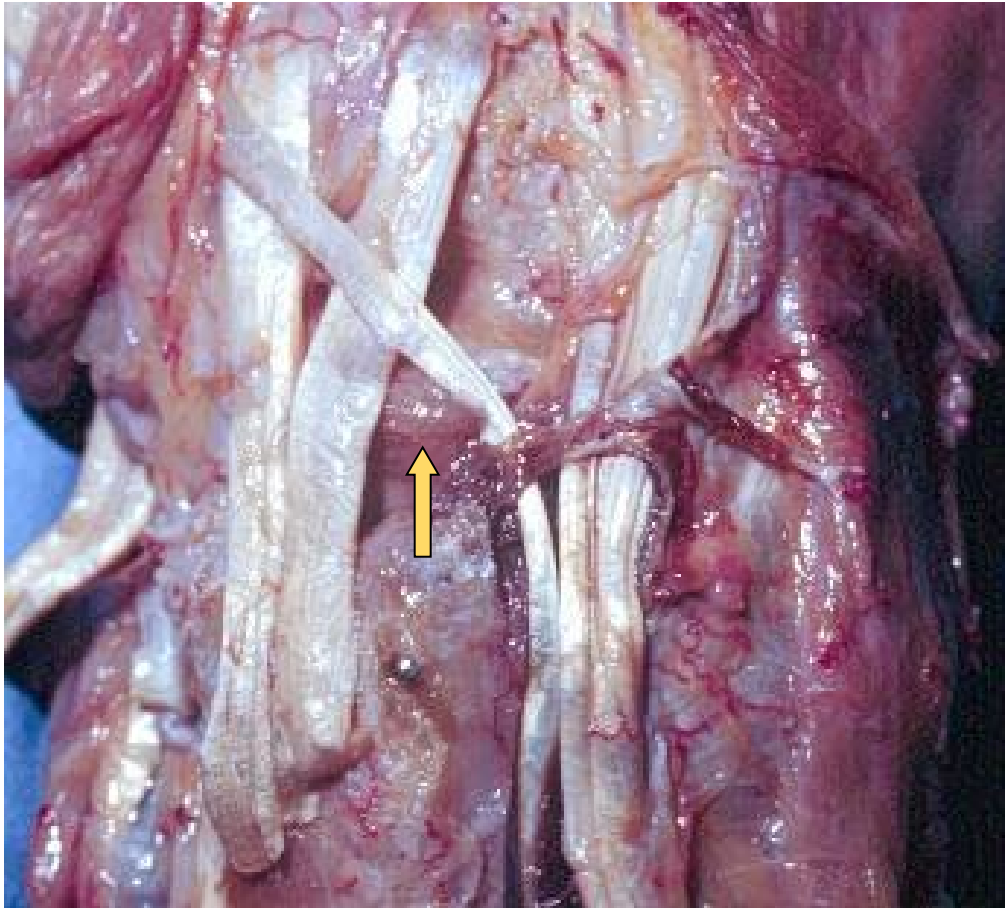
### **1.5.3 Midcarpal joint**

The joint lies between the proximal carpal bones (scaphoid, lunate, triquetrum) and the distal carpal bones (hamate, capitate, trapezium, trapezoid). The ulnar two-thirds show a concave curvature to distal, the radial third has a convex curvature in the distal direction. The joint cavity has numerous lateral recesses that extend between the carpal bones. In many cases, there is a continuous connection to the carpometacarpal joints, often between the trapezium and trapezoid.<sup>9</sup>

## II. Anatomical variations

Rubin et al. describe rare anomalies of the course of the extensor pollicis longus tendon. The most frequent is a group of different tendon duplications that pass the fourth compartment without causing symptoms. The second type includes variations of the course of the EPL that have a clinical significance due to the predisposition of the development of tenosynovitis of the EPL, which imitates other types of tenosynovitis. Clinical symptoms of radial dorsal wrist pain imitating crossover syndrome or de Quervain's disease with the "absent snuff box" sign should raise suspicion of an abnormality in the course of the EPL.<sup>10</sup>

In everyday clinical practice it must be considered that numerous anatomical variations can significantly complicate orientation and dissection. The following figures show some of these possible variations.



**Fig. 7** This anatomical dissection of a right hand from the dorsal side shows an atypical course of the EPL tendon, which does not lie in its usual tendon compartment, but in the fourth compartment. Lister's tubercle is marked by a yellow arrow. The tendon courses with a clear distance from the Lister's tubercle and runs further distally in a radial direction.



**Fig. 8** This variant shows a tendinous connection of the two carpi radialis tendons on the distal forearm.<sup>11</sup>



**Fig. 9** This right hand from dorsal aspect shows a paired attachment of the EPL tendon (two tendons cross the extensor carpi radialis tendons).

### III. Approaches

#### ***III.1 Dorsal access to the distal radius***

During this standard approach, a straight skin incision is made over the distal shaft of the radius to the level of the radiocarpal joint. Subcutaneous veins must be precisely ligated. The incision of the fascia is made between the third and fourth extensor tendon compartments.<sup>12</sup>



**Fig. 10** Standard dorsal access to the distal radius between the 3<sup>rd</sup> and 4<sup>th</sup> tendon compartments.

This is most reliably done by identifying the tendon of the extensor pollicis longus muscle by passively moving the thumb. Distally, the tendon of the extensor pollicis longus muscle bends dorso-radially at an angle of approximately 30-40° around Lister's tubercle and crosses the tendons of the second compartment (Fig. 11).<sup>12</sup>

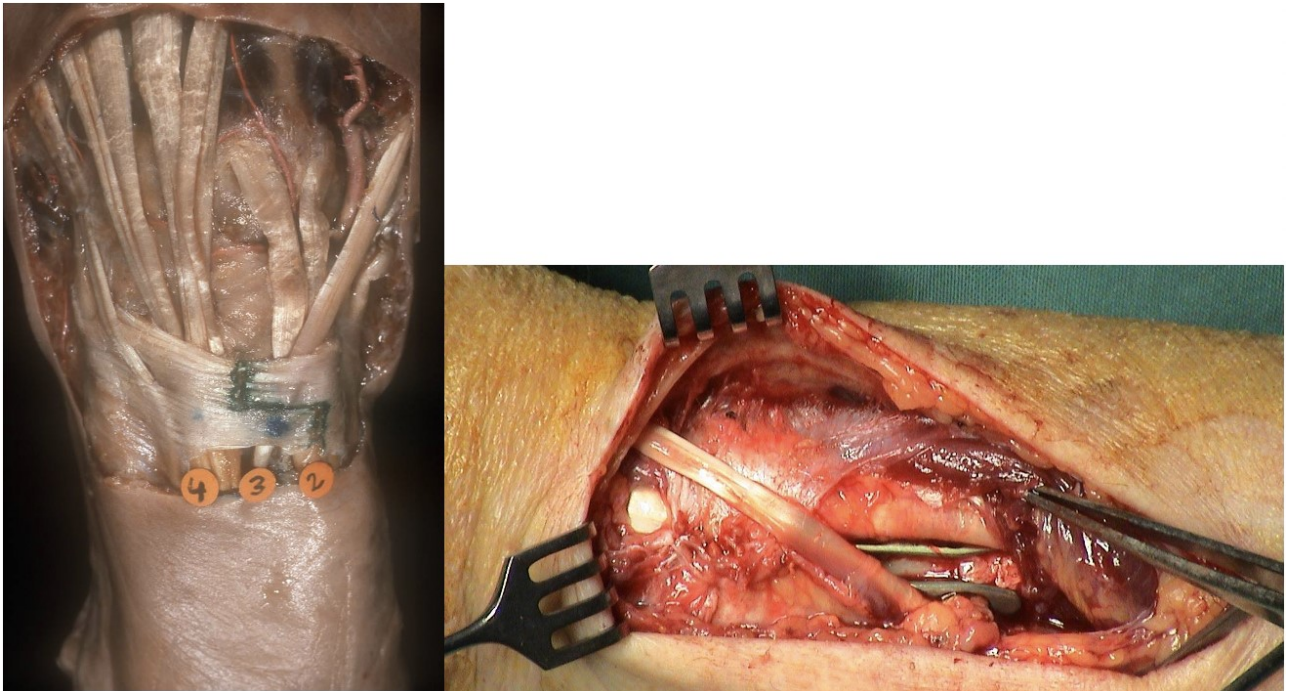


**Fig. 11** Course of the EPL tendon around Lister's tubercle and radial to this landmark

Further dissection is performed up to the periosteum of the radius, whereby the tendon compartments are detached en bloc subperiosteally from the radius on both sides. Ideally, the extensor tendons remain in their tendon compartments and are not exposed during dissection. Only when open reduction and visualization of the radius joint surface is required, the joint capsule is incised in a T-shape. This must be closed at the end of the surgery.<sup>12</sup>

If en bloc mobilization of the tendons is not possible or if there is extensive injury to the tendon sheath of the extensor pollicis longus, a flap from the extensor retinaculum can be sewn between the tendon and the plate at the end of the operation (Fig. 12) to avoid direct contact between the osteosynthesis material and the tendon. Further transposition of the tendon in a radial direction is also possible. Furthermore, the extensor retinaculum can also be incised in a staircase

or Z-shape at the beginning of the dissection to ensure soft tissue protection between the tendon and the plate.<sup>12</sup>



**Fig. 12** Dorsal approach to the distal radius of a left upper extremity. The retinaculum is cut in a staircase fashion so that a retinaculoplasty can be performed between the osteosynthesis material and the extensor pollicis longus tendon at the end of the operation

### ***III.2 Dorso-radial distal access***

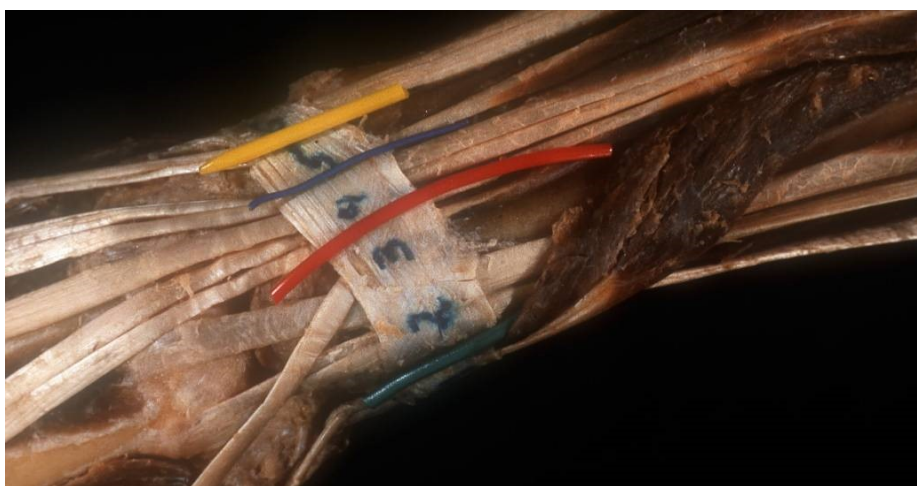
This approach is used especially for corrective surgeries with necessary radial additive correction. The skin incision is made dorso-radially, whereby the superficial branch of the radial nerve, which passes through the fascia at the volar edge of the brachioradialis muscle in a dorso-radial direction, must be spared. To ensure that the dissection is performed along the nerve division sites, the nerve is always dissected from proximal to distal. This allows injury to its branches to be largely avoided. Anatomical studies have demonstrated considerable variability of 3-10 branches of this nerve at the distal radius. Among these, the most dorsal branch was on average 2.5 cm and the most volar branch at a mean of 0.65 cm proximal to the radial styloid process. In 80% of all cases, one branch courses

above the styloid process. Furthermore, dissection proceeds between the first and second tendon compartments, whereby the attachment of the tendon of the brachioradialis muscle is exposed in depth. In the case of prolonged, significant radial malposition, this tendon must be extended in a Z-shape or incised.

If further dissection distal to the radial styloid process is required, the radial artery must be spared in the Tabatière anatomique.<sup>12</sup>

### ***III.3 Special dorsal accesses to the distal radius***

For limited exposure of an ulnar key fragment, access between the fourth and fifth tendon compartments is recommended. As described above, the tendon compartments are detached subperiosteally from the bone (Fig. 13). To visualize the distal radioulnar joint, access is gained between the fifth and sixth tendon compartments, always mobilizing the extensor digiti minimi tendon and sparing the extensor carpi ulnaris tendon as a stabilizer and component of the triangular fibrocartilage complex. The joint is opened in a T-shape to the sacciform recess. If extensive exposure of the articular disc is required, an incision is made opening of the ulnocarpal joint distal to the articular disc.<sup>12</sup>



**Fig. 13** Anatomical specimen showing a right wrist from the dorsal side. Red marks the standard access to the distal radius, blue the access to an ulnar key fragment and yellow the access to the distal radioulnar joint between the individual extensor tendon compartments.

### ***III.4 Access expansion***

Proximally, the approach can be extended into the Thompson approach. Distally, the accesses can be extended as desired to the carpus and the dorsum of the hand.<sup>11</sup>

The insertion of Schanz screws to the distal radius during external fixation is also performed via a sufficient skin incision while protecting the anatomical structures. Avoidance of fixation of local soft tissues is essential. During drilling as well as during insertion of the Schanz screws, the use of a drill sleeve is obligatory, which specifies the drilling direction, facilitates locating the drill hole with the Schanz screw and avoids soft tissue damage.<sup>12</sup>

#### IV. Rupture of the extensor pollicis longus tendon

In most cases of direct injury to the long extensor tendon of the thumb in the context of cuts, open fractures or soft tissue injuries, direct tendon suturing with functional follow-up treatment is possible.

However, rupture of the long extensor tendon often occurs as a result of degenerative changes, for example in the context of rheumatic diseases, wrist synovitis or also typically as a result of a distal radius fracture (Fig. 14). Furthermore, a late rupture of the long extensor tendon of the thumb in the wrist area is also possible in the case of a wrist contusion.



**Fig. 14** X-ray of a typical fracture of the distal radius with dorsal displacement

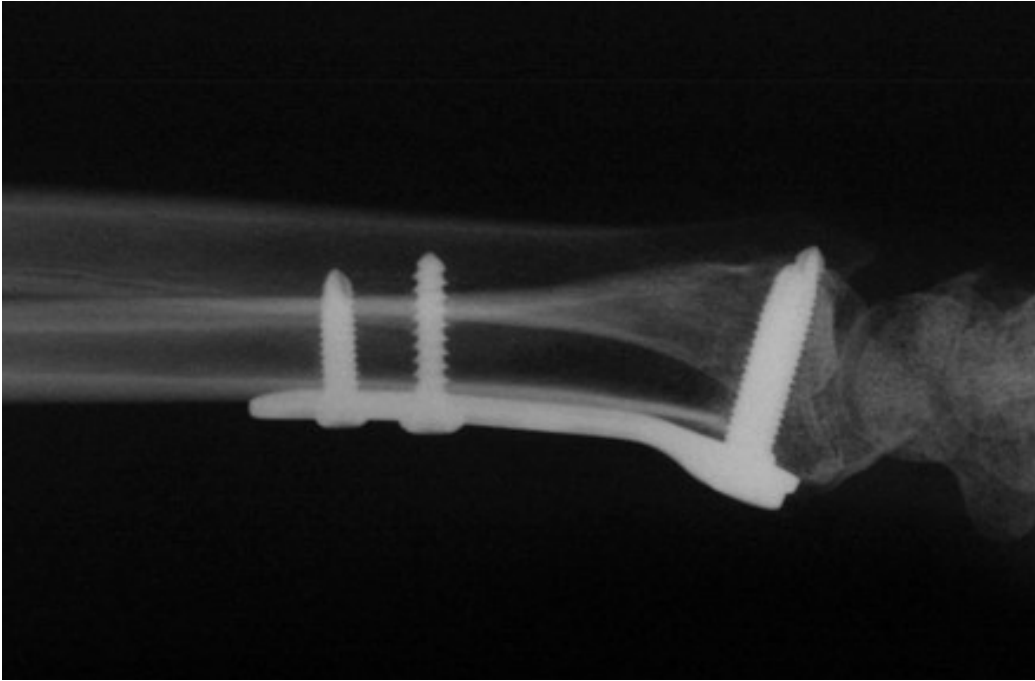
Secondary ruptures can occur during conservative and surgical therapy of distal radius fractures. In addition to local injuries (haematoma, contusion, callus

formation), a local circulatory disturbance in the tendon sheath can also lead to rupture.

Moreover, injuries to the tendon can occur due to local irritation through horizontal implants (dorsal plates, Kirschner wires) or also due to protruding screws of plates inserted from the volar side (Figs. 15-18).



**Fig. 15** This X-ray shows the treatment of a distal radius fracture via angular stable volar plate osteosynthesis



**Fig. 16** X-ray documenting a dorsally protruding screw inserted from volar-ulnar to Lister's tubercle



**Fig. 17** This X-ray documents a dorsally protruding screw ulnar to Lister's tubercle



**Fig. 18** Dorsally protruding screw tip after treatment of a radius fracture via volar angular stable plate osteosynthesis

Naito et al. described tendon floor fibrillation in 52% and tendon laceration in 36% of all cases, in their study of 25 distal radius fractures with dorsal roof fragments.<sup>13</sup>

Sato and colleagues evaluated the incidence of EPL tendon rupture after plate osteosynthesis of the radius in a literature survey. EPL rupture was reported in 1.8% of all cases (2/114) in Arora et al. (2007), in 1.9% (7/335) in Casaletto et al. (2009) and in 0.3% (2/665) of all cases in Esenwein and colleagues (2013).<sup>14</sup>

## V. Surgical treatment of extensor pollicis longus tendon rupture

Following degenerative rupture of the EPL tendon, the proximal stump is often retracted far proximally, therefore the restoration of the tendon by primary suture is not possible. In those cases, the restoration is done by repositioning the tendon of the extensor indicis muscle.

The distal stump of the EPL tendon is exposed through a skin incision, sparing the superficial branch of the radial nerve. The extensor indicis tendon, which lies ulnar to the extensor digitorum tendon, is then exposed via a small incision ulnar to the metacarpophalangeal joint of the index and obliquely detached. The local stump is then sutured. The tendon is now mobilized and pulled radially, sparing the soft tissues, and sutured with the thumb tendon stump. The tendon is pulled radially beneath the vessels and nerves (Figs. 19, 20).<sup>15</sup>



**Fig. 19** Exposure of the distal stump of the EPL and preparation for subsequent Pulvertaft suture



**Fig. 20** This image shows the tendon of the extensor indicis muscle after mobilization to radial

Most important is the correct tension of the tendon stumps while they are sutured. When the thumb is fully extended, the thumb extensor tendon must be under full tension. Probatory clinical testing of the range of motion during passive extension and flexion of the wrist is performed. At maximum flexion, the thumb must be in the extended position, at maximum extension, it must be in slight flexion.

Post-operative patients undergo immobilization using splint bandage for 4 weeks.

## VI. Wrist arthroscopy

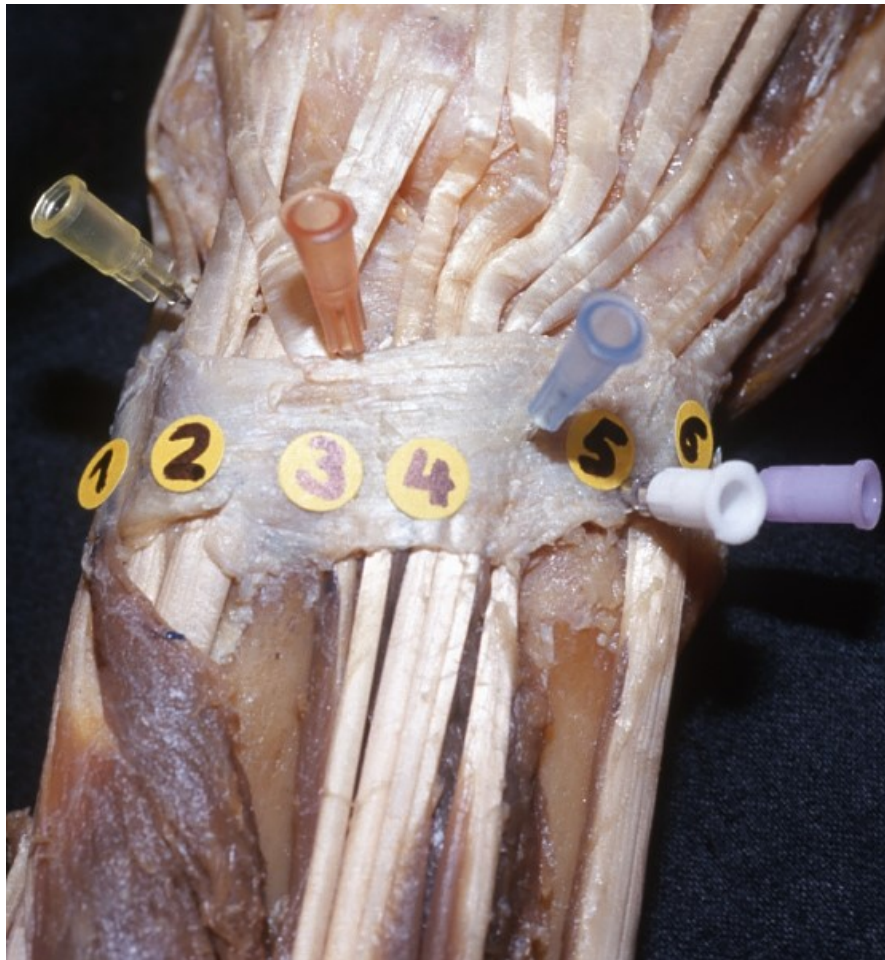
Wrist arthroscopy is performed from the dorsal side, whereby the orientation of the approaches is based on the extensor tendon compartments.

In principle, a distinction is made between arthroscopy of the radiocarpal joint, the midcarpal joint, and the distal radioulnar joint, which are anatomically separate compartments (Fig. 21). The radial styloid process and the tendon of the extensor pollicis longus muscle (third compartment) serve as orientation for the portals.<sup>16</sup>



**Fig. 21** Depiction of the distal radioulnar joint (orange), the radiocarpal joint (blue) and the midcarpal joint (pink)

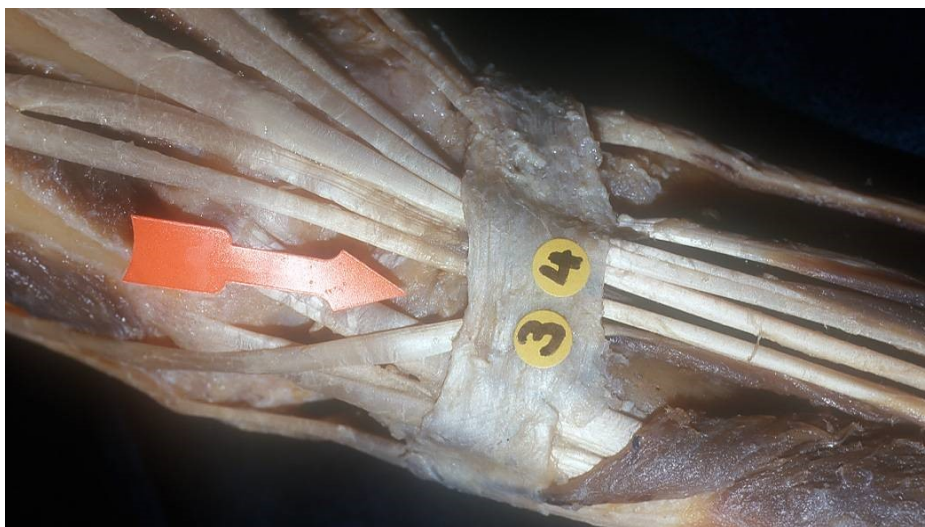
The arthroscope is inserted via portal III/IV, which means between the third and fourth tendon sheath compartments, and instrument access is performed through portal VI/R (radial to the sixth tendon sheath compartment), see Fig. 22.



**Fig. 22** Anatomy of standard approaches to wrist arthroscopy between the individual extensor tendon compartments

The portal III/IV is considered as the standard approach. There is a well-palpable "soft spot" between the tendons of the extensor pollicis longus muscle and the extensor digitorum communis muscle. Furthermore, after incision of the skin, blunt spreading of the tissue is performed longitudinally (parallel to the tendons), followed by perforation of the joint capsule. With the blunt trocar (puncture instrument), still without the arthroscopy shaft, the joint is opened under slight pressure and the portal is dilated by means of light circular movements. The arthroscopy shaft is then inserted with the blunt trocar in position and the pump for

irrigation connected. This portal is located in the area of the scapholunate joint.<sup>16</sup>  
(Fig. 23)

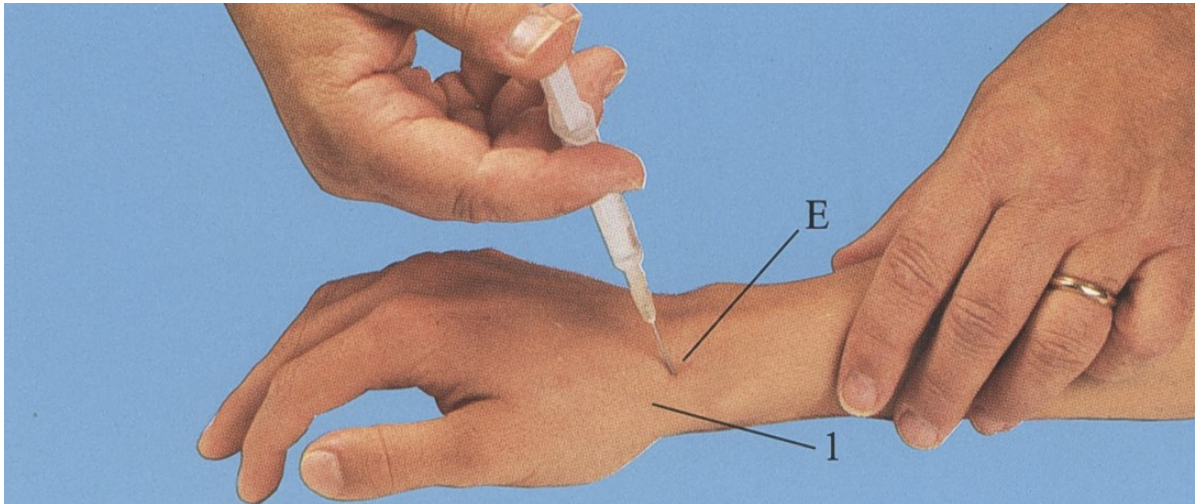


**Fig. 23** Between the tendons, the so-called soft spot is visible, through which the access point to the joint can be easily palpated from the dorsal side



**Fig. 24** After removal of the capsule, the space of the so-called soft spot between the tendon compartments 3 and 4 is revealed

Puncture of the wrist (diagnostic puncture or for application of medication) is also performed from dorsally between the extensor tendon compartments.



**Fig. 25** Puncture of the radiocarpal joint from the dorsal side via the standard approach

Also, during local infiltration treatments, for example in chronic tendinopathy, inflammation in the area of the tendon compartments, joint diseases (thumb saddle joint, scaphotrapezotrapezoid joint or radiocarpal joint) or during infiltrations of the periosteum (radial styloid process), radiocarpal orientation is carried out using the extensor tendon compartments and bony landmarks. Here, the course of the extensor pollicis longus tendon is also an essential help for orientation.

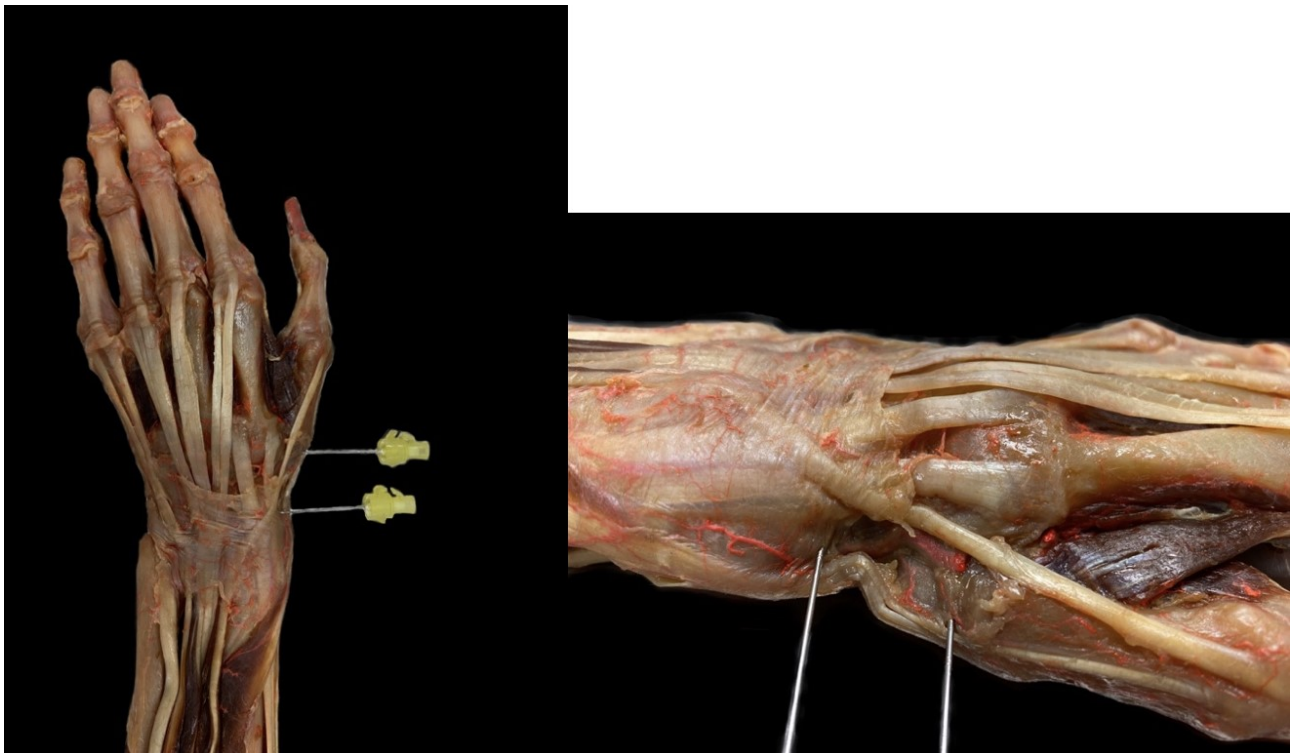
The course of the extensor pollicis longus tendon and the soft tissue window between the third and fourth tendon compartments are also essential in the percutaneous treatment of scaphoid fractures, which is performed from the dorsal approach, especially in cases of smaller proximal pole fragments.<sup>17</sup>

## VII. Material and Methods

Twenty upper extremities from ten adult human cadavers embalmed with Thiel's method were used for this study.<sup>18</sup> Cadavers with macroscopically obvious pathologies of the upper limb were not included. Body donors had given their written informed consent to participate in anatomical studies during their lifetime.

After removal of the skin, subcutis and forearm fascia, the respective muscles were carefully examined. Furthermore, the courses of the tendons were dissected and care was taken to avoid manipulation of the extensor retinaculum.

In a first study series, the functional positions which lead to the greatest possible extension of movement of the tendons were defined. The distance between the center of the first carpometacarpal joint (reference point [RP] 1) and the center of the EPL tendon and the interval between the tip of the radial styloid process (reference point [RP] 2) to the EPL tendon center were evaluated (Fig. 26).



**Fig. 26** In this figure cannulas illustrate the reference points 1 and 2

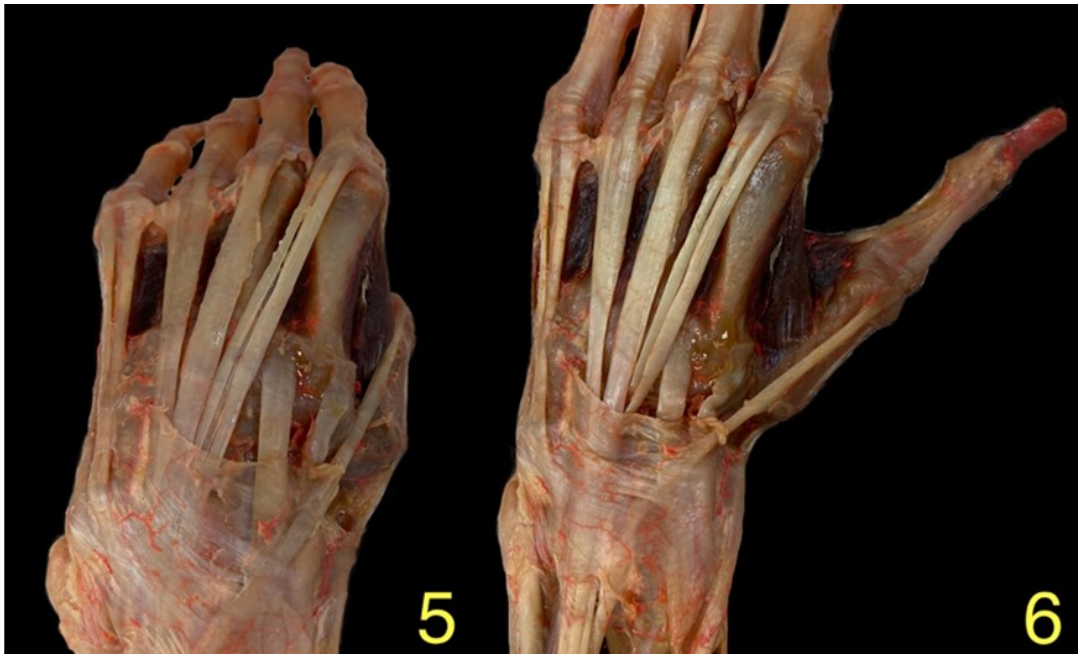
Subsequent functional positions of wrist joint and the thumb ray were evaluated:



**Fig. 27** 1 - Wrist in neutral position, thumb in extension, 2 - Wrist in extension, thumb in extension



**Fig. 28** 3 - Wrist in extension, thumb in opposition 4 - Wrist in flexion, thumb in extension



**Fig. 29** 5 - Wrist in flexion, thumb in opposition, 6 - Wrist in radial deviation, thumb in extension



**Fig. 30** 7 - Wrist in ulnar deviation, thumb in adduction

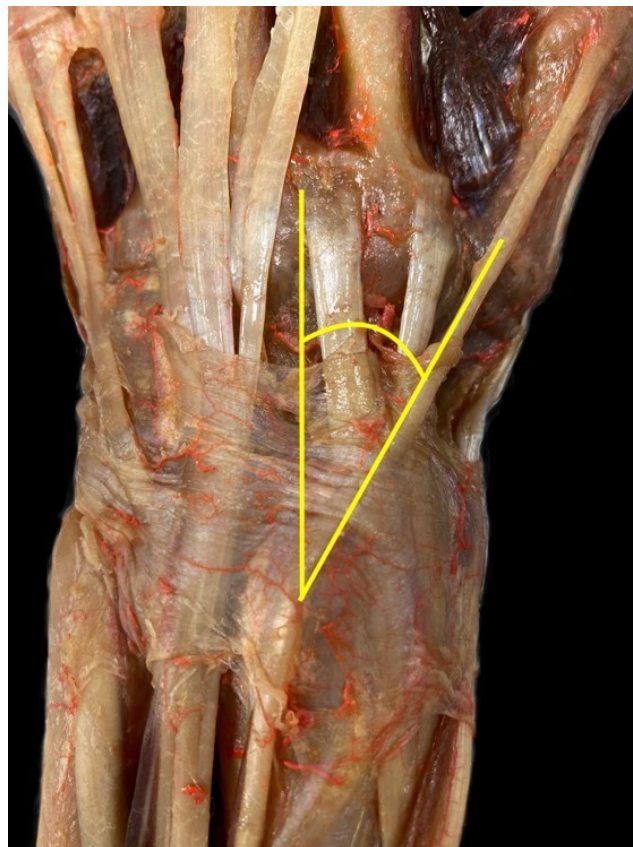
The angle at which the EPL tendon wraps around Lister's tubercle and courses across the extensor carpi radialis longus and brevis (ECRL and ECRB) was also recorded with an angle measurement and evaluated in all functional positions. In this series, the functional positions that lead to the greatest possible and smallest possible extent of movement of the tendon across the ECRL and ECRB were defined:

Maximum angle:

- Wrist in extension, thumb in abduction
- Wrist in radialduction, thumb in abduction

Minimum angle:

- Wrist in ulnaruction, thumb in abduction
- Wrist in ulnaruction, thumb in opposition



**Fig. 31** Depiction of the angle at which the EPL tendon wraps around the Lister tuberosity

During the course of this work, tendon slippage was also determined. As reference points, the portion of the EPL tendon distal to the extensor retinaculum was marked with a cannula and further measured in all functional positions with reference to the most prominent point of the Lister tubercle.

The greatest movement of the EPL tendon from the tubercle of Lister in a distal direction was documented in the following functional positions:

- Wrist in neutral position, thumb in opposition
- Wrist in extension, thumb in opposition
- Wrist in radialduction, thumb in opposition

The maximum movement of the EPL tendon to the tubercle of Lister in a proximal direction was documented in the following functional positions:

- Wrist in flexion, thumb in extension
- Wrist in ulnaruction, thumb in extension

## VIII. Results:

### ***VIII.1 Range of movement***

The range of movement of the thumb ray with the wrist in neutral position and the thumb in extension averaged 15.80 mm from RP 1 and 14.40 mm from RP 2. The results for the wrist and thumb in extension position were 19.76 mm for RP 1 and 21.23 mm for RP 2.

For the wrist in extension and thumb in opposition the values for RP 1 were 19.62 mm and for RP 2 20.55 mm. The means for the wrist in flexion and the thumb in extension were 15.14 mm (RP 1) and 10.55 mm (RP 2). For the wrist in flexion and the thumb in opposition, the average values were 13.79 mm (RP 1) and 10.33 (RP 2). The values for wrist in radial induction and thumb in extension were 15.90 mm for RP 1 and 14.94 mm for RP 2.

For the wrist in ulnar duction and thumb in adduction the values for RP 1 were 14.64 mm and for RP 2 17.12 mm.

<b>Wristposition - Thumbposition</b>	<b>Referencepoint 1</b>	<b>Referencepoint 2</b>
Extension - Extension	19.76 mm	21.23 mm
Extension - Opposition	19.62 mm	20.55 mm
Radial - Extension	15.94 mm	14.90 mm
Neutral - Extension	15.80 mm	14.40 mm
Flexion - Extension	15.14 mm	10.55 mm
Ulnar - Adduction	14.64 mm	17.12 mm
Flexion - Opposition	13.79 mm	10.33 mm

**Table 1** Range of movement

### ***VIII.2 Angle around Lister's tubercle***

The largest possible angle was achieved for the wrist in extension and thumb in abduction (mean: 46°) and the wrist in radialduction and thumb in abduction position (55°).

The smallest possible angle was achieved for the wrist in ulnaruction and thumb in adduction position (13.5°) and the wrist in ulnaruction and thumb in opposition (14°).

<b>Wristposition - Thumbposition</b>	<b>Angle around Lister's tubercle</b>
Radialduction - Abduction	55°
Extension - Abduction	46°
Ulnaruction - Opposition	14°
Ulnaruction - Adduction	13.5°

**Table 2** Angle around Lister's tubercle

### ***VIII.3 Tendon gliding***

The values for the wrist in neutral position combined with thumb in opposition showed a distal tendon movement of 10.41 mm. The values for the wrist in extension and thumb in opposition showed a mean of 10.64 mm and for the wrist in radialduction and thumb in opposition the mean value was 10.41 mm.

The values for the wrist in flexion and thumb in extension were -6.34 mm and for wrist in ulnaruction and thumb in extension the mean value was -7.71 mm (negative values represent tendon movement in a proximal direction).

<b>Wristposition - Thumbposition</b>	<b>Tendon gliding</b>
Extension – Opposition	10.64 mm
Neutral – Opposition	10.41 mm
Radialduction – Opposition	10.41 mm
Flexion – Extension	-6.34 mm
Ulnarduction - Extension	-7.71 mm

**Table 3** Tendon gliding

## IX. Discussion

As surgeries are increasingly performed using minimally invasive techniques, reduction maneuvers are performed via small incisions, fragments are fixed, arthroscopically assisted techniques are used, and implants are inserted. Therefore, knowledge of the topographic anatomy and, in particular, the possible variants is even more important.<sup>19</sup>

Due to the large functional range of the thumb ray in combination with the functional position of the wrist, there is a large range of variation and movement of the thumb extensor tendon regarding its radiocarpal position.

The localization of this tendon in diagnostic imaging (MRI, ultrasound) in relation to bony landmarks and the radiocarpal joint space is therefore highly variable. In case of injuries in this area, the visible wound (skin injury) and a possible underlying tendon injury may be far apart and therefore, knowledge of the precise course of the EPL and its variations is essential.

During movement of the hand in the sagittal plane (flexion and extension), it should be noted that the tendon moves out of the frontal plane with reference to the wrist. It should also be mentioned that when the muscle is contracted (active muscle tension), the tendon protrudes from the metacarpal bone, while in the wrist region the tendons are fixed in the tendon compartments by the extensor retinaculum.

During surgical treatment of a symptomatic chronic rupture of the EPL tendon, knowledge of the anatomical course is also a basis for treatment. The treatment is carried out by means of a so-called extensor indicis transfer, during which the thumb extensor tendon is replaced by a part of the extensor indicis proprius tendon.<sup>20</sup>

Similarly, in the case of chronic complaints (pain, tendon crepitation) following osteosyntheses, the positional relationship to the extensor pollicis longus tendon must be evaluated in relation to relevant functional positions (activities of daily living).

For example, the end of a protruding intramedullary wire (these wires are inserted either in the area of the tuberculum Lister or radially in the area of the styloid and are then capped above bone level so that subsequent removal is possible) can be inserted in a neutral position at a clear distance from the tendon, but in certain functional positions contact between the tendon and the wire can still occur with the possibility of subsequent tendopathy.<sup>21</sup>

## X. Conclusion

In summary, knowledge of the anatomical course of the extensor pollicis longus tendon and the possible extent of movement and resulting change in position is an essential basis during diagnostics and surgical treatment of patients with complaints/injuries in the dorsoradial wrist region.

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