An anatomic guide for arthroscopic visualization of the wrist capsular ligaments

Wrist arthroscopy allows examination of the palmar capsular wrist ligaments without extensive exposure. Arthroscopic examination of the wrist requires an accurate knowledge of the ligamentous anatomy as seen from inside the joint. In this study 13 fresh cadaver wrists were examined from the inside out to provide a visual guide for ligament identification during arthroscopy. The major palmar capsular ligaments seen from the inside of the wrist at the radiocarpal joint include the radioscaphoid, radioscapoholunate, radiolunate, radioscapoholunatulnate, ulnolunate, ulnotriquetral ligaments, and the ulnar capsule. At the midcarpal joint, the scaphocapitate, radioscapoholunate, triquetrococapitate, and triquetrohamate ligaments are identified palmarly. Dorsally, constant capsular structures at the radiocarpal joint are the radiolunate and radioulnocapitular ligaments along with a prominent synovial fold. (J HAND SURG 1988;13A:815-22.)

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Carpal instability syndromes are generally described in terms of abnormal carpal movement. An exception was seen in 1972 when Linscheid et al. described two collapse patterns in the wrist and related these to specific interosseous ligament disruptions. Kaplan alluded to the difficulty in delineating the capsular ligaments of the wrist with anatomic dissection. Mayfield, Johnson, and Kilcoyne showed the importance of the palmar capsular wrist ligaments in stabilizing the carpus. Wrist-imaging techniques have provided limited information regarding the capsular ligaments. At operation the palmar capsular ligaments are poorly visualized through a dorsal approach because distraction sufficient to see around the carpal bones is rarely achieved, and a palmar surgical approach does not allow clear delineation of the capsular ligaments either. Although arthograms, bone scans, x-ray films, and motion studies are important in the diagnosis of the unstable and painful wrist, arthroscopy can provide additional information for our understanding of these wrists.

The arthroscope allows direct examination of the capsular ligaments with minimal disruption. Arthroscopy of the wrist has been used to evaluate tears of the scapholunate and lunotriquetral interosseous ligaments, as well as the triangular fibrocartilage complex. It can also be used to see the capsular ligaments and identify wrist ligament injuries. The goal of this study is to provide a panoramic view of the inside anatomy of the wrist, a road map for capsular ligament identification during arthroscopy.

Materials and methods

Thirteen fresh, skeletally mature, cadaver wrists were frozen. The wrists were thawed before dissection and examination was completed within 2 hours. Dissection was performed sharply, opening sufficient capsule to allow visualization of the remaining capsular structures. The capsule to be examined was not dissected further but was photographed and a diagram was made of it in its natural state to display, unaltered, what would be seen through the arthroscope. An osteotome was used to remove portions of the capitate and hamate to allow inspection of the ligament insertion sites in three wrists, and the scaphoid was entirely removed in two specimens.

Stresses were applied to these dissected wrists, placing tension across the ligaments to make them stand out better for illustrative purposes and to demonstrate their roles in wrist stability. This distraction simulated the distraction that occurs during arthroscopy so that the relationship of the ligaments in the photos and at arthroscopy is similar. Ligament disruptions noted in
Fig. 1. The palmar capsule of the radiocarpal and midcarpal joints as viewed from a dorsal approach. From radial to ulnar at the radiocarpal joint is the radioscaphoid ligament (RS), the radioscaphocapitate ligament (RSC), the radiolunate ligament (RL), the radioscapholunate ligament (RSL), the ulnolunate ligament (UL), the ulnotriquetral ligament (UT), and the ulnar capsule (UC). From radial to ulnar at the midcarpal joint is the scaphocapitate ligament (SC), the radioscaphocapitate ligament (RSC), the triquetrocapitate ligament (TC), and the triquetrohamate ligament (TH). The scapholunate (SL) and lunotriquetral (LT) interosseous ligaments are also seen.

Fig. 2. The radial capsule as seen from an ulnar approach with the joint hinged open on the radial capsule. The radius (R), scaphoid (S), and lunate (L) can be seen along with the radioscaphoid ligament (RS), and the dorsal capsule (DC).

The primary purpose of each dissection was to define the ligaments that could be seen from the inside of the joint. Ligament attachments, thickness, and relationships to joint capsule and adjacent ligaments were noted. The ligament names were chosen to describe anatomically the major proximal attachment followed by the major distal attachment. The exception to this was the radioscaphocapitate ligament where the scaphoid was included because of the importance of this ligament in stabilizing the scaphoid through its sling effect.

Results

Fig. 1 is a graphic representation of the palmar capsule as seen through a dorsal approach. From radially to ulnarly, the palmar radiocarpal ligaments are seen as follows: the radioscaphoid ligament (RS), the radioscaphocapitate ligament (RSC), the radiolunate ligament (RL), the radioscapholunate ligament (RSL), the ulnolunate ligament (UL), the ulnotriquetral ligament (UT), and the ulnar capsule (UC). The palmar midcarpal ligaments identified are the scaphocapitate ligament (SC), the radioscaphocapitate ligament (RSC), the triquetrocapitate ligament (TC), and the triquetrohamate ligament (TH).

The RS ligament has been called the radial collateral ligament.
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Fig. 4. The palmar radial capsule. The radioscaphocapitate (RSC), radiolunate (RL), and radioscapholunate (RSL) ligaments can be clearly seen through the arthroscope. The RSL arises more within the joint, closer to the arthroscope than the other capsular structures. The synovial fold of the RSL marks the SL interosseous ligament superiorly.

Fig. 5. With the scaphoid removed, the course of the radioscaphocapitate (RSC) ligament to its attachment on the palmar waist of the capitate (C), and the course of the radiolunate (RL) ligament to attach to the scapholunate interosseous ligament (probe) on the palmar aspect of the lunate (L) can be seen.

Ligament. It lies palmar to the plane of motion and is not a true collateral ligament. Its proximal attachment runs from the palmar radial tip of the styloid to the tuberosity of the scaphoid and on to the trapezium (Figs. 2 and 3). Only the most proximal portion of this ligament can be seen arthroscopically and even that portion is not always visualized. It is small when compared with the other palmar ligaments.

The RSC ligament arises from the radial styloid, but separate from, the attachment of the radiocapitate ligament (Figs. 1 and 4). It has an oblique course across the waist of the scaphoid where it gives off a small, filmy attachment to the scaphoid and the scapholunate interosseous ligament before crossing the scaphocapitate joint to attach to the waist of the capitate palmarly (Fig. 5). This ligament is substantial in size and distinctly separate from the adjacent ligaments (Fig. 6). A probe can be easily passed between it and the RL ligament. Through the arthroscope this ligament is easily seen and in a very loose wrist can be followed to where it crosses the waist of the scaphoid. The RSC ligament lies transverse to the long axis of the radius, but it is oriented obliquely to the slope of the radial articular surface. This appearance is accentuated by wrist distraction that is used during arthroscopy. In these dissections, this sling ligament for the scaphoid was noted to tighten during pronation against resistance, and appeared to transmit pronatory force from the radius to the carpus.

The RL ligament arises from the palmar edge of the radius just ulnar to the RSC ligament and radial to the intercondylar crista of the radius (Figs. 1, 4 and 5). It has an oblique course from the radius to the scapholunate interosseous ligament palmarly where it attaches...
in part to that ligament (Fig. 6). Its major attachment is to the palmar radial aspect of the lunate. After attaching here, there is a substantial continuation to the triquetrum palmarly to contribute to the palmar portion of the lunotriquetral intersosseous ligament. This ligament has been previously named the radiotriquetral ligament, but because of its major attachments to the lunate, it has been designated here as the RL ligament. It appears as a broad oblique ligament through the arthroscope and the proximal portion can be easily visualized. This ligament became taut with forced dorsal displacement of the scaphoid and lunate on the radius.

The RSL ligament, also known as the ligament of Testut, originates just palmar to the intercondylar crest of the distal radius, and runs distally attaching palmarly to the scapholunate intersosseous ligament, as well as to the scaphoid and lunate on each side of the interosseous ligament (Figs. 1 and 4). When viewed through a dorsal arthroscopic approach, this ligament sits closer to the viewer than the adjacent RL ligament. It is completely separate from the RL ligament, and although it appears substantial through the scope, on direct inspection it is one of the least substantial and most elastic of the palmar wrist ligaments (Fig. 6). The RSL ligament marks the site of the scapholunate intersosseous ligament seen superiorly through the scope.

Ulnar to the RSL ligament the palmar capsule is thin to the ulnar edge of the radius. Here the UL ligament arises from the palmar ulnar-most edge of the distal radius and the palmar edge of the TFC. It sweeps distally to attach to the palmar ulnar half of the lunate and the lunotriquetral intersosseous ligament (Figs. 1 and 7). The UL ligament is substantial on cross section (Fig. 8) and appears to tighten with palmar displacement of the lunate and triquetrum on the TFC.

The UT ligament attaches to the ulnar side of the TFC and sweeps transversely in a palmar direction to gradually assume a vertical position in relationship to the long axis of the ulna. Distally it attaches to the palmar distal aspect of the triquetrum, just proximal to the pisotriquetral articulation, and it also blends substantially with the palmar portion of the lunotriquetral intersosseous ligament (Figs. 1, 7 and 9). As viewed through the arthroscope, the transverse sweep of this ligament is obvious. The UT ligament is not distinctly separated from the UL ligament, and these two ligaments compose an ulnar sling that supports the ulna...
Fig. 9. Just dorsal to the section seen in Fig. 8, a large expanse of ulnotriquetral (UT) ligament can be seen arising from the TFC (lower pointer) and attaching to the palmar inferior surface of the triquetrum (T) (upper pointer). At the midcarpal joint, note the remnant portion of the triquetrohamate ligament.

The ulnar-most structure of the wrist capsule has been termed the ulnar capsule (UC) (Figs. 1, 7, 10, and 11). This structure originates near the base of the ulnar styloid and runs distally to attach to the dorsal and ulnar aspect of the triquetrum. Between this structure and the UT ligament, an opening into the pisotriquetral joint, the pisiform recess, is usually seen (Figs. 7 and 10). Proximally, the UC blends with both the TFC and UT ligament. The UC forms the floor of the extensor carpi ulnaris tendon sheath. This structure, substantial in size, was tight with maximum radial deviation of the wrist. It has been referred to as the ulnar collateral ligament of the wrist.

The midcarpal joint is generally tighter than the radiocarpal joint, and in the absence of injury, admission of the arthroscope far enough to visualize the palmar capsule may be impossible. However, when possible, four ligaments can potentially be seen (Fig. 1). The palmar ligaments between the scaphoid and trapezium cannot be seen. The radial-most ligament visualized is the SC ligament (Fig. 12). This short, taut, and substantial ligament runs from the palmar ulnar portion of the tubercle of the scaphoid to the palmar midcapitate surface. The SC ligament binds the scaphoid and capitate so tightly together that unless it is torn or lax, the arthroscope cannot be inserted far enough to see it. Its size and tautness suggest that it may have a role in stabilization of the distal scaphoid.

The distal portion of the RSC ligament that crosses the midcarpal joint should be visible through the scope (Fig. 1). However, it does not stand out at this location either anatomically or arthroscopically. It appears that with distraction of the wrist, the midcarpal portion of this sling ligament is relaxed and therefore, not distinguishable from the adjacent capsule.

Directly palmar to the lunate is thin palmar capsule that represents the space of Poirier. Ulnar to this space is the TC ligament, a strong structure that originates from the palmar radial half of the triquetrum, and travels obliquely in a radial direction where it forms a sling palmar to the proximal end of the hamate (Figs. 1 and 13). This ligament does not attach to the hamate, but rather proceeds to the waist of the capitate. When the wrist moves from radial to ulnar deviation, the proximal tip of the hamate glides across the TC ligament.
The remaining palmar midcarpal ligament is the TH ligament, which is distinctly separate from the TC ligament (Figs. 1 and 13). It arises from the palmar ulnar side of the triquetrum, adjacent to the TC ligament, and attaches onto the palmar ulnar portion of the waist of the hamate, proximal to the hamate hook. Both the TC and TH ligaments are best seen arthroscopically through an ulnar midcarpal portal.

The dorsal radiocarpal capsular structures and ligaments are illustrated in Fig. 14. These include the dorsal radiolunate ligament (DRL), the constant synovial fold (SYN), the dorsal radioulnotriquetral ligament (DRUT), and the ulnar capsule (UC). Although illustrated, the dorsal intercapsular ligament (DIC) at the midcarpal joint was not described in detail because there is no way to visualize it arthroscopically. Significant distraction of the wrist is necessary to tighten the dorsal capsular ligaments. Even with such distraction they appear relatively insignificant when compared with size of the palmar ligaments. Although the dorsal capsule is not routinely examined arthroscopically, it may be possible to do so. There does not appear to be a dorsal radioscaphoid ligament. The dorsal radiolunate (DRL) ligament attaches proximally on the radius or the dorsal aspect of the scaphoid and lunate fossae, and proceeds obliquely and distally in an ulnar direction to insert into the dorsal portion of the lunotriquetral intersosseous ligament and the distal dorsal aspect of the lunate (Figs. 14 and 15).

Attached to the dorsal ulnar aspect of the lunate and ulnar edge of the radius is a prominent and constant synovial fold (Figs. 14 and 15). This fold often prevents visualization of the dorsal ulnar capsule through a radial portal. When entering the wrist through a dorsal-ulnar portal, this fold blocks the view of the dorsal aspect of the distal radius and lunate.

Ulnar and dorsal to this synovial fold is the dorsal radioulnar-triquetral (DRUT) ligament (Figs. 14 and 15). This arises from the distal ulnar aspect of the radius and the dorsal edge of the TFC to attach to the dorsal aspect of the triquetrum. This ligament forms the dorsal portion of the ulnar sling.

**Pathologic findings**

Both ligament disruptions and cartilage wear were noted in many of these wrists. Seven specimens showed...
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Fig. 14. The dorsal capsular ligaments as viewed through a palmar approach. Adjacent to the radioscaphoid (RS) ligament is a broad expanse of thin dorsal capsule. The radiolunate (DRL) ligament is adjacent to a constant synovial fold (SYN). The dorsal radioulnotriquetral (DRUT) ligament and the ulnar carpal (UC) are represented. The dorsal intercarpal (DIC) ligament is difficult to visualize from within the joint. The scapholunate (SL) and lunotriquetral (LT) interosseous ligaments are also seen.

large tears of the lunotriquetral interosseous ligament and four tears were noted in the TFC. Three tears were seen in the scapholunate interosseous ligaments, and one tear was noted in each of these ligaments: the radiolunate, ulnolunate, and ulnotriquetral.

No wrist had extensive arthritic changes, but most showed focal areas of cartilage wear. These were located as follows: advanced radioscaphoid erosions in three specimens, mild radiolunate chondromalacia in one, moderate chondromalacia between the distal ulna and lunate in two, and significant erosions between the distal end of the ulna and proximal carpus in four. Two of these latter erosions appeared to be related to instability of the distal ulna, with eburnation occurring between the ulnar styloid and triquetrum. Seen at the radiocapitate joint were advanced wear at the distal end of the scaphoid and proximal ends of the trapezium and trapezoid in four specimens, advanced scaphocapitate erosions and mild scaphocapitate chondromalacia in one each, chondromalacia between the corresponding articulations of the lunate and hamate in two, and advanced triquetral erosions in two. Determination of a relationship between ligament injury and cartilage defects was impossible because of the small number of specimens.

Fig. 15. The dorsal wrist capsule as seen through a palmar approach. These ligaments are more indistinct than the palmar capsular structures. The proximal ends of the scaphoid (S), lunate (L), and triquetrum (T) can be seen along with the dorsal radiolunate ligament (DRL) and the synovial fold (SYN) arising at the dorsal junction of the radius (R) and TFC. The triquetrum lies in the shadow and only the proximal end of the dorsal radioulnotriquetral (DRUT) ligament is visible.

Discussion

The key stabilizing wrist ligaments are described as palmar and intracapsular. These ligaments are interposed between fibrous and synovial capsular layers, which makes visualization during surgery very difficult. Study of the palmar capsular ligamentous anatomy requires exposure which results in destruction of joint integrity and stability. This situation has made anatomic capsular exposure during surgery impractical. As a result surgeons have not fully visualized the extent of ligamentous injury before proceeding with surgical stabilization. With arthroscopy one can now see the capsular ligaments through a thin synovial layer and manipulate them with a probe to test their integrity, all without extensive dissection of the wrist joint.

The radioscapholunate ligament appears imposing through the arthroscope. Whipple and associates pointed out that the synovial fold accompanying this ligament is an excellent landmark for the arthroscopist to orient himself or herself. However imposing this ligament may appear arthroscopically, it is rather flimsy on anatomical inspection. The findings of Mayfield demonstrating the elasticity, failure force, and cross-sectional areas of the wrist ligaments show that this is one of the most elastic and least strong of the capsular structures. Berger and Blair showed that histologically it contained more loosely organized collagen and was highly vascular compared with the other capsular ligaments. On the basis of the physical characteristics of the radioscapholunate ligament, it is doubtful that it provides significant stabilization to the wrist.
The anatomic findings in this study are in agreement with those noted in the articles by Mayfield et al. and Taleisnik. However, those authors did not demonstrate anatomically separate triquetrocapitate and triquetrorhamate ligaments. In addition, there seems to be a difference of opinion regarding the existence of an ulnar collateral ligament. Mayfield and colleagues noted the presence of such a ligament but Taleisnik et al. stated the structure designated as the ulnar collateral ligament is but a thickening of the joint capsule. We found the capsule to be substantial at this location and have named it the ulnar capsule (UC). That this structure, i.e. the floor of the ECU tendon sheath, plays a role in stabilization of the wrist does not seem to be disputed. Taleisnik et al. described the infratendinous retinaculum of the ECU tendon as an "adaptable dynamic collateral ligament system." King et al. found that the "infratendinous portion of the extensor carpi ulnaris tendon sheath is a major restraint against dorsal and palmar subluxation" of the distal radioulnar joint. Whatever the ultimate function of this structure is shown to be, it can be visualized arthroscopically.

Little is known about the stabilizing function of each capsular ligament during wrist activity. Forced pronation or supination activities, such as turning a screwdriver or opening a jar, are often difficult for patients with painful and unstable wrists. Cyriax noted an average of 19 degrees rotation of the carpus on the longitudinal axis of the forearm. What limits the rotation of the carpus on the forearm? In these dissections the RSC ligament was taut with forced pronation and the UT ligament with forced supination. Although the observations made here do not confirm the biomechanical significance of the various ligaments, they do suggest functions that should be further investigated by formal biomechanical studies.

In this study ligament injuries to the wrist were commonly seen as were focal sites of arthritis. Clinically in this age group, wrist pain is not a frequent complaint, suggesting that a number of these lesions do not exhibit symptoms or they are minimally symptomatic. Thus we see the first limitation of arthroscopic examination of the wrist. Once the acute injury stage has passed, the relative ages of the lesions are not discernible. Where multiple ligament injuries exist, it may not be possible to determine arthroscopically which injuries are symptomatic and which are incidental. Abnormal arthroscopic findings must be carefully correlated with clinical findings to determine their significance.

Another major limitation of arthroscopy is that only a portion of the ligaments can be seen through the arthroscope. A tear or avulsion may occur outside the field of the arthroscope and may not be fully appreciated. Not infrequently, synovitis obscures the view, especially on the ulnar side of the wrist. A wrist previously operated on may be too tight to allow adequate visualization of the ligaments.

With these limitations considered, it is apparent that arthroscopy is not an all inclusive diagnostic technique for the wrist. Traditional methods including physical examination, x-ray films, motion studies and arthrograms should be used in conjunction with arthroscopy as they provide useful information not available through arthroscopy alone. The arthroscope provides a method of obtaining additional information regarding the capsular ligaments of the wrist, their injuries, and resulting instability syndromes. When anatomic pathology is correlated with clinical findings of instability, a more accurate picture of wrist pathomechanics will be achieved. This will allow creation of an anatomically based classification of wrist instability syndromes. Such a classification scheme should favor the advancement of more reliable and predictable treatment methods.

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REFERENCES