IJSPT
INTERNATIONAL JOURNAL OF SPORTS PHYSICAL THERAPY

Manske RC, Wolfe C, Page P, Voight M. Diagnostic Musculoskeletal Ultrasound in the Evaluation of the Triangular Fibrocartilage Complex. *IJSPT*. 2026;21(3):337-341. doi:10.26603/001c.157566

MSK Ultrasound Bites: Tips and Tricks

Diagnostic Musculoskeletal Ultrasound in the Evaluation of the Triangular Fibrocartilage Complex

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Keywords: musculoskeletal ultrasound, wrist, triangular fibrocartilage complex, rehabilitation, dynamic imaging

https://doi.org/10.26603/001c.157566

International Journal of Sports Physical Therapy

Vol. 21, Issue 3, 2026

The wrist joint is a common site of pain and injury due to either overuse or acute trauma. Many instances of wrist pain occur on the ulnar side of the wrist. This side of the wrist is commonly referred to as the "black box" of the wrist due to its small size and complex anatomy. Housed within the ulnar side of the wrist is the triangular fibrocartilage complex (TFCC). The TFCC is a complex of soft tissues that serves as a shock absorber and stabilizer of the distal radioulnar joint (DRUJ). This entire complex around the DRUJ and TFCC is composed of a central articular disc, a dorsal/volar radioulnar ligament, ulnar collateral ligament, and the extensor carpi ulnaris sheath.

Diagnostic musculoskeletal ultrasound (MSKUS) offers a portable, real-time, and cost-effective alternative that is gaining traction in rehabilitation and sports medicine settings. MSKUS has emerged as a valuable, non-invasive imaging modality for evaluating wrist ligaments, discs, and bone. MSKUS is excellent at detecting changes in ligament composition and continuity. This manuscript will review the utility of MSKUS in evaluating TFCC and DRUJ injuries, including anatomy, common injury patterns, sonographic techniques, and clinical implications for rehabilitation professionals. Due to the small size and variety of structures in a confined space, diagnosing acute injury by physical examination is often difficult. By integrating MSKUS into clinical practice, providers can improve diagnostic accuracy, enhance diagnostic confidence, monitor healing progression, and guide rehabilitation strategies to achieve optimal patient outcomes for patients with wrist injuries.

INTRODUCTION

ANATOMY OF THE RADIOCARPAL JOINT

The distal radioulnar joint (DRUJ) is a uniaxial pivot joint with only one degree of freedom.[1] This joint connects the distal ends of the radius and ulna and is essential for rotation of the forearm. DRUJ movements are also important for functional activities such as twisting, gripping, carrying, and weight bearing of the upper extremities. One of the important stabilizers of the DRUJ is the triangular fibrocartilage complex (TFCC). The TFCC is named for its triangular shape. The TFCC is a complex structure that provides intrinsic stability to the DRUJ. The TFCC is composed of multiple structures, including both superficial and deep portions of the dorsal and volar radioulnar ligaments, the fibrous disk and ulno-meniscus homologue, the sub-sheath of the extensor carpi ulnaris, the wrist ulnar collateral ligament, and the ulnocarpal ligaments of the volar wrist that include the ulnolunate and ulnotriqeutral ligaments. Due to its anatomical complexity, this portion of the wrist has historically been called the "black box" of the wrist.[2] Clinicians' understanding of the complex anatomy of this area has improved greatly due to anatomical, cadaveric, and biomechanical studies.[3-7] The TFCC has 3 main functions: 1) stabilize the DRUJ, 2) stabilize the ulnocarpal space, and 3) act as a shock absorber to transmit ground reaction forces or loads through the ulnar side of the wrist.[8,9]

Injuries to the ulnar side of the wrist are generally overuse or traumatic, such as a fall on an outstretched hand (FOOSH). Patients will report pain on the ulnar side of the wrist, predominantly during twisting or during movements into radial or ulnar deviation. Patients will present with popping or clicking sensations, weakness, limited range of motion, swelling, and instability, characterized by the sensation that the wrist is "giving out" or "slipping". These symptoms will make most wrist activities difficult, especially those with rotation, such as opening door knobs, cooking, and/or using a screwdriver.

THE ROLE OF MSK ULTRASOUND IN TFCC INJURY

ADVANTAGES

- Non-Invasive: Point of care ultrasound is a non-invasive imaging technique that can be used for the ex-

amination of the soft tissue and ligaments DRUJ and TFCC in the distal ulnar side wrist.
- Real-Time Imaging: MSKUS enables evaluation of structures, such as the DRUJ and TFCC, as well as associated ligaments.
- High-Resolution Visualization: MSKUS provides detailed images of the DRUJ, TFCC, and ligaments.
- Accessibility and Cost-Effectiveness: MSKUS is portable, widely available, and less expensive than magnetic resonance imaging (MRI).

LIMITATIONS

- Operator Dependency: MSKUS requires skill and experience for accurate interpretation of findings. The ability to sonograph the distal ulnar side of the wrist is to a large extent influenced by the operator and the availability and technical considerations of state-of-the-art equipment.
- Depth Limitations: Visualization is usually not a problem for the superficial wrist structures.
- Artifacts and Shadows: Bone and calcifications may create image artifacts, requiring adjustments to transducer positioning and frequency.

SONOGRAPHIC TECHNIQUE FOR EVALUATING THE TFCC

Equipment Setup:

- Transducer Type: Because of the superficial nature of the wrist structures, a standard high-frequency, linear array transducer is normally used. In some instances, an L-shaped, hockey-stick-type transducer may be required.
- Patient Position: the patient typically sits with the volar forearm on the surface with the dorsal wrist facing superior. The dorsal surface is normally viewed as the structures are more superficial and easier to visualize. The transducer will be placed in the long axis (LAX) and short axis (SAX) to view the TFCC.
- Dynamic Assessment: Dynamic views can be obtained by having the patient supinate or pronate the wrist, or flex or extend the wrist while visualizing the ulnar-sided structures.

NORMAL SONOGRAPHIC APPEARANCE

Normal TFCC appears as a thin, continuous, triangular band of homogeneous echogenicity extending from the distal ulna toward the ulnar carpal bones. The margins are smooth and well defined, without fiber disruption or adjacent fluid collection. No abnormal gapping is observed at the ulnocarpal interface, and the surrounding joint recess remains collapsed in the absence of effusion.

PATHOLOGIC FINDINGS IN INJURED TFCC

Direct ultrasound findings of TFCC injury include:

- Hypoechoic or anechoic cleft seen within the normal fibrillar pattern of a normal TFCC.
- Irregular or disrupted margins of the articular disk.
- Thinning or fissuring of the TFCC indicates a partial-thickness tear.
- Abnormal thickness of the TFCC, such as thinning (degeneration) or thickening (edema or chronic overuse), may be seen as pathology.
- A complete disruption of the continuity of fibers of ligaments or the disk with fluid extending into the joint would indicate a complete full-thickness tear of the TFCC.
- Associated joint effusion and/or synovitis (synovial hypertrophy) and cysts. Joint effusion will appear as anechoic or hypoechoic fluid within the DRUJ or TFCC area. Joint effusion is somewhat compressible and mobile when transducer pressure is applied to the area. This is different from synovitis, which appears as hypoechoic or isoechoic, non-compressible tissue within the joint recess. Lastly, a ganglion cyst will appear as a well-defined, round or lobulated cystic structure with anechoic or hypoechoic internal contents. The cyst typically has a small, smooth wall and exhibits posterior acoustic enhancement. These cysts will typically be minimally or non-compressible and painful.

Indirect ultrasound findings of TFCC injury include:

- Anechoic or hypoechoic fluid indicating effusion in the joint.
- Excessive translation of the ulna relative to the radius during dynamic visualization of the movements of pronation and supination may indicate DRUJ instability.
- A bony avulsion of the ulnar styloid attachment site would be indicative of an associated peripheral TFCC tear.

CLINICAL IMPLICATIONS FOR REHABILITATION PROVIDERS

MSK ultrasound provides real-time feedback to rehabilitation professionals, facilitating early diagnosis of TFCC injuries and interventions. Key applications include:

- Early Detection of Injury / Accurate Injury Grading: MSKUS can detect small anechoic or hypoechoic fluid collections in the ulnocarpal space, indicating injury and effusion in the joint or soft tissues. Identifying this early will help guide treatment planning. Additionally, small ligament sprains or partial tears may be seen on ultrasound as irregular loss of normal fibrillar patterns.
- Dynamic Functional Testing: MSKUS can be used to dynamically stress the tissues with gentle wrist motion of supination/pronation, ulnar/radial deviation, and wrist flexion and extension to reveal signs of excessive movement or instability at the DRUJ, soft tissue impingement between bones, or abnormal findings such as cysts.

- Guided Interventions: Ultrasound imaging assists with dry needling or precision-guided injections, such as corticosteroid injections for inflammation.
- Patient Education: Real-time imaging serves as a visual aid to explain the nature of the injury and set realistic expectations for recovery.

LIMITATIONS AND CHALLENGES

As with any use of MSKUS, image interpretation and quality are operator dependent and rely heavily on experience and skill. The peripheral soft tissues are easier to see than the central portion of the disk, which is deeper and thinner, making visualization more difficult. The TFCC is a complex multicomponent structure of bones, ligaments, and soft tissues, which makes distinguishing its components difficult for the novice. Anisotropy of ligaments and disk from poor transducer placement can make TFCC fibers or ligaments appear hypoechoic or torn. Lastly, because the TFCC is housed in a relatively small area, the field of view is limited.

CONCLUSION

MSKUS is a valuable, dynamic, and cost-effective imaging modality for evaluating the TFCC. It provides high-resolution, real-time visualization of bones, cartilage, and soft tissues and can be used in both acute and chronic settings. Ultrasound allows dynamic visualization of the ulnar side of the wrist. Incorporating MSKUS into the physical therapist's clinical practice for distal wrist examination enhances diagnostic accuracy, supports timely management decisions, and ultimately improves patient outcomes in cases of suspected TFCC injury.

Published: March 01, 2026 CST.

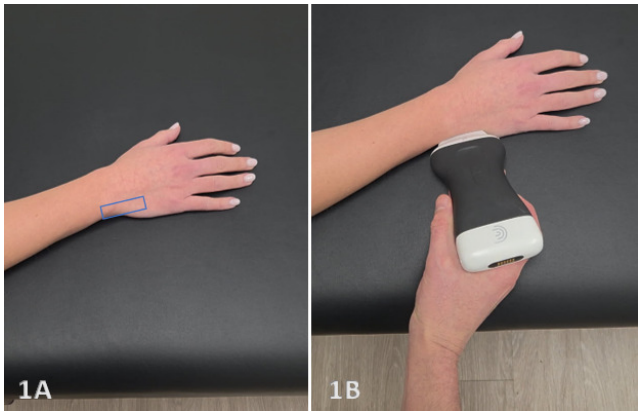
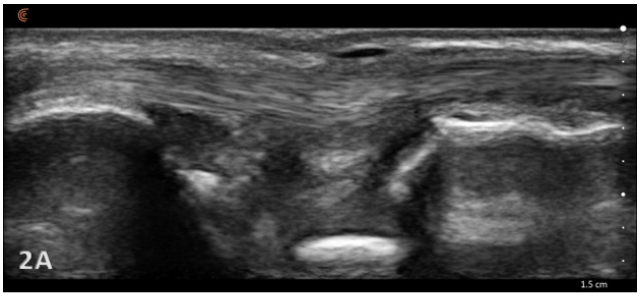
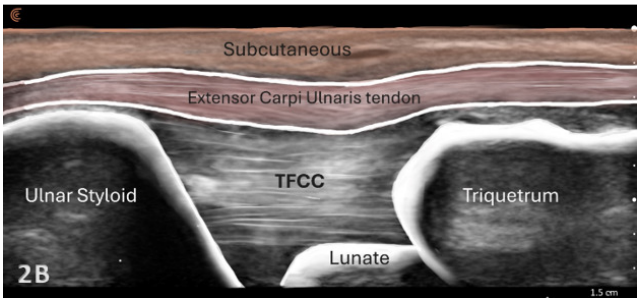


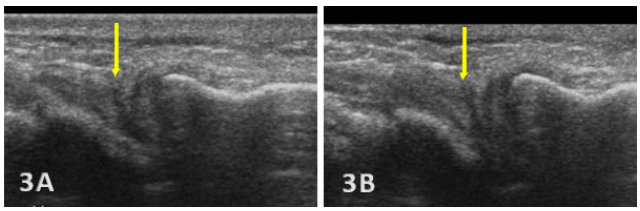
Figure 1A: Patient Positioning for the TFCC
The patient is seated facing the examiner with the forearm supported on the examination table. For imaging, the forearm is kept in pronation, and the wrist is commonly kept in neutral for initial scanning purposes. The wrist can also be placed in radial deviation to open the lateral TFCC recess. This can be done statically or dynamically during the exam for a more comprehensive view with active stress applied to the TFCC. For reference in Figure 1A above, the blue box shown indicates the placement of the transducer for long axis (LAX) viewing of the TFCC.

Figure 1B: Transducer Placement over the TFCC
For the LAX assessment of the TFCC, the transducer is placed longitudinally along the ulnar aspect of the wrist, centered over the distal ulna and ulnar styloid. The extensor carpi ulnaris (ECU) tendon serves as a key surface landmark, with the TFCC located deep to the ECU tendon and between the distal ulna and the triquetrum. Gentle transducer translation and toggling are used to optimize visualization of the TFCC and reduce anisotropy. Additional gel or standoff pad may be helpful to accommodate the curved ulnar wrist contour and improve visualization of this superficial structure.

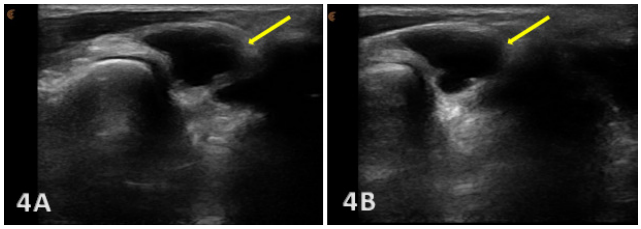




Figures 2A and 2B: TFCC in LAX
When evaluating the TFCC in LAX with ultrasound, the examination is performed along the ulnar aspect of the dorsal wrist using the ulnar styloid as the primary proximal landmark. The transducer is aligned longitudinally just distal to the ulnar styloid and oriented parallel to the distal ulna. Superficially, the ECU tendon is identified and serves as an important surface landmark, with the TFCC located immediately deep to the ECU tendon. The distal attachment of the TFCC can be oriented using the triquetrum as a bony landmark, while the lunate is visualized deep to the TFCC as part of the proximal carpal row. With careful inspection, the ulnar collateral ligament may also be visualized deep to the ECU tendon and superficial to the TFCC, further confirming correct transducer positioning.
Dynamic assessment may be performed by guiding the patient through repeated radial deviation of the wrist while maintaining visualization of the TFCC. This maneuver allows real-time assessment of TFCC biomechanics and may accentuate subtle abnormalities, including increased gapping, abnormal motion, or deeper structural compromise within the complex.
In LAX view, the normal TFCC appears as a thin, continuous, triangular band of homogeneous echogenicity extending from the distal ulna toward the ulnar carpal bones. The margins are smooth and well defined, without fiber disruption or adjacent fluid collection. No abnormal gapping is observed at the ulnocarpal interface, and the surrounding joint recess remains collapsed in the absence of effusion.



Figures 3A and 3B: Tear of the TFCC
As shown in Figures 3A and 3B above, a TFCC tear (highlighted with the yellow arrows) is characterized by disruption of the normally smooth, continuous triangular echogenic band of the complex. Sonographic findings may include focal hypoechoic or anechoic defects within the TFCC, irregular or frayed margins, thinning, or complete discontinuity of fibers. Associated findings often include ulnocarpal joint effusion, abnormal gapping at the ulnocarpal interface, or altered TFCC motion during dynamic wrist maneuvers such as radial deviation or forearm rotation. In chronic or degenerative tears, the TFCC may appear diffusely thinned and inhomogeneous rather than sharply disrupted. Dynamic assessment may accentuate abnormal motion or pain reproduction, support the diagnosis, and help differentiate partial from more extensive injury.



Figures 4A and 4B: TFCC Ganglion Cysts
Ganglion cysts at the TFCC region appear as well-defined, anechoic or hypoechoic cystic structures adjacent to the ulnocarpal joint, often arising from the TFCC or the ulnar joint capsule. These lesions typically demonstrate smooth margins, posterior acoustic enhancement, and absence of internal vascularity on Doppler imaging. Unlike TFCC tears, ganglion cysts are extra-articular, maintain a consistent shape, and show minimal compressibility with transducer pressure or dynamic wrist motion. During dynamic assessment, the cyst remains relatively unchanged while surrounding tendons and joint structures move independently. Associated findings may include localized capsular thickening or mild adjacent joint effusion, but the TFCC fibers themselves remain intact and continuous.

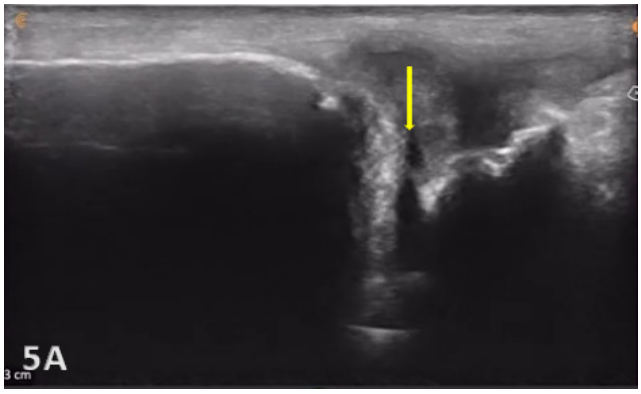


Figure 5A: Osteoarthritis with a Central Tear in the TFCC
Osteoarthritis with a central tear of the TFCC on diagnostic MSKUS is characterized above by degenerative changes at the ulnocarpal joint accompanied by disruption of the central fibrocartilaginous portion of the TFCC. Sonographic findings include irregular or uneven cortical margins of the adjacent carpal bones, capsular thickening, and narrowing of the ulnocarpal joint space. The central TFCC tear (yellow arrow) appears as focal thinning or discontinuity within the normally homogeneous triangular structure, presenting as a hypoechoic or anechoic defect. Associated findings include ulnocarpal joint effusion and synovial hypertrophy.

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