Dynamic high-resolution ultrasound of intrinsic and extrinsic ligaments of the wrist: how to make it simple

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Learning objectives

• To enlighten readers about the normal sonographic appearance of intrinsic and extrinsic carpal ligaments;
• To describe a systematic approach for US assessment of intrinsic and extrinsic carpal ligaments with detailed anatomic landmarks, dynamic manoeuvres and scanning technique.
Background

Intrinsic and extrinsic ligaments of the wrist stabilize the carpal bones during movement, acting as a guide with respect to the forearm bones and metacarpals, and transmitting motion from one carpal bone to another. They are intracapsular, extrasynovial structures, termed for the origin and insertion bones, proximal to distal and radial to ulnar. Extrinsic ligaments connect the carpus with the forearm bones or distal radioulnar ligaments; intrinsic ligaments are entirely situated within the carpus and connect adjacent bones within the proximal or distal row (interosseus ligaments), or pass over the midcarpal joint (midcarpal ligaments).

Lesions of wrist ligaments have been demonstrated to occur largely, mostly in patients with history of wrist trauma and carpal instability. In the setting of acute trauma, the prevalence of extrinsic and intrinsic ligament injury has recently been reported as 75% and 60%, respectively, being higher in case of concomitant osseous lesions. Carpal ligament abnormalities may also occur as a result of chronic, progressive diseases, such as rheumatoid arthritis. Early diagnosis is crucial to ensure optimal clinical management. Arthroscopy is regarded as the reference standard, but it is invasive and may be complicated by injuries of adjacent tendons, nerves, and vessels. Thus, imaging plays an essential role in the evaluation of wrist ligaments. Wrist ligaments are effectively examined with MR imaging and MR arthrography, which are however relatively expensive and burdened by artefacts if metallic implants are present; further, they are often unavailable in the context of acute trauma. Promising results have been published on US of carpal ligaments. Currently, this examination is not performed in routine clinical practice, maybe due to its technical feasibility considered as quite complex. Doubtless, more energy should be invested in this diagnostic tool that is inexpensive and largely available and, more importantly, allows to address the clinical question quickly with a focused examination of the injured structure.
General Principles of US Examination

Intrinsic and extrinsic ligaments of the wrist consist of bundles of parallel-oriented type I collagen fibers and show a fibrillar pattern at US examination. The US beam must be directed as perpendicular as possible to the evaluated structure in order to avoid anisotropy, an artifactual decrease in echogenicity that may be misinterpreted as a pathological change.

The assessment of carpal ligaments is achieved with commercially available high-frequency linear-array transducers, typically 12 MHz or greater. All images here presented were acquired with a RS80A prestige US System (Samsung Medison, Seoul, Korea) equipped with a 16-3 MHz linear probe ideally suited for small parts and musculoskeletal imaging. A large amount of US gel is recommended for optimal visualization.

The patient sits opposite the operator with the hand and forearm lying on a flat surface. Anatomic bony landmarks are essential for correct alignment of US probe and proper identification of carpal ligaments. Wrist ligaments are primarily visualized along their longitudinal axis and appear as fibrillar structures deeper than wrist tendons; short axis examination may be helpful to confirm imaging findings. A tear is suspected if ligament fibers are discontinuous, or the ligament is not seen in the expected anatomic location. Ligamentous thinning as well as fragmentation, heterogeneous echotexture or blurred surface suggest chronic abnormalities.

Dynamic manoeuvres can be performed to stress the wrist joint and produce tension in the carpal ligaments. This enables to straighten the ligament and make it more perpendicular to US beam to examine thoroughly from origin to insertion. Pertinent dynamic manoeuvres as well as specific anatomic landmarks are detailed for each subgroup of ligaments below.

Palmar Extrinsic and Intrinsic Midcarpal Ligaments

The extrinsic palmar ligaments are examined with the wrist in supination; dynamic manoeuvre of wrist extension is valuable to best detect the ligaments along their entire length. On the radial side of the volar wrist, the transducer is placed in the longitudinal plane using the radial styloid process as the starting anatomic landmark. It is then translated distally and medially and slightly rotated in order to assess, from lateral to medial, the radioscapohapitate, long radiolunate and short radiolunate ligaments. The radioscapohapitate ligament (Figs. 1-2) arises at the distal radius, from the styloid process to approximately the lateral half of the scaphoid fossa, and attaches to the scaphoid and, after crossing over the midcarpal joint, to the capitate. The long radiolunate
ligament (Figs. 3-4), also known as the palmar radiotriquetral or radiolunotriquetral ligament, spans over the remaining part of the scaphoid fossa; it courses over and stabilizes the proximal pole of the scaphoid, without any attachment to it, before inserting into the lunate and triquetrum. The short radiolunate ligament (Figs. 5-6) connects the lunate fossa of the radius and the lunate.

On the ulnar side of the volar wrist, the probe is placed in the longitudinal plane using the ulnar styloid process as the starting anatomic landmark. Thereafter, it is shifted distally and laterally and mildly rotated in order to visualize, from medial to lateral, the palmar ulnotriquetral, palmar ulnocapitate and palmar ulnolunate ligaments. The palmar ulnotriquetral (Figs. 7-8) and ulnolunate (Figs. 9-10) ligaments have no clear proximal demarcation as they share a common origin, from the volar distal radioulnar ligament, and inserts into the triquetrum and lunate, respectively. The palmar ulnocapitate ligament (Figs. 11-12) arises directly from the ulnar head, in the region of fovea, and extends distally between the ulnotriquetral and ulnolunate ligaments lying in a superficial position; it crosses over the midcarpal joint and reaches the capitate, interdigitating with the radioscapohcapitate ligament and thus forming an arc-like ligamentous structure called the arcuate ligament.

The volar midcarpal ligaments include the palmar scaphotriquetral, scaphotrapeziotrapezoid, scaphocapitate, triquetrohamate and triquetrocapitate ligaments. Among them, only the palmar scaphotriquetral ligament has been described in US studies. It is examined by positioning the transducer in the transverse plane on the radial side of the volar wrist, over the distal radius as the starting anatomic landmark. The transducer is shifted distally and translated medially along the first carpal row to visualize the palmar scaphotriquetral ligament along its entire length. The palmar scaphotriquetral ligament (Figs. 13-14) originates from the scaphoid, extends over the capitate with no attachment to it, and terminates on the triquetrum. Its fibers interweave with the arcuate ligament.

Dorsal Extrinsic and Intrinsic Midcarpal Ligaments

The dorsal extrinsic and intrinsic midcarpal ligaments include the dorsal radiocarpal and the dorsal intercarpal ligaments, respectively. They are examined with the wrist in pronation; dynamic manoeuvre of wrist flexion may help in strengthening the ligaments and appreciating their full length. On the dorsal wrist, the transducer is positioned in the transverse plane using the Lister tubercle as the starting anatomic landmark. The transducer is then shifted distally and slightly rotated toward the lunate and triquetrum to identify the dorsal radiocarpal ligament. The dorsal radiocarpal ligament (Figs. 15-16), also known as the dorsal radiotriquetral or radiolunotriquetral ligament, arises from the radius, distally to the Lister tubercle, and inserts into the lunate and triquetrum; it is deeper than the IV extensor compartment of the wrist. The dorsal intercarpal ligament (Figs. 17-18), also known as the dorsal radioscapohcapitate ligament, arises from the triquetrum and emits a proximal band inserting into the scaphoid and a distal band terminating on the
the trapezoid, thus having a V-shaped configuration; it may also have additional attachments to the lunate or trapezium. In order to evaluate the proximal band of the dorsal intercarpal ligament, from the position previously described the probe is rotated with its radial edge toward the scaphoid and then aligned along the first carpal row. Thereafter, the probe is pointed at the triquetrum and further rotated with its radial edge toward the trapezoid to identify the distal band of the ligament. The dorsal ulnotriquetral ligament described in the radiology literature is a capsular thickening more than a proper ligament. With the wrist in pronation or in pronation and slight flexion, the probe is positioned in the longitudinal plane over the ulnar styloid process as the starting anatomic landmark and then moved distally and in the ulnar direction. The dorsal ulnotriquetral ligament (Figs. 19-20) appears as an echogenic band extending between the dorsal aspect of the ulnar head and the triquetrum.

**Intrinsic Interosseus Ligaments**

The proximal interosseus ligaments consist of both a volar and a dorsal band connected at their proximal pole, thus dividing the radiocarpal and midcarpal joint spaces. The volar bands of the proximal interosseus ligaments are evaluated with the wrist in supination; slight wrist extension creates tension in the ligaments and then optimizes their visualization. On the volar aspect of the wrist, the transducer is placed in the transverse plane using the distal radius as the starting anatomic landmark. It is shifted distally and then medially along the first row of carpal bones in order to identify, from radial to ulnar, the volar band of the scapholunate and lunotriquetral ligaments. The dorsal bands of the proximal interosseous ligaments are examined with the wrist in pronation; dynamic manoeuvre of wrist flexion may help in strengthening and then best depicting the ligaments. On the dorsal side of the wrist, the transducer is positioned in the transverse plane over the Lister tubercle as the starting anatomic landmark. It is then translated distally and moved in the ulnar direction along the first carpal row to identify, from radial to ulnar, the dorsal bands of the scapholunate and lunotriquetral ligaments. Both the volar and dorsal bands of the scapholunate (Figs. 21-24) and lunotriquetral (Figs. 25-28) ligaments are visualized as triangular-shaped structures that connect the scaphoid and lunate and the lunate and triquetrum, respectively. On the volar aspect of the wrist, the scapholunate and lunotriquetral ligaments interdigitate with the extrinsic long radiolunate and ulnocapitate ligaments, respectively.

The distal interosseus ligaments separate the midcarpal and carpometacarpal joint spaces and include, from radial to ulnar, the trapeziotrapezoid, trapezocapitate and capitohamate ligaments. Although accessible to US assessment, the distal interosseus ligaments do not usually need to be examined in routine clinical practice, as they are extremely powerful and seldom torn.

**Extrinsic Collateral Ligaments**
The extrinsic collateral ligaments described in the radiology literature represent capsular thickening more than proper ligaments. They are examined with the wrist in pronation; ulnar and radial deviation are valuable dynamic manoeuvres to image the radial and ulnar collateral ligaments, respectively. On the radial side of the dorsal wrist, the probe is placed in the longitudinal plane, using the radial styloid process as the starting anatomic landmark, and then shifted distally toward the scaphoid. The radial collateral ligament (Figs. 29-30) is visualized as an echogenic structure extending from the radial styloid process to the scaphoid, deeper than the I extensor compartment of the wrist. Similarly, the ulnar collateral ligament is identified on the ulnar side of the dorsal wrist by placing the transducer in the longitudinal plane, over the ulnar styloid process as the starting anatomic landmark, and then shifting it distally toward the triquetrum. The ulnar collateral ligament (Figs. 31-32) appears as an echogenic structure connecting the ulnar styloid and the triquetrum, deeper than the VI extensor compartment of the wrist. It belongs to the triangular fibrocartilage complex, which stabilizes the ulnar wrist.
**Fig. 1:** Radioscaphocapitate ligament, schematic drawing. This ligament (yellow) arises at the palmar aspect of the distal radius, from the radial styloid to approximately the middle of the scaphoid fossa, and attaches to the scaphoid and capitate. R, radius; S, scaphoid; C, capitate.

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Fig. 2: Radioscaphocapitate ligament, US scan. This ligament (arrowheads) arises at the palmar aspect of the distal radius, from the radial styloid to approximately the middle of the scaphoid fossa, and attaches to the scaphoid and capitate.

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Fig. 3: Long radiolunate ligament, schematic drawing. This ligament (yellow) originates at the volar aspect of the distal radius, from the medial half of the scaphoid fossa, and inserts into the lunate and triquetrum. R, radius; L, lunate; T, triquetrum.

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**Fig. 4:** Long radiolunate ligament, US scan. This ligament (arrowheads) originates at the volar aspect of the distal radius, from the medial half of the scaphoid fossa, and inserts into the lunate and triquetrum.

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Fig. 5: Short radiolunate ligament, schematic drawing. This ligament (yellow) extends between the lunate fossa, on the palmar aspect of the distal radius, and the lunate. R, radius; L, lunate.

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Fig. 6: Short radiolunate ligament, US scan. This ligament (arrowheads) extends between the lunate fossa, on the palmar aspect of the distal radius, and the lunate.

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Fig. 7: Palmar ulnotriquetral ligament, schematic drawing. This ligament (yellow) originates at the volar aspect of the distal ulna, properly from the volar distal radioulnar ligament, and attaches to the triquetrum. U, ulna; T, triquetrum.

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**Fig. 8:** Palmar ulnotriquetral ligament, US scan. This ligament (arrowheads) originates at the volar aspect of the distal ulna, properly from the volar distal radioulnar ligament, and attaches to the triquetrum.

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Fig. 9: Palmar ulnolunate ligament, schematic drawing. This ligament (yellow) arises at the volar aspect of the distal ulna, properly from the volar distal radioulnar ligament, and inserts into the lunate. U, ulna; L, lunate.

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Fig. 10: Palmar ulnolunate ligament, US scan. This ligament (arrowheads) arises at the volar aspect of the distal ulna, properly from the volar distal radioulnar ligament, and inserts into the lunate.

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Fig. 11: Palmar ulnocapitate ligament, schematic drawing. This ligament (yellow) originates at the volar aspect of the ulnar head, from the region of fovea, extends distally superficial to the ulnolunate and ulnotriquetral ligaments, and terminates on the capitate. U, ulna; C, capitate.

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Fig. 12: Palmar ulnocapitate ligament, US scan. This ligament (arrowheads) originates at the volar aspect of the ulnar head, from the region of fovea, extends distally superficial to the ulnolunate and ulnotriquetral ligaments, and terminates on the capitate.

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Fig. 13: Palmar scaphotriquetral ligament, schematic drawing. This ligament (yellow) extends between the scaphoid and triquetrum on the volar aspect of the carpus. S, scaphoid; T, triquetrum.

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Fig. 14: Palmar scaphotriquetral ligament, US scan. This ligament (arrowheads) extends between the scaphoid and triquetrum on the volar aspect of the carpus.

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**Fig. 15:** Dorsal radiocarpal ligament, schematic drawing. This ligament (yellow) originates from the dorsal aspect of the distal radius, distally to the Lister tubercle, and attaches to the lunate and triquetrum. R, radius; L, lunate; T, triquetrum.

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Fig. 16: Dorsal radiocarpal ligament, US scan. This ligament (arrowheads) originates from the dorsal aspect of the distal radius, distally to the Lister tubercle, and attaches to the lunate and triquetrum.

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**Fig. 17:** Dorsal intercarpal ligament, schematic drawing. This ligament (yellow) has a V-shaped structure: it originates from the dorsal aspect of the triquetrum, and emits a proximal band attaching to the scaphoid and a distal band inserting into the trapezoid. S, scaphoid; T, trapezium; Td, trapezoid.

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Fig. 18: Dorsal intercarpal ligament, US scan. This ligament has a V-shaped structure: it originates from the dorsal aspect of the triquetrum, and emits a proximal band (arrowheads) attaching to the scaphoid and a distal band inserting into the trapezoid.

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**Fig. 19:** Dorsal ulnotriquetral ligament, schematic drawing. This is a capsular thickening more than a proper ligament (yellow) and connects the dorsal aspect of the ulnar head with the triquetrum. U, ulna; T, triquetrum.

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Fig. 20: Dorsal ulnotriquetral ligament, US scan. This is a capsular thickening more than a proper ligament (arrowheads) and connects the dorsal aspect of the ulnar head with the triquetrum.

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Fig. 21: Scapholunate ligament (volar band), schematic drawing. This ligament extends between the scaphoid and the lunate, and consists of both a volar (yellow) and a dorsal band connected at their proximal pole, thus dividing the radiocarpal and midcarpal joint spaces. S, scaphoid; L, lunate.

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**Fig. 22:** Scapholunate ligament (volar band), US scan. This ligament extends between the scaphoid and the lunate, and consists of both a volar (arrowheads) and a dorsal band connected at their proximal pole, thus dividing the radiocarpal and midcarpal joint spaces.

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Fig. 23: Scapholunate ligament (dorsal band), schematic drawing. This ligament extends between the scaphoid and the lunate, and consists of both a volar and a dorsal (yellow) band connected at their proximal pole, thus dividing the radiocarpal and midcarpal joint spaces.

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**Fig. 24:** Scapholunate ligament (dorsal band), US scan. This ligament extends between the scaphoid and the lunate, and consists of both a volar and a dorsal (arrowheads) band connected at their proximal pole, thus dividing the radiocarpal and midcarpal joint spaces.

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Fig. 25: Lunotriquetral ligament (volar band), schematic drawing. This ligament extends between the lunate and the triquetrum, and has both a volar (yellow) and a dorsal band connected at their proximal pole, thus separating the radiocarpal and midcarpal joint spaces. L, lunate; T, triquetrum.

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**Fig. 26:** Lunotriquetral ligament (volar band), US scan. This ligament extends between the lunate and the triquetrum, and has both a volar (arrowheads) and a dorsal band connected at their proximal pole, thus separating the radiocarpal and midcarpal joint spaces.

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**Fig. 27:** Lunotriquetral ligament (dorsal band), schematic drawing. This ligament extends between the lunate and the triquetrum, and has both a volar and a dorsal (yellow) band connected at their proximal pole, thus separating the radiocarpal and midcarpal joint spaces. L, lunate; T, triquetrum.

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Fig. 28: Lunotriquetral ligament (dorsal band), US scan. This ligament extends between the lunate and the triquetrum, and has both a volar and a dorsal band (arrowheads) connected at their proximal pole, thus separating the radiocarpal and midcarpal joint spaces.

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**Fig. 29:** Radial collateral ligament, schematic drawing. This is a capsular thickening more than a proper ligament (yellow) and extends between the radial styloid process and the scaphoid. R, radius; S, scaphoid.

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**Fig. 30:** Radial collateral ligament, US scan. This is a capsular thickening more than a proper ligament (arrowheads) and extends between the radial styloid process and the scaphoid.

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**Fig. 31:** Ulnar collateral ligament, schematic drawing. This is a capsular thickening more than a proper ligament (yellow) and extends between the ulnar styloid process and the triquetrum. U, ulna; T, triquetrum.
Fig. 32: Ulnar collateral ligament, US scan. This is a capsular thickening more than a proper ligament (arrowheads) and extends between the ulnar styloid process and the triquetrum.

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Conclusion

US provides an imaging modality alternative to MR imaging and MR arthrography in the assessment of the intrinsic and extrinsic ligaments of the wrist. Taking advantage of the high resolution of latest-generation US systems, a proper understanding of anatomic landmarks, dynamic manoeuvres and scanning technique allows to comprehensively evaluating the intrinsic and extrinsic carpal ligaments with exquisite detail.
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