MRI of Normal Anatomy and Injuries of Extrinsic Ligaments

M. Shahabpour, P. Ceuterick, B. Allemon, N. Pouliart, S. Provyn, and M. De Maeseneer

Carpal instability is usually the consequence of a fracture and/or of ligamentous injuries. Sometimes, instability does not evolve and hardly hampers the movements of the wrist or merely provokes a slight pain. But occasionally, on the contrary, instability can lead to functional disability and increasing pain and even result in osteoarthritis [1–3].

MRI and arthroscopy are examinations which allow the direct visualisation and analysis of wrist ligaments. The main goal of the exploration of the ligaments is to recognise and to point out the injuries which can badly evolve and require a specific treatment. They are 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].

Most authors agree on the fact that in case of carpal instability, intrinsic and extrinsic ligaments are injured [6]. Nevertheless, interosseous (scapholunate and lunotriquetral) ligaments have to be completely injured to develop a significant carpal instability.

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.

M. Shahabpour (✉) • B. Allemon • N. Pouliart • M. De Maeseneer
Department of Medical Imaging,
Universitair Ziekenhuis Brussel, Brussels, Belgium
e-mail: maryam.shahabpour@uzbrussel.be

P. Ceuterick
Department of Orthopaedics and Hand Surgery,
Cliniques de l'Europe, Brussels, Belgium

S. Provyn
Department of Experimental Anatomy,
Vrije Universiteit Brussel, Brussels, Belgium

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This chapter aims at describing 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.

Our work is based on the retrospective analysis of 132 wrist MR examinations of 79 patients (from 17 to 57 years old – mean age of 33) who suffer from midpalmar or middorsal chronic pain. These examinations have been performed on a 1.5 T magnet (Symphony-Vision by Siemens) using a wrist coil with four channels. Two-mm-thick slices were obtained in the three orthogonal planes, using spin echo proton density and T2-weighted sequences and proton density sequence with fat saturation as well as 1-mm-thick coronal slices in T2-weighted 3D gradient echo sequence. A detailed arthroscopic correlation has been obtained in 27 cases out of 79 patients (who have systematically been operated by the same hand surgeon) [7].

The anatomy of the extrinsic ligaments is complex. They are intracapsular and link the radius and the ulna to the carpal bones. They 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 thin adjacent slices to analyse the whole ligaments. They appear as fasciculate and striated structures, presenting bands of low signal intensity alternating with bands of intermediate or high signal intensity 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 stronger than dorsal ligaments. They are important stabilisers of wrist movements [10–12].

Although there are several variations within the nomenclature and the description of the ligaments, we will keep in mind two groups on the palmar side (with a reversed 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, three strong extrinsic radiocarpal ligaments were clearly identified: the radioscaphocapitate, long radiolunate and short radiolunate ligaments (Fig. 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 on the palmar side of the capitate. It acts like a spindle around which revolves the scaphoid and is paramount in the scaphoid stability [13–16].

The radiolunotriquetral ligament (*RLT*) or long radiolunate ligament is paralleled to the radioscaphocapitate ligament, extends from the anterior margin and from the styloid process of the radius to the radial margin of the palmar surface of

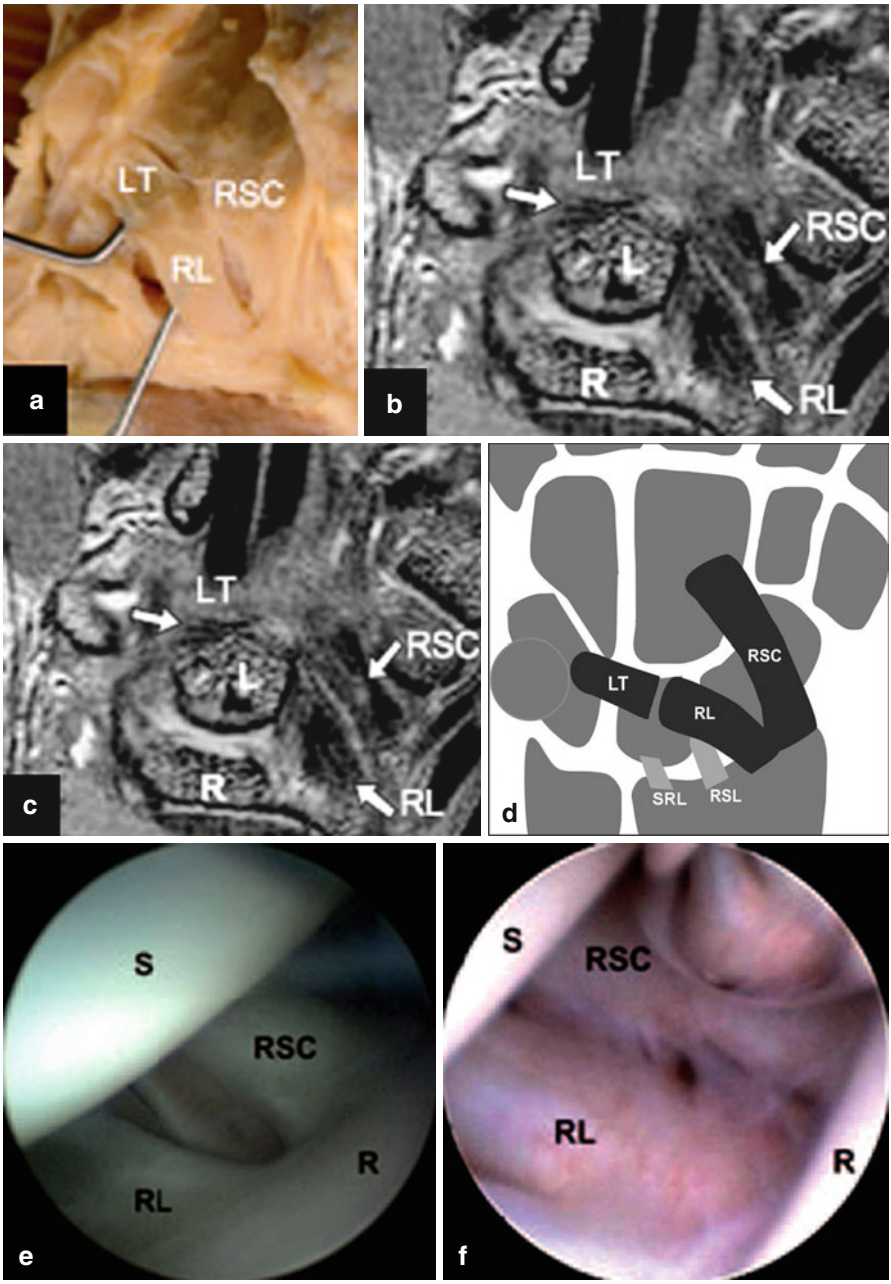


Fig. 1 Palmar extrinsic ligaments : Radioscaphocapitate (*RSC*) and long radiolunate (*RL*) ligaments. Notice the (normal) interruption of the fibres on the lunate attachment with a separated palmar lunotriquetral (*LT*) bundle, which corresponds to an anatomic variation (**a**, **b**). *R* radius, *L* lunate, *S* scaphoid. (**a**) On a cadaveric specimen (Courtesy of David Connell, London), (**b**) normal MR appearance on a thin slice (1 mm thick) obtained in 3D gradient echo sequence, (**c**) partial rupture of the RSC and RL ligaments, (**d**) drawing which shows the trajectory of these two ligaments together with the radioscapholunate ligament (*RSL*) and the inconstant short radiolunate ligament (*SRL*), (**e**) normal arthroscopic view, (**f**) arthroscopic view of the injured RSC and RL ligaments showing synovitis filling the interligamentous sulcus

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 [17–20].

The radioscapholunate 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].

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 (with decreased signal intensity on T2) can also be described in chronic partial ruptures (Fig. 2). Moreover a cyst can sometimes appear and develop itself in the ligaments or anterior to it, and be associated to a chronic ligamentous rupture (Figs. 3 and 4) [22].

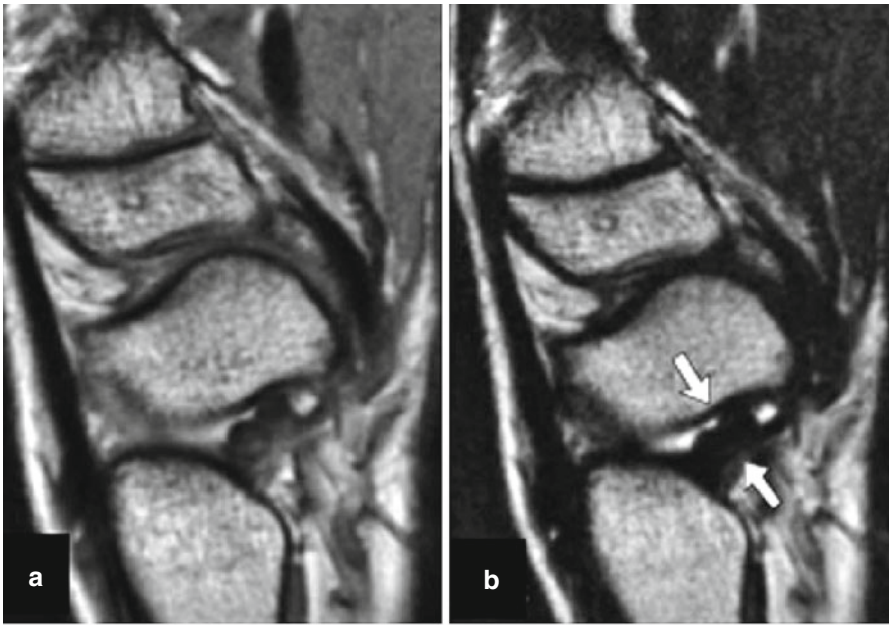
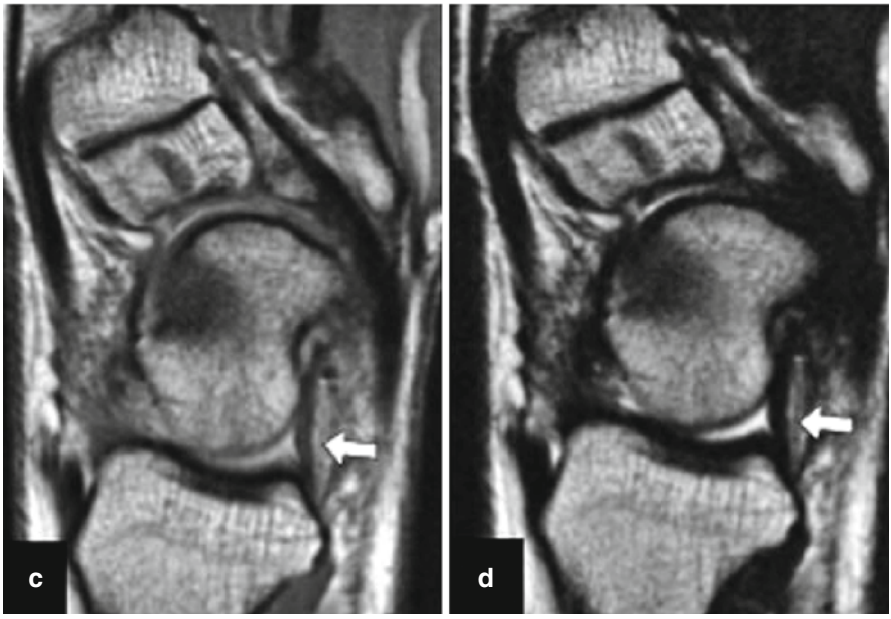


Fig. 2 Chronic fibrous thickening of the radioscaphocapitate ligament (**a**, **b**, *arrows*) of a gymnast who suffered from midcarpal pain. The presence of an associated rupture of the intrinsic scapholunate ligament results in a rotatory subluxation of the scaphoid (with a horizontal orientation of the latter), which is clearly pointed out on the thin sagittal slices (2 mm thick) in proton density (**a**) and T2 (**b**). The ligament seems to be thickened and presents a heterogeneous signal in proton density and weak in T2; it has irregular outlines. Compare with the contralateral wrist (**c**, **d**) where the ligament seems normal (*arrow*), as well as the scaphoid axis



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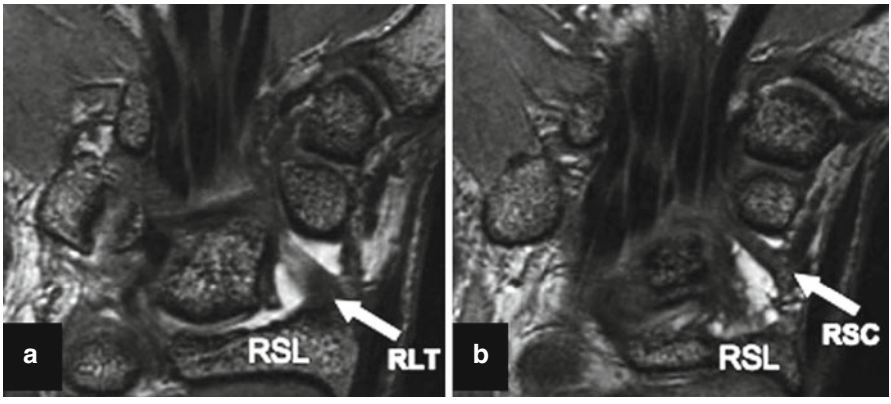

Fig. 3 Synovitis with chronic cystic distension around the radioscapholunate ligament in a patient complaining of palmar radiocarpal pain. On anterior coronal section (of a 3D gradient echo sequence) (**a**, **b**), a cystic distension with a chronic multilobular aspect is put forward at the level of the radioscapholunate ligament (*RSL*). The radiolunotriquetral (*RLT*, **a**) and radioscaphocapitate ligaments (*RSC*, **b**) are continuous

These three palmar ligaments can be visualised by arthroscopy. It is however necessary to precise that the extrinsic ligamentous structures are only reachable during arthroscopic examination for their very short intra-articular part.

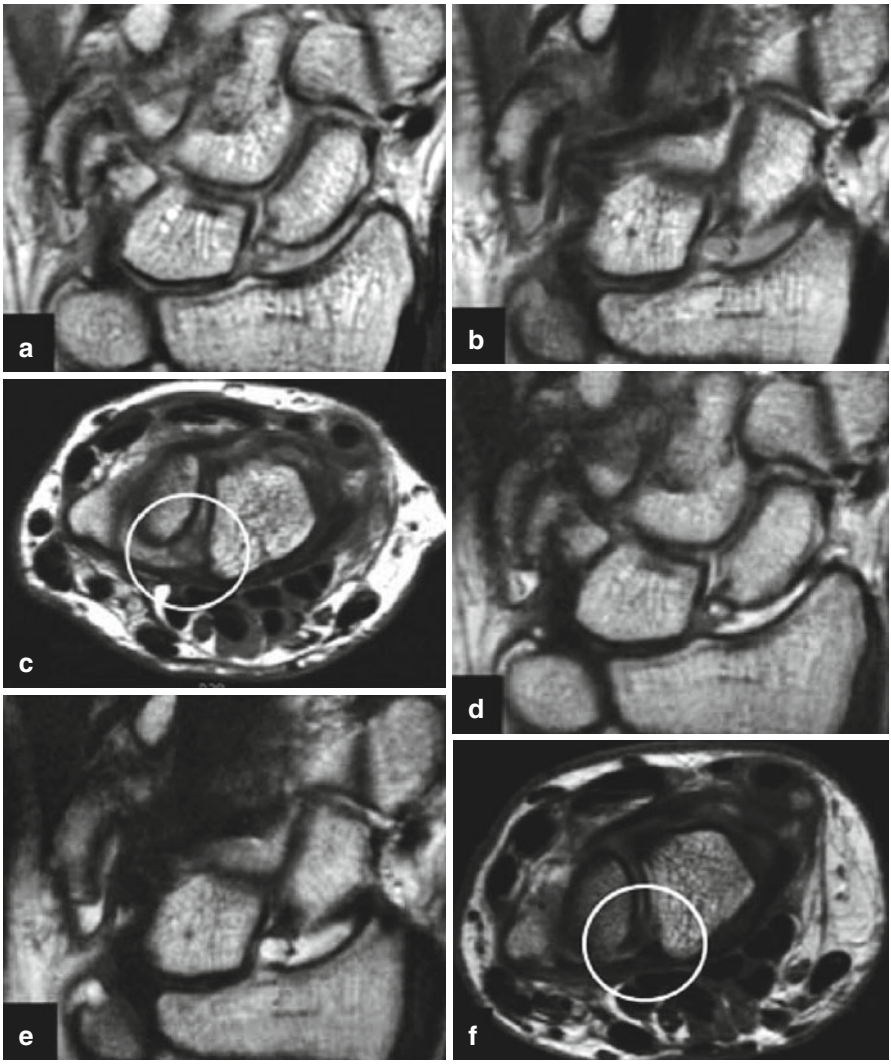

Fig. 4 Thickening of the radioscapholunate ligament and surrounding synovitis associated with a rupture of the intrinsic scapholunate ligament. The patient is a 40-year-old gardener who developed a localised palmar distension after he had pruned trees; he had already fallen from a ladder 4 years before 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 with a cystic aspect at the level of the palmar fibres of the scapholunate and the radioscapholunate ligament with a widening of the scapholunate space. The rupture of the palmar bundle 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 contralateral uninjured wrist (**f**); the dorsal bundle was also torn (not shown) (**c** *circle*, torn palmar bundle of scapholunate ligament; **f** *circle*, normal palmar bundle of scapholunate ligament). The radioscapholunate ligament appears thickened with a heterogeneous signal on the sagittal section (**h**) (*arrow*), whereas the contralateral 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 tilted lunate (compare to the normal contralateral sagittal section) (**g**). *R* radius, *L* lunate, *S* scaphoid

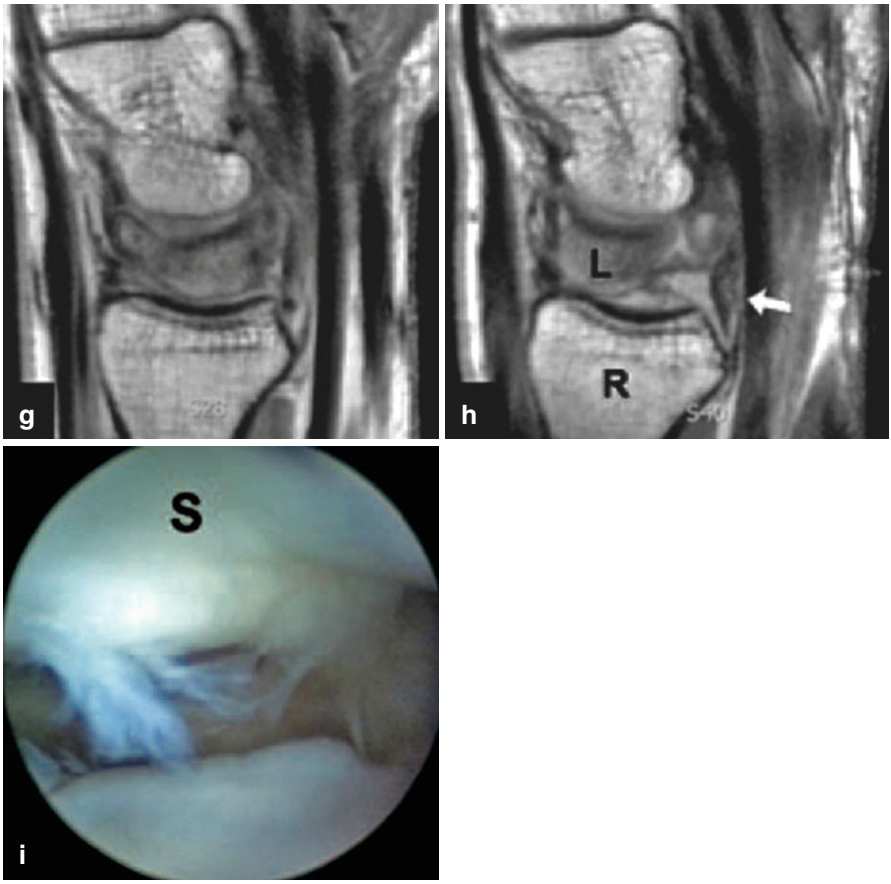

Fig. 4 (continued)

The general configuration of the palmar ligaments has a "V" structure which is weaker at one point, a triangular area in the capsule, so-called space of Poirier. This space is situated between the two palmar arcs with a V shape, above the lunocapitate joint where the lunate can dislocate [23].

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 usually described 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 stabilises the lunate [23] (Fig. 1).

The *distal palmar* ligamentous group (with a reversed V shape) is composed of the intrinsic triquetrocapitate ligament on the medial side and of the extrinsic radioscaphocapitate ligament and of the intrinsic scaphocapitate ligament on the lateral side. This group stabilises the capitate and thus the distal row of the carpal

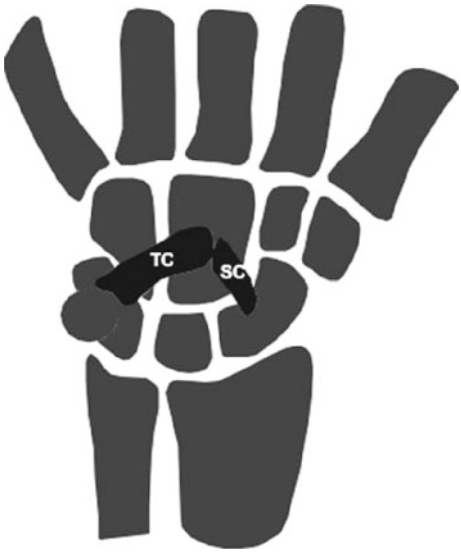

Fig. 5 Image showing the components of the arc-shaped (intrinsic midcarpal): triquetrocapitate (*TC*) and scaphocapitate (*SC*) ligaments

bones. The *intrinsic triquetrocapitate and scaphocapitate ligaments* form the arc-shaped ligament of the wrist or *volar arcuate ligament* (terminology used by hand surgeons) which is an important palmar midcarpal stabiliser. Theumann et al. identified it as the *palmar scaphotriquetral ligament* [7, 24] (Fig. 5).

2 Palmar Ulnocarpal Ligaments

The *proximal palmar* ligamentous group (with a reversed V shape) is made of the extrinsic ulnotriquetral and ulnolunate ligaments, on the medial side and of the extrinsic radiolunotriquetral ligament on the lateral side. This group stabilises the lunate and thus the proximal row of the carpal bones.

The ulnocarpal ligaments originate on the anterior rim of the palmar radioulnar ligament or of the triangular fibrocartilage or the base of the styloid process of the ulna (according to the different authors). 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 medial to the former and inserts on the triquetrum [25] (Fig. 6).

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.

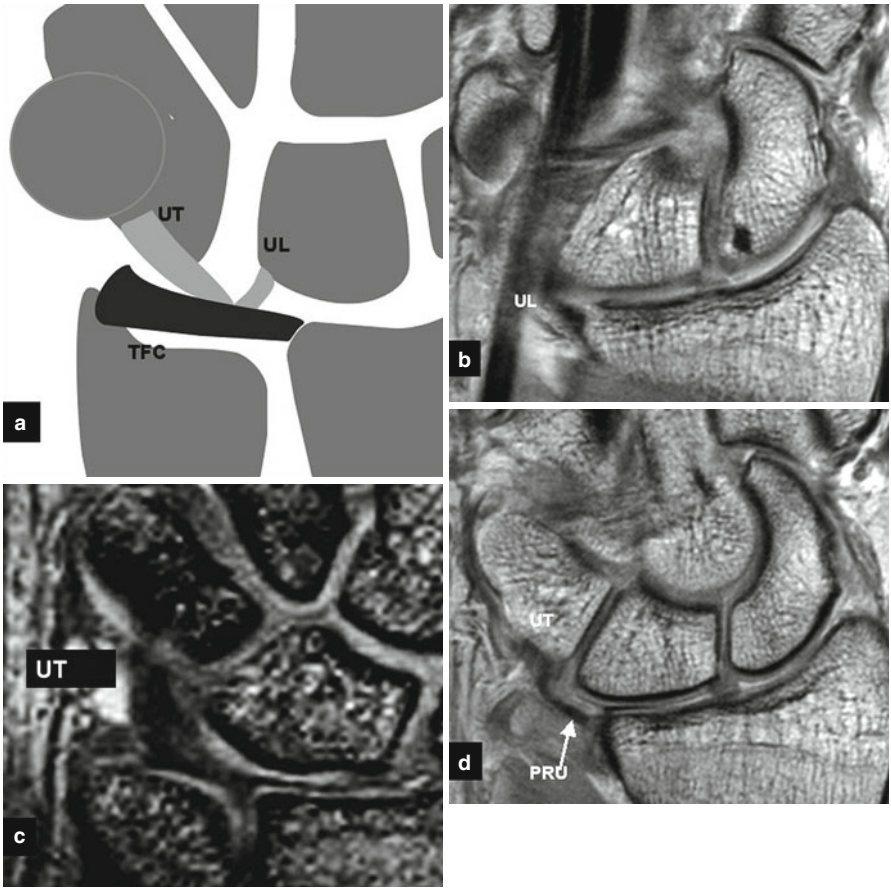

Fig. 6 Normal palmar ulnocarpal ligaments: (**a**) Drawing demonstrating the palmar ulnotriquetral (*UT*) and ulnolunate ligaments (*UL*) attached to the triangular fibrocartilage (*TFC*). (**b**) Normal ulnolunate ligament (*UL*) on an anterior coronal section (2 mm thick) obtained in proton density spin echo sequence. (**c**) Ulnotriquetral ligament (*UT*) on the triangular fibrocartilage observed on a thin section (1-mm-thick) 3D gradient echo image. (**d**) Ulnotriquetral ligament (*UT*) attached on the palmar radioulnar ligament (*PRU*) on an anterior coronal section obtained in proton density spin echo sequence (posterior to (**b**) and anterior to (**c**))

Several dorsal midcarpal ligaments link the carpal bones. Among these ligaments are the *dorsal intercarpal ligament*, which includes the triquetroscaphoidal and the triquetro-trapezoido-trapezial ligaments [23, 26–28] (Figs. 7 and 8).

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 MR arthrography, radiocarpal ligaments cannot be accurately analysed on a MRI, even with thin slices [29, 30]. According to our experience, ligamentous injuries could be suspected

on a MRI with intravenous injection of contrast, by detecting oedematous reaction and granulation tissue at the level of the injured ligaments. An intra-articular injection of contrast might hide signs associated to a clinically important partial

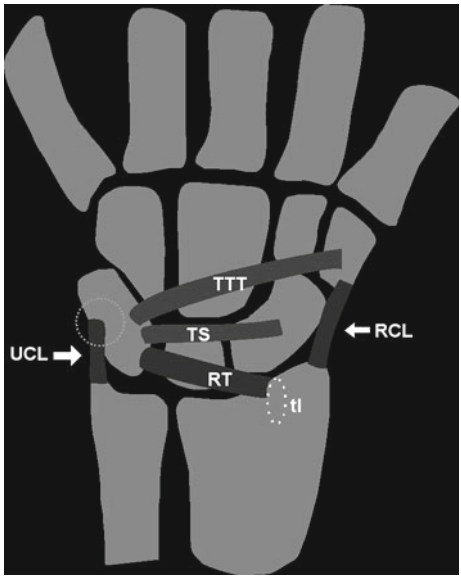

Fig. 7 Image indicating the dorsal radiotriquetral ligament (*RT*) with its proximal insertion on the tubercle of Lister (*tl*). The other two ligaments are midcarpal ligaments: the triquetroscaphoidal (*TS*) and the triquetro-trapezoido-trapezial (*TTT*), also called "dorsal intercarpal ligament." *RCL* radial collateral ligament, *UCL* ulnar collateral ligament

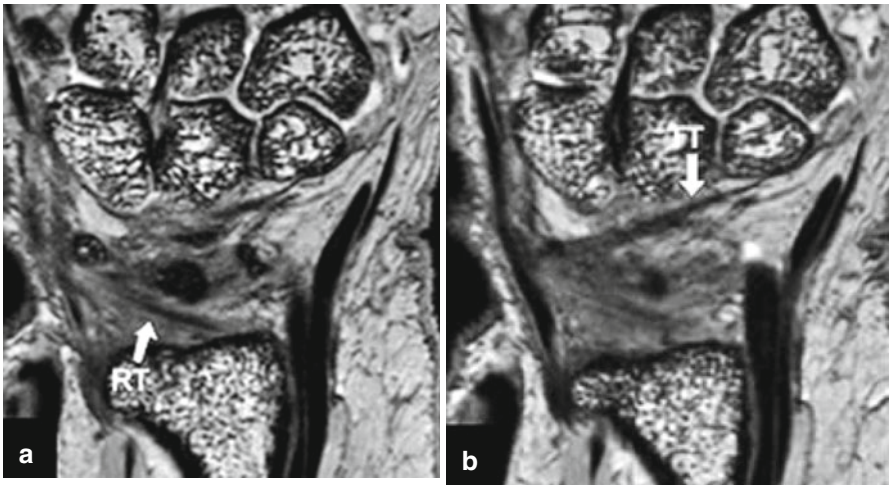

Fig. 8 Normal extrinsic dorsal radiotriquetral ligament (*RT*), normal midcarpal triquetroscaphoidal (*TS*) and triquetro-trapezoido-trapezial ligaments (*TTT*). (**a**, **b**) Thin coronal slices (1 mm) in 3D gradient echo sequence obtained on a cadaveric specimen. (**c**) Thin coronal slice (1 mm) in 3D gradient echo sequence on a patient whose dorsal ligaments were normal. (**d**, **f**) Coronal slices (2 mm) in STIR sequence on a gymnast presenting clinical signs of dorsal impingement, whose triquetroscaphoidal ligament was thinned but continuous (**d**) with cystic distension between the dorsal ligaments. (**e**) Photograph of the cadaveric specimen

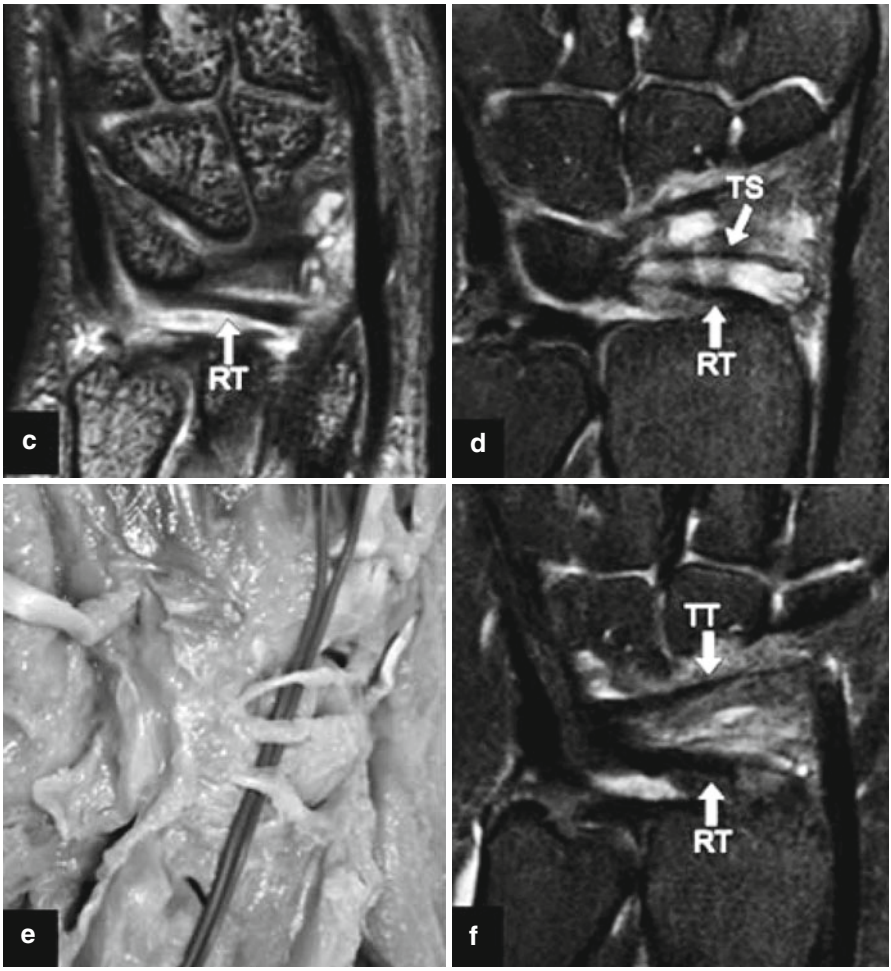

Fig. 8 (continued)

ligamentous rupture. These signs could be the presence of a native cyst, a local 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. 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 insert on the scaphoid waist (Fig. 7).

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). It is distally connected to the triquetrum and to the pisiform [23] (Fig. 7).

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 3 T) and dedicated wrist coils, MRI could become a supplementary paramount help to the imaging methods already used to detect carpal instabilities (dynamic radiographs, CT arthrography etc.). It may in the future even replace diagnostic arthroscopy of the wrist. Nevertheless, the positive aspect of arthroscopy is to give a dynamic approach 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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References

1. Linscheid RL, Dobyns JH, Beabout JW et al (1972) Traumatic instability of the wrist: diagnosis, classification and pathomechanics. J Bone Joint Surg Am 54A:1612–1632
2. Trail IA, Stanley JK, Hayton MJ (2007) Twenty questions on carpal instability. J Hand Surg Eur Vol 32(3):240–255
3. Schmitt R, Frochner S, Coblenz G et al (2006) Carpal instability. Eur Radiol 16:2161–2178
4. Roulot E (2001) Arthroscopie du poignet. In: Godefroy D et al (eds) Intérêt diagnostique et thérapeutique dans Imagerie du poignet et de la main. Sauramps Médical, Paris
5. Dautel G, Et Blum A (2001) In: Godefroy D et al (eds) Place de l'arthroscanner et de l'arthroscopie dans le diagnostic des instabilités du poignet dans Imagerie du poignet et de la main. Sauramps Médical, Paris
6. Theumann NH, Etechami G, Duvoisin B (2006) Association between extrinsic and intrinsic carpal ligament injuries at MR arthrography and carpal instability at radiography: initial observations. Radiology 238:950–957
7. Shahabpour M, Van Overstraeten L, Ceuterick P, Milants A, Goubau J, Boulet C, De Mey J, Demaeseneer M (2012) Pathology of extrinsic ligaments: a pictorial essay. Semin Musculoskelet Radiol 16(2):115–128
8. Totterman SM, Miller R, Wasserman B, Blebea JS, Rubens DJ (1993) Intrinsic and extrinsic carpal ligaments: evaluation by three-dimensional Fourier transform MR imaging. AJR Am J Roentgenol 160:117–123
9. Brown RR, Fliszar E, Cotten A, Trudell D, Resnick D (1998) Extrinsic and intrinsic ligaments of the wrist: normal and pathologic anatomy at MR arthrography with three-compartments enhancement. Radiographics 18:667–674
10. Viegas SF, Patterson RM, Hokanson JA, Davis J (1993) Wrist anatomy: incidence, distribution, and correlation of anatomic variations, tears, and arthrosis. J Hand Surg Am 18: 463–475
11. Viegas SF, Patterson RM, Ward K (1995) Extrinsic wrist ligaments in the pathomechanics of ulnar translation instability. J Hand Surg Am 20A:312–318

12. Feipel V, Rooze M (1999) The capsular ligaments of the wrist: morphology, morphometry and clinical applications. Surg Radiol Anat 21:175–180
13. Taleisnik J (1976) The ligaments of the wrist. J Hand Surg Am 1:110–118
14. Berger RA, Landsmeer JM (1990) The palmar radiocarpal ligaments: a study of adult and fetal human wrist joints. J Hand Surg Am 15:847–854
15. Reicher M (1990) Normal wrist anatomy, biomechanics, basic imaging protocol, and normal multiplanar MRI of the wrist. In: Reicher MA (ed) MRI of the wrist and hand. Raven Press, New York, pp 17–48
16. Theumann NH, Pfirrmann CW, Antonio GE, Chung CB, Gilula LA, Trudell DJ (2003) Extrinsic carpal ligaments: normal MR arthrographic appearance in cadavers. Radiology 226:171–179
17. Smith DK (1993) Volar carpal ligaments of the wrist: normal appearance on multiplanar reconstructions of three-dimensional Fourier transform MR imaging. AJR Am J Roentgenol 161:353–357
18. Rominger MB, Bernreuter WK, Kenney PJ, Lee DH (1993) MR imaging of anatomy and tears of wrist ligaments. Radiographics 13:1233–1246
19. Timins ME, Jabnke JP, Krah SF, Erickson SJ, Carrera GE (1995) MR imaging of the major carpal stabilizing ligaments: normal anatomy and clinical examples. Radiographics 15: 575–587
20. Boutry N, Lapegue F, Masi L et al (2005) Ultrasonographic evaluation of normal extrinsic and intrinsic carpal ligaments: preliminary experience. Skeletal Radiol 34:513–521
21. Berger RA, Kauer JM (1991) Radioscapholunate ligament: a gross anatomic and histologic study of fetal and adult wrists. J Hand Surg Am 16:350–355
22. Connell D, Page P, Wright W, Hoy G (2001) MRI of the wrist ligaments. Australas Radiol 45(4):411–422
23. Resnick D, Kang HS, Pretterklieber ML (2007) Wrist and hand in internal derangements of joints, vol 1, 2nd edn. Saunders, Philadelphia, pp 1218–1418
24. Chang W, Peduto AJ, Aguiar RO, Trudell DJ, Resnick DL (2007) Arcuate ligament of the wrist: normal MR appearance and its relationship to palmar midcarpal instability: a cadaveric study. Skeletal Radiol 36:641–645
25. Tanaka T, Ogino S, Yoshioka H (2008) Ligamentous injuries of the wrist. Semin Musculoskelet Radiol 12:359–378
26. Smith DK (1993) Dorsal carpal ligaments of the wrist: normal appearance on multiplanar reconstructions of three-dimensional Fourier transform MR imaging. AJR Am J Roentgenol 161:119–125
27. Mitsuyasu H, Patterson RM, Shah MA, Buford WL, Iwamoto Y, Viegas SF (2004) The role of the dorsal intercarpal ligament in dynamic and static scapholunate instability. J Hand Surg Am 29:279–288
28. Sarazin L, Godefroy D, Rousselin B, Drapé JL, Chevrot A (2005) Imagerie par résonance magnétique du poignet et de la main dans les situations normales. Atlas anatomique. Encycl Méd Chir. Elsevier SAS, Paris
29. Scheck RJ, Romagnolo A, Hierner R, Pfluger T, Wilhelm K, Hahn K (1999) The carpal ligaments in MR arthrography of the wrist: correlation with standard MRI and wrist arthroscopy. J Magn Reson Imaging 9:468–474
30. Maizlin ZV, Brown JA, Clement JJ, Grebenyuk J, Fenton DM, Smith DE, Jacobson JA (2008) MR arthrography of the wrist: controversies and concepts. Hand (N Y) 4(1):66–73