

WRIST LIGAMENT INJURIES IN HANDBALL PLAYERS

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INTRODUCTION

Upper limb injuries are common in handball players and an accurate diagnosis is mandatory to limit time to return to play and to avoid chronic complications. Nevertheless, wrist sprains are often underestimated and can lead to chronic pain and carpal instability. Wrist injuries include scapholunate, lunotriquetral, triangular fibrocartilage complex (TFCC) and dorsal extrinsic ligaments tears.

A thorough understanding of the ligament anatomy helps clinicians better diagnose and treat wrist injuries. Imaging plays an important role in the evaluation of the intrinsic and extrinsic wrist ligaments and TFCC. The accuracy of the different imaging methods vary widely. MR arthrography and CT arthrography are the best tools to assess ligament injuries but arthroscopy is still considered the gold standard. Radiographs are always necessary at the initial stage of diagnosis to depict fractures. It is also now proven that ultrasound is an additional tool to depict occult fractures and ligament sprains. It is a widely-available technique which helps to provide quick information on a suspected

damaged structure and has gained a lot of interest in recent years¹.

The purpose of this article is to describe different kinds of ligament sprains and to discuss the strengths and weaknesses of the various imaging modalities.

SCAPHOLUNATE LIGAMENT TEARS

The scapholunate (SL) ligament is an intrinsic ligament between the scaphoid and lunate with three bundles:

- **Dorsal and ventral bundles** are composed of collagen fibres. The dorsal one is thicker and plays a major role in wrist stability.
- **Central (or proximal) bundle** is fibrocartilaginous and may present degenerative and asymptomatic changes in elderly patients².

Traumatic injury may be partial if one or two bundles are torn or complete if the three segments are involved. For each bundle, a tear can either be full-thickness or partial³. A tear is considered acute when the initial trauma occurred within 6 weeks which means that ligament viability allows surgical reconstruction. Partial tears are usually stable whereas complete ones may

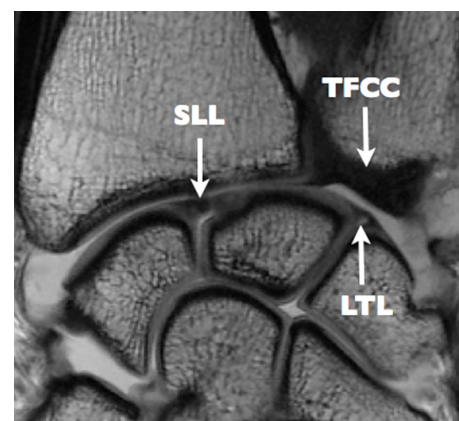


Figure 1: MR arthrography of the wrist. T1-weighted sequence in a coronal plane shows scapholunate ligament (SLL), lunotriquetral (LTL) and articular disk of the triangular fibrocartilage complex (TFCC).

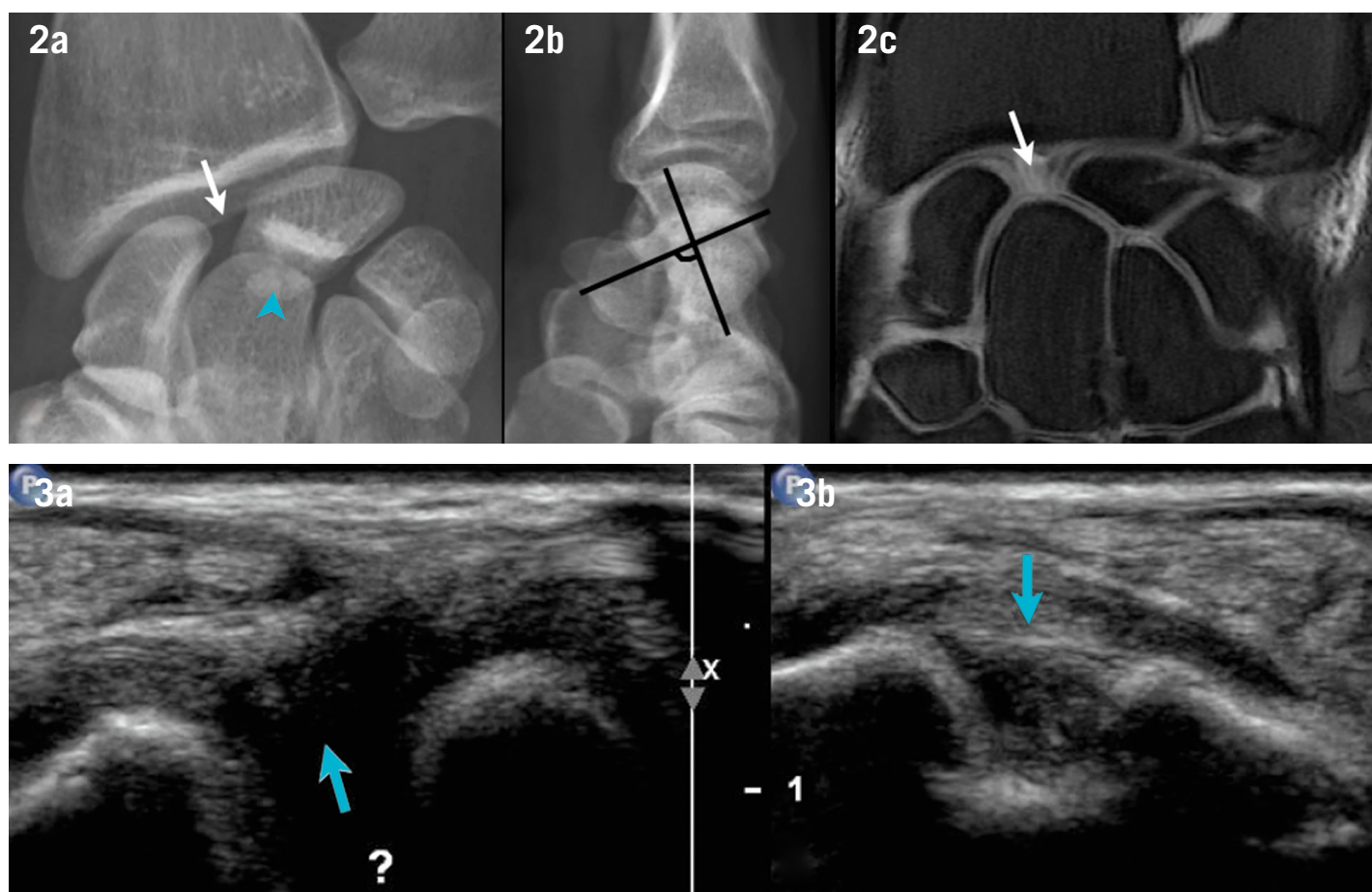


Figure 2: Dissociative SL instability. Anteroposterior radiograph a) shows widening of the SL joint space (white arrow) with dorsal tilt of the posterior horn of the lunate (blue arrowhead) while the lateral view b) shows an increase of the scapholunate angle. MR arthrography in coronal plane in T1-weighted sequence with fat-saturation c) shows SL tear and widening of the SL joint space. SL=scapholunate, DISI= Dorsal Intercalated Segmental Instability

Figure 3: Ultrasound in axial plane shows torn a) and normal fibrillar appearance b) of the scapholunate ligament.

lead to scapholunate instability and wrist osteoarthritis. Scapholunate instability may be due to flexion of the scaphoid, extension of the lunate and widening of the scapholunate joint space. Such instability may cause cartilage tears and osteoarthritis (Scapho-Lunate Advanced Collapse) which starts from the radial styloid and the proximal pole of the scaphoid at the beginning and extends to the midcarpal joint at an advanced stage. Functional outcome is better when treatment prevents instability and thereby prevents osteoarthritis⁴.

Clinical examination usually reveals pain and tenderness at the dorsal side of the wrist with a positive Watson's test (audible clunk at the scapholunate joint space during axial compression when the wrist is deviated from radial to ulnar deviation)⁴.

Plain radiographs will be normal in the case of a partial tear or if stability is only dynamic at an early stage. Widening of

the scapholunate joint space by 3 mm or more can be suggestive of dissociation but can be encountered in case of hyperlaxity or lunatotriquetral coalition. Conversely, it may not be a predictable or reliable finding in the setting of ligament injury^{1,5,6}.

On the lateral view, the scapholunate angle will be increased over 70° because of the palmar tilt of the scaphoid and the dorsal extension of the lunate (DISI). Care should be taken when assessing the scapholunate angle because it requires high-quality lateral view⁶.

Dynamic radiographs may show dynamic instability if plain radiographs are normal and ulnar or radial deviations show asymmetric scapholunate joint widening. According to Ozcelik, scapholunate instability is dynamic in 80% of patients and static in only 20%⁷.

Ultrasound is a widely available technique and is useful to assess the SL ligament. The visibility of the ligament

varies from 91 to 98% due to its superficial location⁸⁻¹⁰. The dorsal segment is superficial and can be easily assessed just distally to the Lister's tubercle. Suspected injury must be compared to the opposite side which is easy with ultrasound. Partial or full-thickness tears may be described, however it is the loss of the fibrillar appearance of the ligament which must alert the sonographer. Dynamic examination allows diagnosis of SL dislocation with a widening of the SL joint space over 4 mm¹¹.

According to previous published studies, sensitivity and specificity vary respectively from 42 to 100% and from 92 to 100%^{12,13}. In our institution, both radiographs and ultrasound are performed following each wrist trauma because it allows diagnosis of occult fractures and may provide information about SL ligament morphology due to excellent negative predictive value. Detection of a normal dorsal portion of the SL ligament essentially negates the

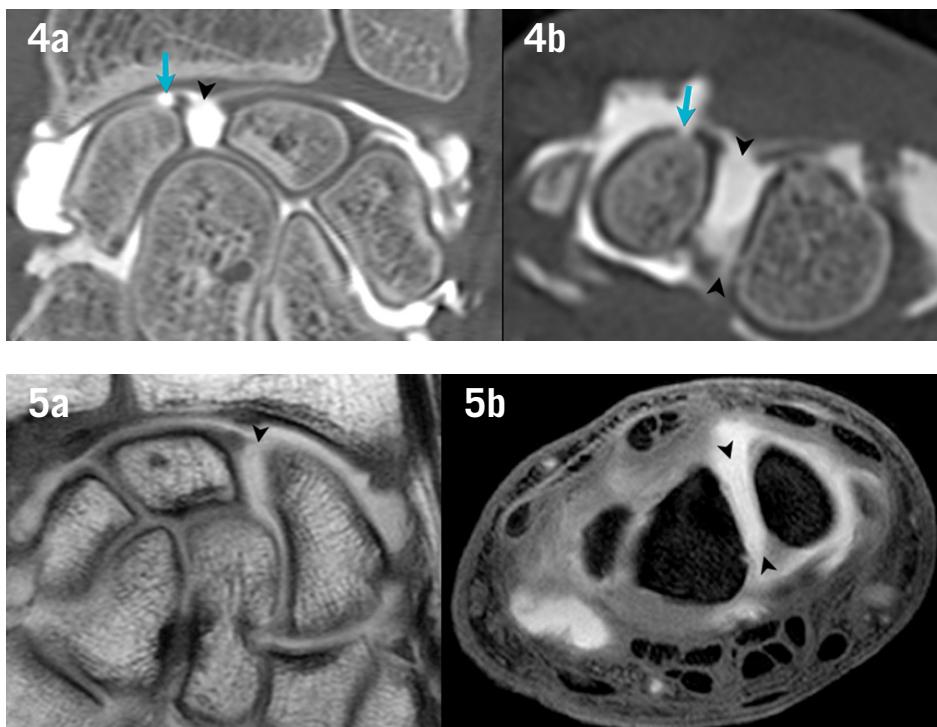


Figure 4: CT-arthrography in coronal and axial planes show complete tear of the SL (arrowheads) and chondral defect of the proximal scaphoid (blue arrows).

Figure 5: MR arthrography with coronal T1-weighted sequence a) and axial T1-weighted sequence with fat-saturation shows full-thickness tear of the three bundles of the SL ligament.



Functional outcome is better when treatment prevents instability and therefore OA



presence of dissociation. If there is any doubt, CT arthrography or MR arthrography is performed. As a matter of fact, MRI without previous arthrography is not the best diagnostic tool to depict SL tears. In a published meta-analysis for the depiction of SL ligament tears including six previous studies, sensitivity and specificity were 70 and 90%, respectively¹⁴. High signal intensity within the ligament may lead to suspect a tear but this is not specific because it can be due to degenerative changes. Tears of the ligament are diagnosed on the basis of MRI findings or irregular morphology, abnormal signal intensity and fluid partially or completely transecting the ligamentous structures¹⁵. Using 3-Tesla (3-T) MRI scanners may increase diagnosis performance according to a recent study by Magee reporting a sensitivity of 89% and a specificity of 100%¹⁶.

CT arthrography allows accurate assessment of intrinsic ligaments, TFCC, carpal bones and cartilage. The presence of iodinated contrast within the ligament is a sign of ligament tear³. CT arthrography is really useful when a SL ligament tear occurs following a distal radius fracture because it allows diagnosis of subtle chondral defects following fracture. Sensitivity and specificity are excellent (100%) according to studies comparing CT arthrography and arthroscopy^{3,17}.

MR arthrography allows diagnosis of bone marrow oedema, fracture and ligament

and tendons injuries. Its performance is better than MRI alone even if using a 3T-MRI unit¹⁶.

According to Schmitt, sensitivity and specificity vary respectively between 91 and 100% for complete tears and 62.5 and 100% for partial tears¹⁸.

A recent study by Moser found sensitivity and specificity of 100% and 87% for complete tears and 71% and 87% for partial tears but poor accuracy for the depiction of associated cartilage lesions³.

Recent studies have emphasised the role of axial traction during MR arthrography because it increases the width of the radiocarpal and the midcarpal joint spaces and allows better assessment of cartilage¹⁹.

MR arthrography allows depiction of intrinsic and extrinsic ligament tears which are associated in case of SL instability²⁰. It may show bone marrow oedema or tendinopathies that remain undetectable using CT arthrography. Nevertheless, CT arthrography provides excellent image quality and may be more easily readable by surgeons.

LUNOTRIQUETRAL LIGAMENT TEARS

The lunotriquetral interosseous ligament is continuous with the proximal surfaces of the lunate and triquetrum. Much like the SL ligament, the lunotriquetral ligament has dorsal and volar fibrous portions and a proximal membranous portion. The volar portion is thicker and more critical

for lunotriquetral stability than the dorsal portion²¹. Lunotriquetral ligament tears are often proximal and degenerative. If the tear involves the three segments, it can lead to dissociative instability with palmar tilt of the lunate resulting in volar intercalated segmental instability (VISI)^{1,3}.

Ulnar-sided wrist pain and tenderness are the most common clinical signs. Clinical examination is often normal even if an audible clunk can be found when the wrist is deviated from neutral to ulnar deviation under axial compression.

Radiographs will show disruption of the Gilula's lines and a decrease of the SL angle less than 30°⁵.

It is possible to assess normal dorsal lunotriquetral ligament by ultrasound in only 61% of asymptomatic patients according to the study of Boutry⁸. According to Finlay, although specificity was 100%, ultrasound is only 25% sensitive in detecting lunotriquetral tears¹². Compared to SL ligament, such poor results may be explained by the fact the ligament is thinner and that its volar portion, which is the most important one, is deeper and harder to assess.

As for the SL ligament, CT arthrography or MR arthrography have better accuracy than MRI in depiction for tears^{1,3}.

In the diagnosis of ulnar-sided wrist pain, lunotriquetral injuries may be differentiated from TFCC pathology, extensor carpi ulnaris dislocation,

midcarpal instability, distal radioulnar joint or pisotriquetral disorders²².

TRIANGULAR FIBROCARILAGE COMPLEX TEARS

The TFCC comprises the articular disk (triangular fibrocartilage), the meniscus homolog, the dorsal and volar radioulnar ligaments, the ulnolunate and ulnotriquetral ligaments and the sheath of the extensor carpi ulnaris (ECU) tendon. It has several anatomic variants and acts as a stabiliser of the distal radioulnar joint (DRUJ). The articular disk functions as a cushion between the ulnar head and the proximal row of the carpal bones. It is fibrocartilaginous and thicker laterally than in its central avascular portion which explains the frequency of asymptomatic degenerative tears. The thickness is inversely proportional to ulnar length and ulnar variance. The latter describes the length of the ulna relative to the radius. Ulnar positive variant may predispose to thin fibrocartilage and TFC tears²²⁻²⁴.

The meniscus homologue is a fibrous and fatty structure which does not play any role in DRUJ stability. The ECU tendon lies in its own groove within its own synovial sheath at the distal ulna. Some of the ECU sheath fibres fuse with the TFCC and makes a significant contribution to DRUJ stabilisation as the radioulnar and radiocarpal ligaments.

TFCC tears can be degenerative and occur after the third decade. They are usually asymptomatic and have to be differentiated from traumatic tears. Palmer's classification aims to classifying the kind and location of tear. Central tears (type IA) are common and are located at the horizontal portion of the articular disk just 2 to 3 mm from the

radial origin. Ulnar tears (type IB) are less common but may lead to DRUJ instability if they are not diagnosed at an early stage²⁵. Recent studies have described new entities such as 'bucket-handle' tears or association between different types of tears²⁶.

Ulnar wrist pain is the main symptom and clinical examination is relatively poor. The goal of imaging is to differentiate degenerative tears from traumatic and unstable ones.

Plain radiographs are often normal but are important to assess ulnar variance which is measured from the centre of the distal articular surfaces of the radius and ulna. Care should be taken to measure it without any degree of pronation or supination of the forearm, which can change the relative lengths of the distal radius and ulna. If the ulna is more than 2 mm longer than the radius, variance is considered positive. Otherwise, it is neutral when there is no difference and negative when ulna is more than 2 mm shorter relative to the radius²².

Ultrasound allows a partial visualisation of the TFCC because the size of the acoustic window varies with the size and the morphology of the ulnar styloid and the ulnar variance. Articular disk assessment may be limited if there is a positive ulnar variance or if the ulnar styloid is hypertrophic²⁷. According to recent studies, sensitivity ranged from 63 to 100% whereas specificity was 100%^{12,28}. Nevertheless, it is not possible to distinguish degenerative tears from traumatic ones and the location of tears has not been described in those studies²⁷. For these reasons, ultrasound is not the modality of choice in order to assess TFCC integrity. CT may show indirect sign of TFCC injuries if DRUJ dislocation is present. CT accuracy may be increased when



Figure 6: Lateral view shows volar tilt of the lunate resulting in ventral intercalated segmental instability deformation. VISI (Volar Intercalated Segmental Instability) deformation due to lunotriquetral complete tear.

performing additional acquisition in prone and supine position which allows depiction of dynamic instability but CT alone remains unable to diagnose tears¹.

MRI allows diagnosis of central and radial tears with a sensitivity ranging from 93 to 100% and a specificity ranging from 90 and 100%. T2-weighted sequences in coronal and sagittal planes are the most useful to diagnose TFCC tears whereas the axial plane allows to assess DRUJ stability. Nevertheless, ulnar-sided tears (grade IB and IC) remain a challenging problem for MRI when seeking for TFCC injuries. For IB and IC tears, sensitivity is low and ranges from 17 and 25% whereas specificity ranges from 50 to 79%. It is mostly due to the

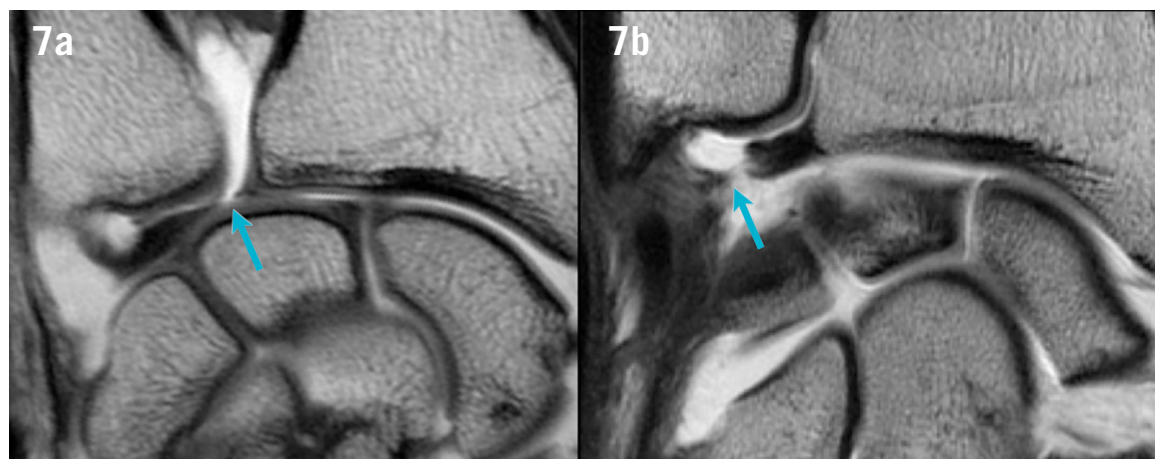


Figure 7: MR arthrography in coronal T1-weighted sequence from two different patients shows central a) and ulnar-sided b) tear.

presence of the ligamentum subcruentum which is a highly vascularised connective tissue which appears hyperintense on T2-weighted sequences^{1,3,15}.

The use of 3-T MRI increases the accuracy of MRI because it allows higher signal/noise ratio and provides images with isotropic resolution¹⁶. CT arthrography is widely used because it gives an assessment of ligament injuries and associated chondral lesions with excellent sensitivity¹⁷. Its weakness remains the analysis of ulnocarpal and extrinsic ligament injuries. MR arthrography is the modality of choice for TFCC assessment because it allows the combined advantages of CT arthrography for depiction of chondral injuries and MRI for soft-tissue abnormalities and bone marrow oedema. 3D-sequences and isotropic resolution are useful to differentiate ligamentum subcruentum from true ulnar-sided tears and to diagnose partial-thickness tears of the articular disk or recently described flap tears^{1,3}.

Differential diagnoses of TFCC injuries include:

- **Ulnar styloid fractures** most will lead to pseudarthrosis or non-union. Type 1

concerns the tip of the styloid whereas type 2 occurs at the basis and may be associated with TFCC injuries and DRUJ dislocation. It is sometimes difficult to differentiate old injuries from recent ones and MRI is superior to any other imaging tool to detect bone marrow oedema due to acute or subacute lesion^{1,22}.

- **Carpal bone fractures** triquetrum fractures are the most common fracture of the carpal bones (20%) after scaphoid fracture and may be under-diagnosed on X-rays. Hamatum and pisiform fractures are less common (2%)²².
- **Kienbock's disease** consists in an osteonecrosis of the lunate and has an unknown origin. It occurs mostly in middle-aged patients and can be revealed by ulnar-sided wrist pain following wrist trauma. Negative ulnar variance or increase of the radial tilt are common risk factors of the disease. At the beginning stage (grade 1), no radiographic abnormalities can be depicted and bone marrow oedema is the only abnormality on MRI. Progressively, sclerosis of the trabecular bone occurs

and may be seen on X-ray and CT (grade 2). At an advanced stage, there is an osseous collapse (grade 3) followed by osteoarthritis involving micarpal and radiocarpal joints (grade 4)²⁹.

- **Ulnocarpal impingement** is a degenerative condition which is due to congenital or acquired (following a distal radius fracture) positive ulnar variance and described as grade 2 injuries according to Palmer classification. Accurate diagnosis is mandatory because if early stages require medical treatment, advanced stages and osteoarthritis may lead to higher disability which can be surgically treated by various methods including ulnar osteotomy, DRUJ arthrodesis or ulnar head resection. Differential diagnosis include radio-ulnar or hamato-lunate impingement which are more uncommon and have lower disability^{22,29}.
- **Extensor carpi ulnaris tendon instability** usually occurs after a tear of the ECU retinaculum which can be acute or chronic. The rupture of the ECU sheath will give rise to instability,

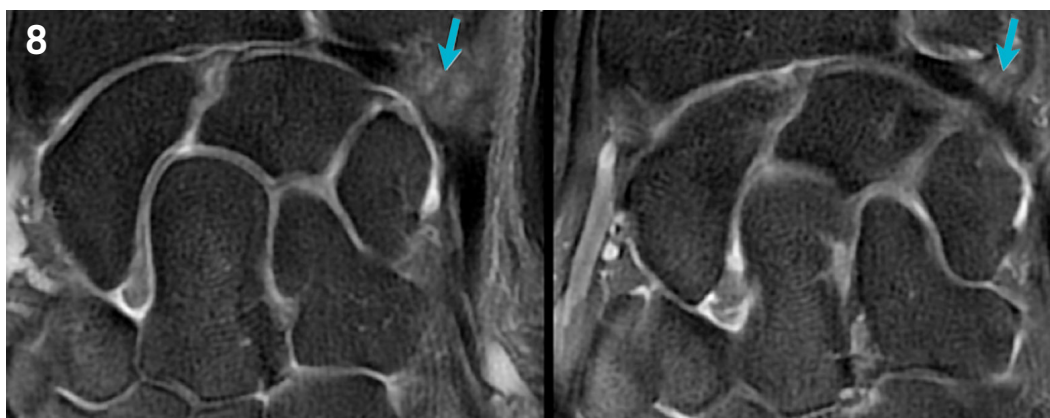


Figure 8: False-positive of an ulnar-sided tear due to presence of ligamentum subcruentum (arrow) which is a vascularised connective tissue appearing hyperintense on T2-weighted sequences at MRI.

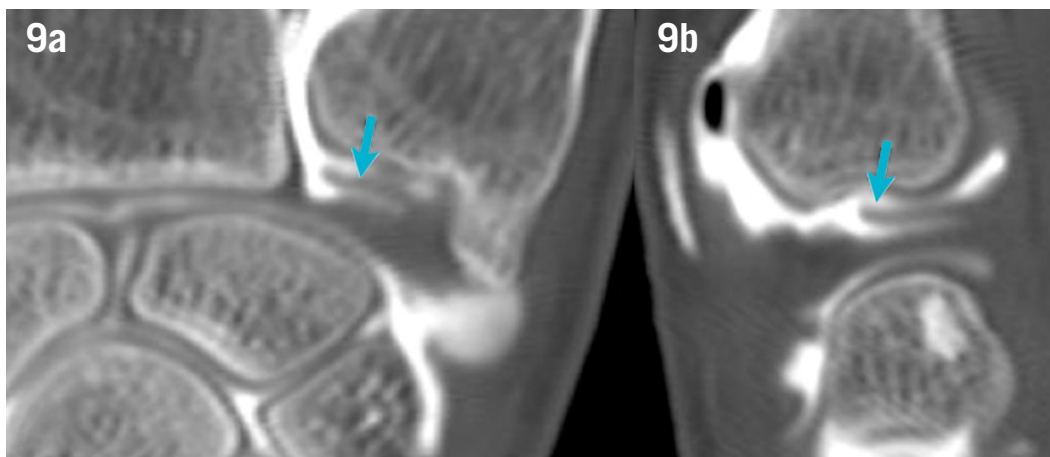


Figure 9: CT arthrography in coronal a) and sagittal b) planes shows a flap tear (arrows) of the articular disk of the triangular fibrocartilage complex.

TABLE 1

| <i>Palmer Class 1: Traumatic</i> | | <i>Palmer Class 2: Degenerative</i> | |
|----------------------------------|---------------------|-------------------------------------|------------------------------------|
| IA | Central perforation | IIA | TFCC tear |
| IB | Ulnar tear | IIB | IIA + Chondromalacia |
| IC | Distal tear | IIC | IIB + Central perforation |
| ID | Radial tear | IID | IIC + Lunotriquetral ligament tear |
| | | IIE | DRUJ + ulnocarpal arthritis |

Table 1: Palmer classification. TFCC= triangular fibrocartilage complex, DRUJ=distal radioulnar joint.

tenosynovitis and tendinopathy. Plain radiographs are usually normal and ultrasound and MRI are the best tools to seek for this condition at the acute phase. In both methods, assessment will have to be performed in prone and supine position to differentiate physiologic subluxation from dislocation¹. MRI has better accuracy than ultrasound and gadolinium intravenous injection is useful to depict former injuries, control healing and after surgical repair³⁰.

EXTRINSIC LIGAMENT TEARS

The extrinsic ligaments are those that have an insertion on the carpus and pass out of the carpus to attach on the radius or ulna³¹. There are numerous palmar extrinsic ligaments and the nomenclature of those ligaments is not really clear. Despite those considerations and anatomic variations, it is proven that palmar extrinsic ligaments play an important role in wrist stability and are torn in case of SL instability²⁰. Nevertheless, extrinsic tears represent rather benign sprains.

At the dorsal side, dorsal radiocarpal (or radiotriquetral) and intercarpal (or scaphotriquetral) ligaments are frequently injured following wrist trauma at an area of weakness located at the dorsal side of the triquetrum when both ligaments join to form a common insertion. A bony avulsion may be seen on radiographs on lateral and oblique views but is frequently underdiagnosed due to its small size. Ultrasound allows good assessment of those structures because they are superficial and easily seen. Examination is guided by the location of the pain which is at the dorsal side of the triquetrum. Ultrasound is useful to control healing and regression of hyperhaemia at doppler colour^{1,31}. Additionally, if the scar is painful, ultrasound may help to guide corticosteroid injection.

MRI may show areas of high-signal intensity on T2-weighted sequences and control healing. Nevertheless, injuries of the capsular ligaments may be missed because the anatomy of those structures remains complex and unknown²⁰.

Bone marrow oedema within the triquetrum can be the only indirect pattern of avulsion and ligament injury. When it is present, it is important to carefully assess dorsal radiocarpal, intercarpal and unocarpal ligaments with thin slices and gradient echo imaging^{32,33}.

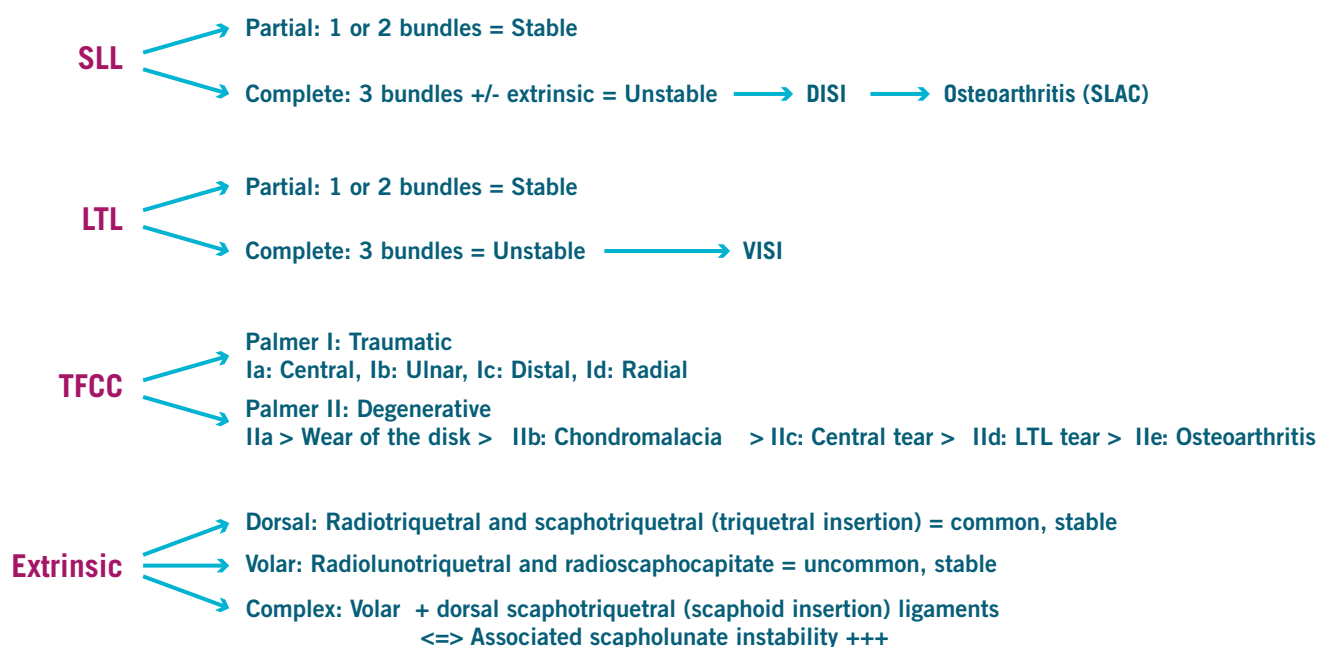


Table 2: Diagram of wrist ligament injuries. SLL=scapholunate ligament, LTL=lunotriquetral ligament, TFCC=triangular fibrocartilage complex, DISI=dorsal intercalated segmental instability, SLAC=scapholunate advanced collapse, VISI=volar intercalated segmental instability.

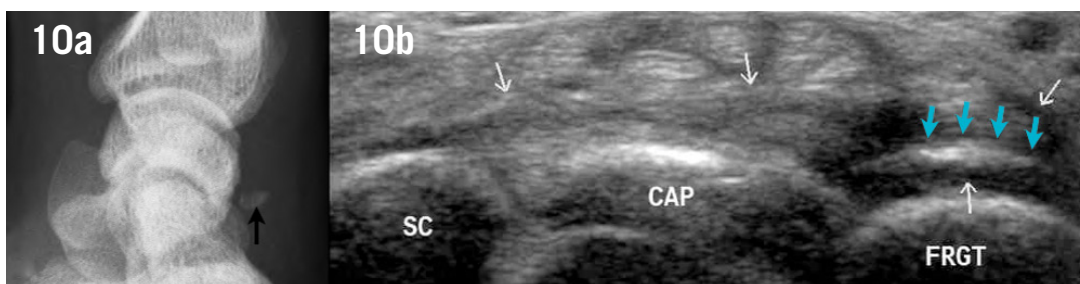


Figure 10: Lateral radiograph a) and ultrasound in axial plane b) show bony avulsion of the dorsal triquetrum (blue arrows) in continuity with dorsal scaphotriquetral ligament (white arrows). SC=scaphoid, CAP=capitulum, FRGT=osseous fragment (avulsion).

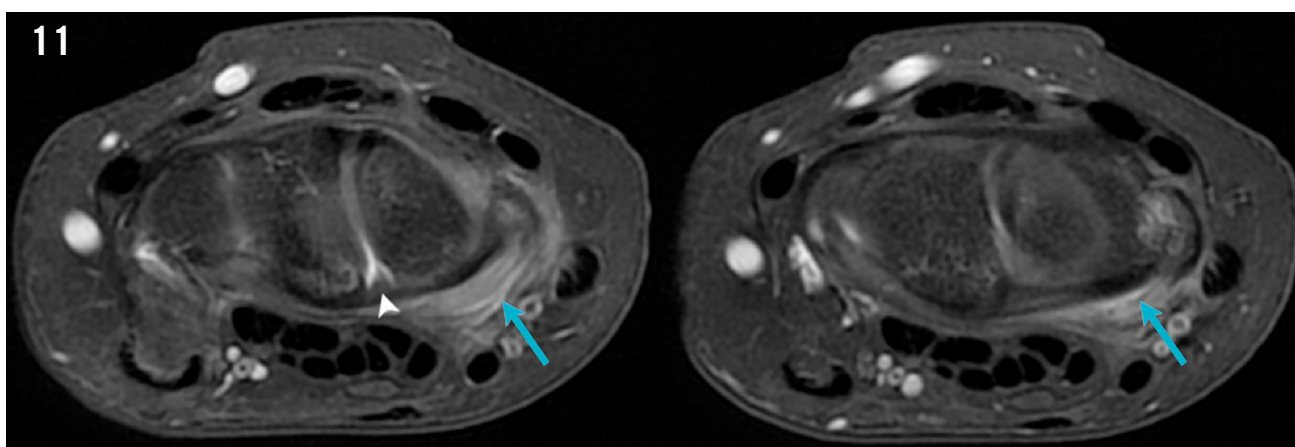


Figure 11: MRI with T2-weighted sequences in axial plane shows non-fluid like high signal intensity of palmar radioscaphocapitate and radiolunate ligaments (blue arrows). Palmar scapholunate (arrowheads) ligament is normal.

CONCLUSION

There are several ways to explore wrist sprains. In handball players, a quick and accurate diagnosis is mandatory to allow a faster return to play. Radiographs and ultrasound both have to be performed at the acute phase. It is important to keep in mind that ultrasound has gained interest in the recent years. It has an excellent negative predictive value to rule out SL ligament injury and may help depict occult fractures, especially for the scaphoid. Recent studies have shown its interest for the knowledge and the assessment of extrinsic ligaments and benign sprains. It remains insufficient for the analysis of TFCC which require further diagnostic tools. If negative, MR arthrography, CT arthrography and arthroscopy are the best methods to assess ligaments in case of suspected severe wrist sprain.

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MR arthrography and CT arthrography are superior to MRI to diagnose wrist ligament injuries



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