High-resolution MR imaging of the ulnar and radial collateral ligaments of the wrist

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Aims and objectives

There have been many studies and classifications of the complex network of ligaments on the ulnar side of the wrist. Comparing various authors' interpretations of the anatomy of terminology of this region, there is little consensus and no universal agreement. A review by Brown, et al. quickly notes the different terminology used by different authors' classifications to describe the ligaments of the wrist.\(^1\) Hogikyan showed the existence of an ulnar collateral ligament (UCL) at that originates in the ulnar styloid, blends with the triangular fibrocartilage complex (TFCC) and meniscus, continuing distally to attach to the triquetrum and hamate, terminating at the base of the fifth metacarpal.\(^2\) Bogumil similarly indicates the UCL beginning at the base and body of the ulnar styloid, extending distally to attach to the pisiform, transverse carpal ligament, and triquetrum, finally attaching to the hamate and terminating the base of the fifth metacarpal.\(^3\) On the other hand, some investigators used different terminology to describe a ligament in this area of the wrist, most notably describing the UCL as part of the TFCC.\(^4,5\) Ishii uses the term "ulnar capsule" which spans the border of the TFCC from the ulnotriquetral ligament palmarly to the sheath of the extensor carpi ulnaris dorsally, blending on the dorsal ulnar aspect of the ulnar styloid.\(^6\) Palmer et al. also describe the UCL as part of the larger TFCC, noting the presence of fibers arising from the ulnar aspect of the ulnar styloid (calling this the UCL), and ultimately inserting distally into the triquetrum, hamate, and base of the fifth metacarpal.\(^7\) They note that the difference between the TFCC and a separate UCL is "not merely a matter of semantics", and that these two structures cannot be separated from one another. Finally, there are authors like who do not believe that the UCL exists as an independent structure, noting that this distinction may be an artificial creation due to dissection techniques that leave behind thicker fibrous tissues mistakenly classified as a separate UCL.\(^8\)

On the radial side, the nomenclature of ligaments is similarly varied, though not as controversial or discrepant as the ulnar half of the wrist.\(^8,9\) Brown identifies the fibers originating from the most radial aspect of the radial styloid, inserting on the waist of the scaphoid.\(^1\) Siegel looked at the origins and dimensions of palmar and dorsal radiocarpal ligaments, and found the radial collateral ligament (RCL) originating from the palmar tip of the radial styloid process in 28/30 wrists, and the dorsal tip in 2/30 wrists. The ligament inserted on the distal pole and waist of the scaphoid and the palmar surface of the trapezium, extending to the base of the thumb metacarpal in 12/30 wrists.\(^10\) Like many authors who found the ulnar collateral to be a part of the TFCC, Berger et al. identified the RCL as a subset of the radioscaphocapitate ligament (RSC). Fibers from the most
extreme distal aspect of the radial styloid, terminating at the radiopalmar surface of the waist of the scaphoid, form their version of the radial collateral ligament.\textsuperscript{11}

Wrist MRI is technically the most difficult and challenging among musculoskeletal MRIs. It requires high-resolution, high signal-to-noise, high contrast with small field of view imaging for accurate assessment of anatomy and pathology, because each structure of the wrist is small and thin. In addition, MRI of the collateral ligaments of the wrist has rarely been reported partially because of anatomical complexity and less consensus. Therefore, the purpose of this study was to identify and classify the morphology of the UCL and RCL of the wrist using high-resolution 2D and isotropic 3D FSE PDWI sequences.
Methods and materials

This study was approved by the institutional review board at our institute. We examined morphology and variations of the ulnar and RCLs of the wrist in 34 subjects (21 males and 13 females; 11 asymptomatic normal volunteers and 23 patients with wrist pain) with high-resolution 3D isotropic and 2D FSE MR images at 3T MRI. Subjects ranged in age from 15 to 84 years, with a mean of 46.5 years (42.9 years for volunteers and 48.3 years for patients). All MR images were obtained using an 8-channel wrist coil at a 3T system (Achieva TX, Philips Healthcare®, Best, The Netherlands). Each subject was placed in supine position with the wrist at side of the body and neutral forearm position. The following MRI sequences were reviewed for evaluation of this study; coronal 3D isotropic FSE proton density weighted images (PDWI): TR (repetition time)/TE (echo time) = 1400/28.3 msec, voxel size = 0.35x0.35x0.35 mm, gap= 0mm, FOV = 70 mm, coronal 2D FSE PDWI for volunteers: TR/TE = 3181/27 msec, voxel size = 0.23x.033x2.0 mm, gap = 0.2mm, FOV = 70 mm, and coronal 2D FSE PDWI for patients: TR/TE = 2863-4136/27 msec, voxel size = 0.23-0.36x0.31-0.50x2.0 mm, gap = 0.2mm, FOV = 90 mm. A parallel imaging technique named sensitivity encoding (SENSE) was used both in 2D and 3D sequences. All 3D images were obtained combined with driven equilibrium (DRIVE) technique. Acquisition time was 5 min and 4 sec for 3D isotropic MR images and 2 min 39 sec to 3 min 29 sec for 2D FSE sequence.

For qualitative UCL analysis, the attachment location and width to the ulnar styloid process of the UCL was evaluated using isotropic 3D and conventional 2D sequences. The attachment location and width of the UCL was classified into 4 types (type 1a: narrow attachment to tip of the ulnar styloid (Tip), type 1b: broad attachment to Tip, type 2a: narrow attachment to medial base of the ulnar styloid (Base), type 2b: broad attachment to Base; Figure 1). First, routinely reconstructed coronal 2D and 3D images were used for the analysis. Then, oblique coronal multiplanar reconstruction (MPR) images created from original coronal isotropic 3D images were used for confirmation of the UCL attachment. Connection of the UCL to the triangular ligament of the TFCC is also evaluated. For qualitative RCL analysis, the RCL width to the scaphoid and extension to the trapezium was evaluated using isotropic 3D and conventional 2D sequences. The attachment width and extension of the RCL has been classified into 4 types (type 1a: separated radioscaphoid and scaphotrapezium ligaments (RS+ST) with narrow scaphoid attachment, type 1b: RS+ST with broad scaphoid attachment, type 2a: continuous radioscaphoid and scaphotrapezium ligaments (RST) with narrow scaphoid attachment, type 2b: RST with broad scaphoid attachment; Figure 2). Anatomic delineation of the UCL and RCL were semiquantitatively evaluated with 3D and 2D sequences according to the following 5-point scorings: 4; excellent, 3; good, 2; satisfactory, 1; poor, and 0; non-identified.
The Wilcoxon Signed-Rank Test was used to determine the significance of the differences in scores between high-resolution isotropic 3D and conventional 2D sequences. In each analysis, a P value of # 0.05 was considered significant.
**Fig. 1:** Illustration of UCL types

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**Fig. 2:** Illustration of UCL types

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Results

In the UCL analysis, two cases out of 34 subjects were excluded from the analysis because of one for juvenile rheumatoid arthritis (JRA) and the other for prior severe fracture. The UCL was not identified in 2 subjects on either isotropic 3D or conventional 2D images. One was a healthy volunteer and the other was a patient with a prior history of ulnar styloid fracture. Table 1 shows the result of classification of the UCL attachment. After using oblique coronal MPR images, eight cases (25%) were changed in classification. 3 cases were classified into either type 1 or 2 from type 0 referred with reference to MPR. Type 1a (narrow attachment to tip of the ulnar styloid process) was the most common type (Figure 3). The UCL type of the patients demonstrated relatively equal distribution with more type 2 cases (attachment to the medial base of the ulnar styloid) than that of the volunteers. Fibrous connection of the UCL to the triangular ligament of the TFCC was identified in 10 cases (33.3%) with high-resolution MRI after excluding 2 cases of type 0. Figure 4 shows the semi-quantitative scoring of delineation of the UCL with 3D and 2D sequences. There was no statistical difference between these two sequences.

In the RCL analysis, one out of 34 subjects was excluded from the analysis because of JRA. The radioscaphoid and scaphotrapezium ligaments were identified in all subjects on both isotropic 3D and conventional 2D images. Table 2 shows the result of classification of the RCL attachment. Type 1a (separated radioscaphoid and scaphotrapezium ligaments with narrow scaphoid attachment) was the most common type (Figure 5). Type 1 attachment of the RCL was more common on both volunteers and patients, and demonstrated 64% of cases (Table 2). The semi-quantitative scoring of delineation of the RCL with 3D and 2D sequences revealed no statistical difference between these two sequences (Figure 4).
Table 1. Morphological classification of UCL

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Table 1: Morphological classification of UCL

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Figure 4. Semi-quantitative evaluation of UCL and RCL

Fig. 4: Semi-quantitative evaluation of UCL and RCL

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Table 2. Morphological classification of RCL

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<tr>
<td>Total</td>
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<td>64%</td>
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Table 2: Morphological classification of RCL

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Figure 3. MRI of UCL

Fig. 3: MRI of UCL

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Figure 5. MRI of RCL

**Fig. 5:** MRL of RCL

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Conclusion

The UCL and RCL were classified into 4 subtypes, respectively. The both UCL and RCL were well identified with high-resolution 2D and isotropic 3D MRI equally. MPR is useful to identify UCL attachment to the ulnar styloid more accurately.


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