MR imaging of normal and pathological extrinsic wrist ligaments using thin slices with clinical and surgical correlation

Poster No.: C-2215
Congress: ECR 2010
Type: Educational Exhibit
Topic: Musculoskeletal
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Keywords: MRI extrinsic ligaments, carpal instability, Wrist Injury
DOI: 10.1594/ecr2010/C-2215

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Learning objectives

To describe the MR imaging appearance of chronic lesions of volar and dorsal radiocarpal and ulnocarpal ligaments on thin orthogonal slices and to correlate them to clinical outcome and to arthroscopic findings when available.

Background

The extrinsic ligaments seem to be as important as the intrinsic ones in the development of carpal instability. Early detection of the ligamentous lesions is necessary to encourage optimal treatment. Injuries to the carpal ligaments can lead to malalignment when not treated and result in functional disability and increasing pain and even progress to osteoarthritis [1,2,3,6]. MRI and arthroscopy are examinations which both allow the direct visualization and analysis of wrist ligaments. But until now, arthroscopy of the radiocarpal and midcarpal joints has been the gold standard in the diagnosis of carpal instability. It is prescribed to a patient who suffers from a functional discomfort with doubtful radio-clinical results or in case of radio-clinical anomalies allowing to resort to healing surgery [4,5]. The main goal of the exploration of the ligaments is to recognize and to point out the injuries which can badly evolve and require a specific treatment. MRI could help to detect ligamentous and other associated joint lesions when using thin slices. Although some correlation studies between the results of MRI and arthroscopy (often dealing with a limited series of patients) have been mentioned in medical literature on intrinsic ligaments (especially the scapholunate), very few works focus on the comparative study of these techniques to diagnose extrinsic ligamentous injuries.

Imaging findings OR Procedure details

Procedure Details:

Our work is based on the retrospective analysis of wrist MR examinations of 89 patients (from 17 to 55 years old - mean age of 33) with chronic middorsal or midpalmar pain. The MRI findings were correlated with the clinical outcome in all cases and with arthroscopy in 35 cases (reported by 2 skilled hand surgeons) [7]. Two mm thick coronal slices were performed in proton density (PD) and fat saturated PD fast spin echo as well as 0.6 or 1mm thick slices in 3D DESS (dual echo with steady state precession) gradient echo sequence.
Sagittal and axial 2mm thick slices were systematically obtained using PD and T2-weighted fast spin echo sequences.

These examinations have been made between 2004 and 2007 thanks to a 1.5 Tesla magnet (Symphony-Vision by Siemens) using a wrist coil with 4 channels and from January 2008 until December 2009 on a 3T magnet (Achieva by Philips) using a wrist coil with 8 channels. In 53 cases, MR examination of the controlateral asymptomatic wrist was subsequently obtained.

Imaging findings:

This poster aims at describing and illustrating the normal and pathological MR appearance of radiocarpal and ulnocarpal extrinsic ligaments. We will go on anatomic descriptions of the literature and personal findings after cadaveric studies and arthroscopic correlations.

The extrinsic ligaments join the distal end of radius or ulna to carpal bones (while the intrinsic ligaments arise and insert on carpal bones). The anatomy of the extrinsic ligaments is complex. They are intracapsular and gather radiocarpal ligaments (between the radius and the carpal bones) and ulnocarpal ligaments (between the ulna and the carpal bones). All the radiocarpal ligaments are proximally attached to the distal extremity of the radius and distally inserted on one or several carpal bones. They are capsular thickenings which have, for most of them, an oblique direction and thus require several adjacent thin slices to analyse the whole ligaments. They appear to have a fascicular and striated structure with alternate hyposignal and hypersignal bands on coronal slices [8, 9]. Several extrinsic ligaments are described at the level of the palmar and dorsal parts of the carpus. Palmar ligaments are thicker and more resistant than dorsal ligaments. They are important stabilizers in the wrist movements [10,11,12].

Although there are several variations within the nomenclature and the description of the ligaments, we will keep in mind: 2 groups on the palmar side (with a V-shape) and a ligamentous group with a transverse direction (with a reversed V-shape) on the dorsal side.

1. Palmar radiocarpal ligaments

On the palmar side, 3 strong extrinsic radiocarpal ligaments were clearly identified: the radioscaphocapitate, long radiolunate and radioscapholunate ligaments (fig. 1,4G).

1.1. The radioscaphocapitate ligament (RSC) extends from the styloid process of the radius; it cravats the scaphoid waist (what enables to maintain the position of the scaphoid as it acts like a seat belt) to insert itself on the palmar side of the capitate. It acts like a
spindle around which revolves the scaphoid and is paramount in the scaphoid stability [13, 14, 15, 16].

1.2. The radiolunotriquetral ligament (RLT) or long radiolunate ligament is paralleled to the radioscapocapitate ligament, extends from the anterior margin and from the styloid process of the radius to the radial margin of the palmar surface of the lunate and obliquely connects on the palmar side of the triquetrum (where it is covered up by the ulnotriquetral ligament). The fibres of this ligament can interrupt at the lunate attachment and thus create two ligamentous structures, the long radiolunate and the palmar lunotriquetral. The RLT ligament is the longest of the wrist [17,18,19,20].

1.3. The radioscapoholunate ligament (or ligament of Testut) originates between the long and short portions of the radiolunate ligament, and has its fibres embedded in the interosseous scapholunate ligament. It is deeper than the RSC and RLT ligaments. It is rather considered as a synovial fold which retains a neurovascular bundle. It corresponds to the anterior brake of the lunate and is used as a reference in arthroscopy to point out the scapholunate ligament [21,23].

In case of injury, the signal of these ligaments can increase and the ligaments can lose their sharp outlines on the thin sections obtained in 3D sequence (fig. 1). A fibrous thickening (hyposignal on T2) can also be described in chronic partial ruptures (fig. 2). Moreover a cyst can sometimes appear and develop itself in the ligaments and testify to a chronic ligamentous rupture (fig. 3 and 4) [22,29,30].

These 3 palmar ligaments can be visualized by arthroscopy. It is however necessary to precise that the extrinsic ligamentous structures are only reachable during arthroscopic examination for their very short intraarticular part.

1.4. The short radiolunate ligament, which is not described by all the researchers, is close to the palmar fibres of the triangular fibrocartilaginous complex. It is an anterior capsular thickening. Its origin is on the palmar and ulnar rim of the distal part of the radius and the ligament inserts at the proximal part of the palmar surface of the lunate. This ligament stabilizes the lunate [23] (fig. 1).

2. Ulnocarpal ligaments

The proximal palmar ligamentous group (with a V-shape) is made of the extrinsic ulnotriquetral and ulnolunate ligaments, on the medial side and of the extrinsic radioscapoholunate ligament on the lateral side. This group stabilizes the lunate and thus the proximal row of the carpal bones.
The ulnocarpal ligaments originate on the anterior rim of the triangular fibrocartilage and the base of the styloid process of the ulna. The **ulnolunate ligament** is situated next to the short radiolunate ligament following the same direction, and then is inserted on the palmar side of the lunate. The **ulnotriquetral ligament** originates outside the former and inserts on the triquetrum [25,29,30] (fig. 5).

In severe traumatic injuries to the TFCC, these ligaments may avulse. MRI using thin slices (preferably with 3D gradient echo) seems to be able to differentiate a palmar or dorsal detachment of the ulnocarpal ligaments (fig. 6,7). Traumatic avulsions of the peripheral volar attachments of the TFCC are graded as "Class IC" lesions in the arthroscopic classification of Palmer. They can present a diffusely increased SI and/or be detached and displaced. A surgical repair is usually attempted in cases of acute or subacute lesions [23].

### 3. Dorsal radiocarpal ligaments

**Dorsal ligaments** are thinner and biomechanically less important than palmar ligaments. The **dorsal radiolunotriquetral ligament** (radiocarpal ligament) is the main extrinsic ligament, extending from the distal radius (at the level of the Lister tubercle and/or the styloid process of the radius) to the lunate and the triquetrum.

Several intrinsic mediocarpal dorsal ligaments link the carpal bones. Among these ligaments, the **dorsal intercarpal ligament**, which includes the triquetroscaphoidal and the triquetro-(trapezoido)-trapezial [23,26 to 30] (fig. 8 and 9).

The dorsal ligamentous group which has a transverse orientation (with a reversed V-shape) is composed by these ligaments. They also participate in the stability of the proximal row of the carpus.

According to the arthroscopic correlation study performed by Scheck et al dealing on 20 patients who were operated and examined by MRI and by arthro-MRI, radiocarpal ligaments cannot be accurately analysed on MRI, even with thin slices [29,30]. According to our experience, ligamentous injuries could be suspected on a MRI (especially when using intravenous injection of contrast) by detecting oedematous reaction and granulation tissue at the level of the injured ligaments. An intra-articular injection of contrast has the disadvantage to hide signs which could be linked to a clinically important partial ligamentous rupture. These signs could be the presence of a cyst, a local native fluid reaction or an associated osseous oedema, which could often be useful to diagnose the injuries.

### 4. Collateral ligaments
Collateral ligaments of the wrist are thickenings of the fibrous capsule; their function is less important than those of the knee or the elbow.

4.1. The **radial collateral ligament** is a dorsal extension of the palmar radioscaphoidal ligament and extends from the apex of the styloid process of the radius to connect itself to the scaphoid waist (fig. 8).

4.2. The **ulnar collateral ligament** reinforces the palmar ulnotriquetral ligament and is proximally connected to the basis and to the body of the styloid process of the ulna (with an extension towards the triangular fibrocartilage of the carpus). It is distally connected to the triquetrum and to the pisiform [23] (fig. 8).

**Images for this section:**

![Images showing the palmar extrinsic ligaments](image_url)

**Fig. 1:** Palmar extrinsic ligaments: Radioscaphocapitate (RSC) and long radiolunate (RL) ligaments. Notice the (normal) interruption of the fibres on the lunate attachment with a separated palmar lunotriquetral bundle (LT), which corresponds to an anatomic variation (A,B,D). R = radius - L = lunate - S = scaphoid. A. on a cadaveric specimen (courtesy of David Connell, London) B. normal MR appearance on a thin slice (1mm
thick) obtained in 3D DESS sequence C. partial rupture of the RSC and RL ligaments D. trajectory of these two ligaments together with the radioscapholunate ligament (RSL) and the inconstant short radiolunate (RLC) E. normal arthroscopic view with interligamentous sulcus between the 2 ligaments F. arthroscopic view of the injured RSC and RL ligaments with synovitis filling the sulcus
**Fig. 2:** Chronic fibrous thickening of the radioscaphocapitate ligament (A and B, arrows) of a gymnast who suffered from mediocarpal pain. The presence of an associated rupture of the intrinsic scapholunate ligament results in a rotatory subluxation of the scaphoid (with an horizontal orientation of the latter), which is clearly pointed out on the thin sagittal slices (2mm thick) in proton density (A) and T2 (B). The ligament appears thickened and presents an heterogeneous signal in proton density and weak in T2 ; it has irregular outlines. Compare with the contralateral wrist (C and D) where the ligament looks normal (arrow), as well as the scaphoid axis.

![Images of wrist MRI](image1.png)

**Fig. 3:** Synovitis around the radioscapholunate ligament (RSL) (B,C) and partial tear of the radiolunotriquetral ligament (RLT) associated with a volar ganglion cyst (E) demonstrated on contiguous coronal slices from a 3D DESS sequence. The RSC ligament (E, F) looked normal at arthroscopy.

![Images of wrist MRI](image2.png)
**Fig. 4:** Sprain of the radioscapoholunate ligament associated with a rupture of the intrinsic scapholunate ligament. The patient is a 40 year-old gardener who developed a localised palmar distension after he had pruned trees; he had already fallen from a ladder 4 years before as his wrist was in dorsal hyperflexion. The coronal slices in proton density (A,B) and T2 (D,E) reveal the presence of a fluid distension at the level of the palmar fibres of the scapholunate and the radioscapoholunate ligament with a widening of the scapholunate space. The rupture of the intrinsic ligament is confirmed on the transverse section (C) on which the ligament has an increased signal intensity, is thickened and has blurred contours in comparison with the normal ligament of the controlateral uninjured wrist (F). The radioscapoholunate ligament seems to be thickened with a heterogeneous signal on the sagittal section (H, arrow), whereas the controlateral sagittal section is normal (G). Arthroscopy (I) reveals the presence of an important synovitis associated with a rupture of the palmar fibres of the scapholunate ligament with partly detached strips. These strips can also be seen on the sagittal section (H) at the level of the anterior radiocarpal space, ahead of the lunate tilting (compare to the normal controlateral sagittal section G). R = radius - L = lunate - S = scaphoid
**Fig. 5:** Normal palmar ulnocarpal ligaments: A) Palmar ulnotriquetral (UT) and ulnolunate ligaments (UL) attached to the triangular fibrocartilage (TFC). B) Normal ulnolunate ligament on an anterior frontal section (2mm thick) obtained in proton density fast spin echo sequence. C) Posterior insertion of the palmar ulnotriquetral ligament on the triangular fibrocartilage, observed on a thin (1mm thick) 3D DESS echo image. D) Ulnotriquetral ligament on an anterior frontal section obtained in proton density fast spin echo sequence (posterior to B and anterior to C).
**Fig. 6:** Partial tear of volar ulnocarpal (UC) ligaments seen on consecutive 1mm thick coronal images obtained with 3D DESS sequence (circled on E) and on arthroscopic view (black arrow). It was treated by debridement and reattachment. The radial tear (A, white arrow) was not sutured (avascular area).

**Fig. 7:** Tear of dorsal ulnotriquetral (UT) ligament. Coronal MR images (A-C) and arthroscopic views (D,E) demonstrate the disrupted and retracted fibres of the dorsal ulnotriquetral ligament (UT, arrow), hanging to the TFC. The TFC was subsequently arthroscopically fixed to the posterior wall.
**Fig. 8:** Dorsal radiotriquetral ligament (RT) with its proximal insertion on the tubercle of Lister (tl). The other two ligaments are mediocarpal ligaments: the triquetroscaphoidal (TS) and the triquetro-(trapezoidal)-trapezial (TT), also called "dorsal intercarpal ligament". CR = radial collateral ligament - CU = ulnar collateral ligament.
Fig. 9: Extrinsic dorsal radiotriquetral ligament (RT) and mediocarpal triquetroscaphoidal (TS) and triquetro- (trapezoido)- trapezial ligaments (TT). A and B) Thin frontal slices (1mm) in 3D DESS sequence obtained on a cadaveric specimen. C) Thin frontal slice (1mm) in 3D DESS sequence in a patient whose dorsal ligaments were normal. D and F) Frontal slices (2mm) in STIR sequence in a patient with a dorsal cyst and whose triquetroscaphoidal (TS) ligament was thinned but continuous (D). E) Photograph of the cadaveric specimen.
Conclusion

The major teaching points of this exhibit are:

- Recognition of MR imaging features in chronic lesions of volar and dorsal radiocarpal and ulnocarpal ligaments on 0.6 mm to 2mm thick slices (obtained in the 3 planes).

- Detection of associated tears of intrinsic ligaments and small cysts.

- Correlation of MRI findings to arthroscopic description.

On the basis of this preliminary retrospective study of MR images compared to arthroscopic findings, it is possible to notice that if we use magnets with high magnetic fields (from 1.5 to 3T) and dedicated wrist coils, MRI could become a supplementary paramount help to the imaging methods already used to detect carpal instabilities (dynamic radiographs, arthro-CT...). It may in the future even replace diagnostic arthroscopy of the wrist. Nevertheless, the positive aspect of arthroscopy is to give a dynamic approach of the ligament status which cannot be given by high resolution MRI. Moreover, numerous injuries of the ligamentous structures of the wrist detected thanks to MRI will always have to be interpreted with caution and associated with clinical findings, to avoid excessive surgical treatments.

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