High-resolution ultrasound of the extrinsic carpal ligaments[☆]

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KEYWORDS

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Abstract Thanks to its intrinsic high spatial resolution, ultrasound is an ideal imaging modality for examining very thin, superficial structures, and this makes it very helpful in the evaluation of extrinsic carpal ligaments. These structures, which arise from the radius and ulna and insert on the carpal bones, are extremely important for wrist stability. Previous studies have assessed the use of ultrasound to study the extrinsic carpal ligaments in cadavers, healthy asymptomatic subjects, and patients with rheumatoid arthritis. In the present report, we review the normal anatomy, biomechanics, and ultrasound appearance of these ligaments.

Sommario L'ecografia è una metodica di imaging che, grazie alla sua elevata risoluzione spaziale, appare ideale nella valutazione di strutture superficiali anche molto sottili. Questa caratteristica la rende una metodica estremamente valida nella valutazione dei legamenti estrinseci del carpo. Tali strutture originano dal radio e dall'ulna e si inseriscono sulle ossa della filiera carpale dando così un contributo fondamentale alla stabilità del carpo. Solo due studi in letteratura hanno descritto l'utilizzo dell'ecografia nella valutazione dei legamenti estrinseci del carpo su cadavere e in pazienti sani asintomatici. Un terzo studio ha invece descritto l'aspetto di tali legamenti in pazienti affetti da artrite reumatoide. Nel presente studio è riportata una revisione dell'anatomia normale, della biomeccanica, e dell'aspetto ecografico dei legamenti estrinseci del carpo.

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Introduction

The concept of wrist stability has been widely discussed in recent years. It is the result of complex interaction between bony structures and the intrinsic and extrinsic ligaments of the wrist [1].

Traumatic and degenerative lesions of the intrinsic carpal ligaments have been well characterized with several imaging modalities, including ultrasound, computed tomography (CT), magnetic resonance (MR), and CT- and MR-arthrography, which involve the intrarticular injection of contrast agents [2–6].

Much has been written about the anatomy and function of the extrinsic ligaments of the wrist. Mayfield et al. [7] described the importance in wrist instability of the volar radiocarpal ligaments. Other studies have confirmed the importance of the dorsal extrinsic ligaments [2–4]. The role of the latter ligaments as secondary wrist stabilizers is well established. The extrinsic ligaments have also been evaluated with a variety of imaging modalities [2–4,8–11], and ultrasonography has proved to be a valuable tool for this purpose in normal subjects and in patients with rheumatoid arthritis (RA) [8–11]. This article provides a review of the literature regarding ultrasound evaluation of the extrinsic carpal ligaments in individuals of both types.

Normal anatomy

The extrinsic ligaments originate from the carpal bones and pass out of the wrist to insert onto the radius or ulna. These features make them important for wrist stability [10,12]. The extrinsic ligaments are subdivided into the dorsal ligaments, the volar (or palmar) ligaments, and the collateral ligaments. The extrinsic ligaments located on the palmar side of the wrist are the radioscaphocapitate (RSC), the radiolunotriquetral (RLT), the radioscapholunate (RSL), the palmar ulnolunate (pUL), and the palmar ulnotriquetral (pUT) ligaments. Those on the dorsal aspect include the radiotriquetral (dRT) and the ulnotriquetral (dUT) ligaments. The collateral ligaments include the radial collateral (RC) and the ulnar collateral (UC).

All of the extrinsic ligaments are intracapsular but extrasynovial: their outer surface is covered by the fibrous portion of the capsule, and their deep surface is covered by synovial membrane [13].

Ultrasound anatomy of the extrinsic carpal ligaments in normal subjects

The normal ultrasound anatomy of the extrinsic carpal ligaments has been documented in two previous studies [8,9], which yielded comparable results in terms of the depiction of these structures. Tables 1 and 2 show the results of the studies regarding ligament thickness and ligament visualization, respectively. The other wrist ligaments are more difficult to visualize, particularly the ulnar collateral and the radiolunate ligaments. Owing to their small size and irregular course relative to the skin surface, they were never identified in either of the studies cited above.

Palmar ligaments

The RSC and RLT ligaments can be easily identified with the aid of bony landmarks. The transducer should initially be moved along the longitudinal axis of the scaphoid bone (RSC ligament) or that of the lunate bone (RLT ligament) and then slowly rotated to achieve a plane parallel to the long axis of the ligament [8,9].

To identify the RSL, UL, and UT ligaments, the patient's wrist should be hyperextended with a cylindrical support (e.g., container of coupling gel) beneath the dorsal aspect. The transducer should be positioned longitudinally over the ulnocarpal joint and moved slowly from the medial to the lateral side to visualize the UT, the UL, and the RSL ligaments [8,9]. The triquetral and lunate bones are helpful landmarks for identifying the expected locations of the UT and UL ligaments, respectively.

The *RSC ligament* arises from the radial aspect of the wrist and extends obliquely to the palmar side of the distal scaphoid pole, where it attaches with a fibrous band. Distally, it is attached to the capitate via a broad fibrous insertion (Fig. 1). The *RLT ligament* arises from the palmar aspect of the styloid process of the radius, passes over the scaphoid bone, and inserts onto the lunate. Distally, it runs along the radial side of the pisotriquetral joint and inserts onto the palmar aspect of the triquetrum. The *RSL ligament* is firmly attached to the deep aspect of the radiolunotriquetral ligament and cannot be differentiated from it on ultrasound. This ligament has been identified and successfully evaluated with MR arthrography [6]. The *palmar ulnolunate (pUL) ligament* originates from the ulna and the palmar radioulnar ligament, runs parallel to the ulnotriquetral ligament, and inserts onto the palmar aspect of the lunate, together with the RLT ligament (Fig. 2). The *palmar ulnotriquetral (pUT) ligament* arises proximally onto the palmar side of the ulna and extends perpendicularly to its insertion on the palmar aspect of the triquetrum.

Dorsal ligaments

To identify the RT and UT ligaments, the wrist should be hyperflexed with the palmar aspect resting on a cylindrical support. The scan commences in the transverse plane over the dorsal radial tubercle (i.e., RT ligament). The UT ligament can be visualized with the transducer positioned longitudinally over the ulnocarpal joint, above the triangular fibrocartilage complex [14,15]. The *dorsal radiotriquetral (dRT) ligament* originates from the dorsal side of the distal radius, passes over the lunate, and inserts on the dorsal side of the triquetrum. The *dorsal ulnotriquetral (dUT) ligament* originates from the ulna and extends to the ulnar aspect of the triquetrum, where it shares an insertion with the dRT ligament.

Collateral ligaments

To assess the RC ligament, the patient's wrist should be placed in ulnar deviation, with the ulnar aspect of the wrist lying on a cylindrical support. To evaluate the UC ligament, the patient's wrist is placed in a pronated position, in radial

Table 1 Thickness of the extrinsic carpal ligaments measured on ultrasound and magnetic resonance arthrography.

		Healthy volunteers/cadavers				Patients with RA
		Ultrasound			MR arthrography	Ultrasound
		Boutry et al.	Lacelli et al.	Sconfienza et al.	Theumann et al.	Sconfienza et al.
Palmar	Radioscaphocapitate	2.5 ± 0.5	2.5 ± 0.3	2.6 ± 0.3	2.9 ± 0.7	1.7 ± 0.3
	Radiolunotriquetral	2.1 ± 0.5	2.1 ± 0.7	2.1 ± 0.3	3.1 ± 0.7	1.6 ± 0.4
	Radioscapholunate	n/a	n/a	n/a	2.2 ± 0.7	n/a
	Ulnolunate	2.1 ± 0.4	1.9 ± 0.7	1.9 ± 0.2	2.6 ± 0.8	1.6 ± 0.3
	Ulnotriquetral	2.3 ± 0.6	2.1 ± 0.4	2.2 ± 0.3	3.0 ± 0.7	1.7 ± 0.3
Dorsal	Radiotriquetral	1.5 ± 0.4	2.6 ± 0.4	2.5 ± 0.3	1.7 ± 0.6	1.6 ± 0.3
	Ulnotriquetral	1.9 ± 0.6	2.2 ± 0.5	2.1 ± 0.3	2.1 ± 0.5	1.6 ± 0.3
Collaterals	Radial collateral	2.2 ± 0.6	1.7 ± 0.4	1.8 ± 0.2	1.2 ± 0.4	1.6 ± 0.3
	Ulnar collateral	n/a	n/a	n/a	n/a	n/a

Note. Thickness is reported in mm (mean ± standard deviation). Abbreviations: RA, rheumatoid arthritis; MR, magnetic resonance.

deviation. In both cases, the transducer should be positioned in a coronal plane [14,15]. The *radial collateral (RC) ligament* arises laterally from the radial styloid process and inserts on the lateral aspect of the scaphoid. The *ulnar collateral (UC) ligament* has never been visualized sonographically [16]. It is part of the triangular fibrocartilage complex and is more appropriately regarded not as a ligament but as a thickening of the joint capsule extending from the ulnar styloid process to the triquetrum and the pisiform [16].

Ultrasound evaluation of extrinsic carpal ligaments in patients with RA

RA is a chronic, progressive systemic disease that affects up to 1% of the adult population [17]. The damage originates mainly in the synovia of joints and tendon sheaths. During the course of the disease, active synovial tissue may extend to bone, tendons, capsule, and ligaments [18]. The hand and wrist are the most frequent sites of involvement in patients with RA [19].

Wrist instability may become a significant problem in advanced RA [19,20]. The structural equilibrium of the wrist balance derives from the integrity of the articular

surfaces of the bones as well as that of the supporting capsular and ligamentous structures [21,22].

Only one group has reported its experience with sonographic assessment of the extrinsic carpal ligaments in patients affected by RA [11]. These ligaments presented diffuse structural damage reflected by fragmented or heterogeneous echotexture and blurred, poorly delimited outer surfaces compared with age- and sex-matched healthy controls (see Table 1). The authors also demonstrated thinning and reduced visibility of the extrinsic carpal ligaments, confirming that these structures can indeed be damaged by the destructive potential of RA [11]. As previously discussed, during sonographic studies of the extrinsic wrist ligaments, the carpal bones can be used as anatomical landmarks to ensure that the transducer is properly oriented along the course of the ligament [8,9]. However, in patients with RA, the surface of the carpal segment of these bones may be severely damaged by the disease and therefore useless as anatomical landmarks [11].

Other imaging modalities

Methods used to image the wrist have evolved from plain radiography and fluoroscopy to CT arthrography, conventional

Table 2 Detection rates of extrinsic carpal ligament visualization on ultrasound and MR arthrography.

		Ultrasound			MR arthrography
		Boutry et al.	Lacelli et al.	Sconfienza et al.	Theumann et al.
Palmar side	Radioscaphocapitate	62%	79%	100%	100%
	Radiolunotriquetral	73%	89%	100%	100%
	Radioscapholunate	0%	0%	0%	0%
	Ulnolunate	70%	65%	95%	100%
	Ulnotriquetral	88%	88%	98%	100%
Dorsal side	Radiotriquetral	93%	96%	100%	100%
	Ulnotriquetral	74%	63%	98%	100%
Collateral	Radial collateral	12%	31%	100%	100%
	Ulnar collateral	0%	0%	0%	0%

Abbreviation: MR, magnetic resonance.

Figure 1 Ultrasound appearance of the radioscaphocapitate ligament in (A) a patient with RA and (B) a normal subject.

MRI, and, more recently, MR arthrography [2–6]. CT arthrography provides valuable assessment of extrinsic carpal ligaments because of its high-resolution [3,5]. Improvements in MR imaging, including the development of thin-section, volume-acquisition sequences [23], have enabled investigators to identify intrinsic and extrinsic ligaments of the wrist that had not been directly visualized with previous imaging techniques [4]. Together with MR arthrography, these advanced techniques offer optimal depictions of all extrinsic carpal ligaments with a diagnostic accuracy of 95% (Fig. 3) [5,6].

Discussion

A variety of imaging modalities have been proposed to evaluate the extrinsic and intrinsic carpal ligaments. Many authors agree that MR arthrography should be considered the reference standard for imaging studies of carpal disorders. Ultrasound can also be used to evaluate the anatomy of the extrinsic carpal ligaments. Boutry et al. [8] and Lacelli et al. [9] reported high rates of complete visualization of extrinsic carpal ligament anatomy except for the collateral ulnar and radiolunate ligaments, which were never identified. Non-visualization of these two ligaments was also reported by Jacobson et al. [14] and Theumann et al. [4].

A study performed on patients with RA [11] revealed significant thinning of all ligaments of the wrist, confirming that even the extrinsic ligaments can be damaged by RA-associated synovitis. Using ultrasound, Sconfienza et al. [11] documented an increased incidence in RA patients (compared with healthy controls) of structural damage (manifested by fragmented echotexture and blurred outer surfaces) to both the dorsal and palmar extrinsic ligaments, which are intracapsular but extrasynovial. This finding suggests that RA can also damage extrasynovial structures. The pUL and pUT were the only ligaments that were

visualized less frequently in patients than in controls. The reason for that is not clear, because these ligaments are both easily identified in normal subjects. It is possible that increased laxity of the entire wrist joint in patients with RA favors early tears that selectively involve these ligaments. However, no surgical inspection was performed in that study [11] and no literature data have been found to support this hypothesis.

Sconfienza et al. [11] also found no correlation between ligament damage and disease characteristics, in particular, with disease activity or duration. Although these findings might be related to the small number of patients examined in this study, the authors suggested that the lack of correlation with disease duration might also reflect treatment-induced attenuation of the destructive potential of RA characteristic of the early phases of the disease [11], as described by Graudal [24]. The latter author reported that the frequency of bone erosions also tends to increase during the initial years of RA and later reach a plateau [24]. Finally, the limited number of patients in this series could have hampered demonstration of changes with disease duration.

In 2004 Muramatsu et al. [21] described an increased frequency of volar intercalated segment instability and scapholunate dissociation in a series of 100 plain films of the wrists of RA patients. Scapholunate instability is more frequently associated with dorsal intercalated segment instability [25], so its presence in the RA patients might be partly due to the rupture of ligaments. In 1995, Viegas et al. [26] used load-bearing X-rays to analyze the various combinations of ligament disruptions capable of causing ulnar translation, a type of wrist instability common in patients with RA. Thus far, no studies have been performed to correlate this finding with the ultrasound appearance of these structures.

Ultrasound evaluation of the extrinsic carpal ligaments has certain limitations. The bony landmarks normally used to orient the ultrasound probe properly along the course of the ligament [8,9] are not always available in patients with RA, because the surfaces of the carpal bones may be

Figure 2 Ultrasound appearance of the palmar ulnolunate ligament in (A) a patient with RA and (B) a normal subject.

Figure 3 Extrinsic ligaments of the palmar aspect of the wrist. (A) Coronal fat-saturated T1-weighted magnetic resonance arthrography. (B) Anatomic diagram.

severely damaged by the disease, thus making this approach suboptimal. For this reason, slight differences in probe orientation between controls and patients might diminish visibility of the extrinsic ligaments in the latter group. On the whole, however, ultrasound appears to provide accurate depiction of the extrinsic carpal ligaments in normal subjects and patients with RA. Future studies should focus on the correlation between ultrasound findings and those of other imaging modalities in the assessment of normal wrists.

Conflict of interest

The authors have no conflict of interest to declare.

Appendix A. Supplementary data

Supplementary data related to this article can be found online at <http://dx.doi.org/10.1016/j.jus.2012.09.004>.

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