



Comparison between conventional MRI and MR arthrography in the diagnosis of triangular fibrocartilage tears and correlation with arthroscopic findings

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ABSTRACT

Purpose: The triangular fibrocartilage complex is one of the most important stabilizers of the wrist and a defect in its anatomical structure is a possible cause of ulnar sided wrist pain. The aim of this study is to compare the diagnostic accuracy between conventional MRI and MR arthrography (MRA) in the depiction of triangular fibrocartilage complex (TFCC) tears.

Methods-materials: A total of 60 patients with clinical findings that suggested TFCC tears underwent wrist MRI and MRA. All the MRI and MRA results were compared with the arthroscopic findings.

Results: 40 tears were confirmed by arthroscopy. 38/40 tears were identified by MRA while MRI identified 26/40 tears. There were also 8 false positives and 13 false negative results identified by MRI. Two false negative results were identified by MRA. No false positive results were identified.

Conclusion: MR arthrography is more sensitive and specific method in terms of the diagnosis of TFCC tears compared to conventional wrist MRI. There was no difference in the diagnostic accuracy between wrist arthroscopy and MRA.

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Introduction

The ligaments of the wrist are divided into extrinsic and intrinsic and their role is to hold together the carpal bones and stabilize the joints. The extrinsic ligaments connect the ulna, radius and metacarpals to carpal bones, while the intrinsic ligaments are intercarpal and play the most important role in terms of the stability of the wrist. The major intrinsic ligaments with the most clinical and mechanical significance are the scapholunate, the lunotriquetral and the triangular fibrocartilage complex (TFCC) [1,2]. The TFCC includes the triangular fibrocartilage disk, volar and dorsal radioulnar ligaments, volar ulnotriquetral ligament, volar ulnolunate ligament, meniscal homologue, ulnar collateral ligament and the extensor carpi ulnaris tendon sheath.

The TFCC has a radial attachment to the distal radius at the sigmoid notch and an ulnar attachment to the ulnar styloid usually with two bands that insert into the styloid process and fovea [3,4].

A major difference between the two attachments is in terms of vascularity. The peripheral portion of the TFCC has adequate vascularity while the central parts are avascular. This fact affects the therapeutic approach, as peripheral tears are amenable to surgery repair [5].

The role of the TFCC is to distribute stresses from the carpus to the forearm and provides stability to the distal radioulnar joint, especially during pronation and supination.

Tears of the TFCC are categorized by Palmer as either traumatic injuries (Palmer class I) or degenerative injuries (Palmer class II) and are proven to be a major factor of ulnar sided wrist pain and carpal instability [6,7].

The diagnosis of a TFCC lesion is a complex and difficult issue. TFCC tears were originally diagnosed by radiographic arthrography [22,23].

Magnetic resonance imaging (MRI) replaced conventional arthrography as being non invasive and providing excellent soft tissue contrast and resolution [24–26]. However, in lower magnetic fields MRI has proved less accurate especially in the diagnosis of peripheral tears having a sensitivity of only 17% [10].

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Higher fields (3 T), dedicated coils and improvements in signal to noise ratio improve MRI sensitivity in detecting the TFCC pathology [9,27,29].

Direct MR arthrography (MRA) combines the advantages of radiographic arthrography and MRI and therefore overcomes the disadvantages of both methods with higher diagnostic performance being reported [8].

The aim of this study was to compare the diagnostic accuracy of conventional MRI and direct MRA with wrist diagnostic arthrography in the detection of TFCC tears.

Materials and methods

Over a 6-year period, patients who presented in our institution with clinical signs consistent with TFCC tears were eligible to participate in the study. Inclusion criteria were willingness of patients to undergo both MRA and MRI investigations for their wrist symptoms and to complete the designed study protocol. Exclusion criteria were elderly patients above the age of 65 and patients lost to follow up. All patients underwent initially a conventional MRI exam followed by a wrist arthrogram and then referred for arthroscopy which correlated the two methods.

MRI exam was performed on a 1.5 T MR system (Magnetom, Symphony, Siemens Medical Solutions, USA).

Patients were examined in the prone position with the elbow extended overhead and with the pronated hand positioned in the center of the wrist coil with the affected wrist extended into the MR scanner beyond the patient's head, ("Superman position").

A coronal T1-weighted spin-echo was performed with TR/TE, 586/23; section thickness, mm without a gap; field of view, 88 × 100 mm; matrix size, 448 × 512. A coronal 3D double-echo steady-state gradient-echo sequence 32.24/7.8; flip angle, 30°; section thickness, 1 mm; field of view, 103 × 150 mm; matrix size, 176 × 256.

A transverse fat-saturated proton density-weighted fast spin-echo sequence was performed with 5,830/16; section thickness 3 mm; field of view, 144 × 144 mm; matrix size, 256 × 320.

MR arthrography was performed with a single compartment radiocarpal injection using 3–5 ml solution of 0,1 ml gadolinium diluted in 20 ml of normal saline and 2–3 ml of iodinated contrast only when we used fluoroscopy as imaging guidance.

In order to perform the injection, the hand was in a semi flexed position. A 22 g needle was introduced either using clinical landmarks, fluoroscopy or ultrasound guidance. The intraarticular position of the needle was confirmed fluoroscopically with the contrast distribution. When we used ultrasound guidance the

distention of the joint capsule confirmed the correct needle position. The clinical landmark that we used was the radial prominence of Lister's tubercle in order to aim the space between 3–4 arthroscopic portal with a needle angulation of 10–15° in order to be parallel to the distal radial articulate surface [31]. When injecting the solution, we ensured that no resistance was present.

The whole procedure was done under strictly sterile conditions. In two cases that there was a strong clinical suggestion of a TFCC tear, a two compartment arthrography was performed in the midcarpal and radioulnar joint.

MRI was initiated within 30 min of the contrast injection and T1 fat saturated images were obtained in axial, sagittal and coronal planes (TR/TE, 525/15; section thickness, 3 mm; intersection gap, 0,3 mm; field of view, 81 × 100 mm; matrix size, 416 × 512).

The imaging findings were retrospectively reviewed by consensus reading of two musculoskeletal radiologists that had more than 10 years of experience regarding musculoskeletal MR examinations. Consensus was achieved when both radiologists agreed on full thickness or partial tears on MRI or MRA. MRI findings suggestive of a central perforation or ulnar avulsion of the TFCC were a linear increased signal intensity extending to surface for central tears and increased signal at ulnar attachment for peripheral tears on fluid sensitive FS images. The findings can be associated with morphologic distortion of the TFCC and distal radio ulnar effusion.

MRA images were categorized as a definite tear when there was a defect line or leakage of contrast into the distal radioulnar joint, probable tear when there was distortion of the normal morphology of the ligaments and possible tear when there was increased fluid in the distal radioulnar joint and increased signal to the anatomic structures of the TFCC [1,34].

Wrist arthroscopy was performed in order to correlate the findings of the diagnostic investigations. Arthroscopy was performed by a fellowship trained and experienced orthopaedic hand surgeon, blinded to the MRI and MRA results. The preoperative MRI and MRA results were categorized as true positive, false positive, true negative and false negative, using wrist diagnostic arthroscopy as the gold standard.

The sensitivity, specificity and accuracy of the two methods were statistically calculated.

Statistical analysis was performed by using the Stata 13.1 software (StataCorp, College Station, TX). All percentages were calculated with a 95% confidence interval.

This study was approved by the institutional review board (IRB) (25/3.2012) and informed consent was obtained from all patients.



Fig. 1. 30 year old man with wrist pain. Peripheral communicating tear proven arthroscopically.

a. 3D coronal MRI image shows a normal ulnar attachment of the TFCC.

b. Coronal T1 image arthrogram obtained with fat saturation reveals contrast leakage to the distal radioulnar joint through a defect in the ulnar attachment of the TFCC.

c. Arthroscopy image revealing the peripheral tear.

Results

A total of 60 (28 male, 32 female) consecutive patients participated in the study with a mean age of 27 years (range 13–65). 16 patients had sustained acute trauma resulting to wrist pain and the remaining 44 had complained about chronic wrist pain for more than a year usually following a traumatic event.

Out of the 60 patients studied, in 40 we used clinical landmarks for injection, in 10 fluoroscopy and in 10 ultrasonographic guidance. Despite the different techniques used for the contrast injection in the radiocarpal joint none had any difference in success

rate and did not affect the accuracy of the results. Arthrography was technically successful in all cases and was well tolerated with mild increase in pain and in discomfort during the first 24 h after the injection. No medications were prescribed, and the symptoms were relieved after 24–72 h. No severe complications occurred.

40 tears were confirmed by arthroscopy, 19 being peripheral and the other 21 being centrally located.

38 tears (sensitivity 95%) were identified by MRA including 21 central and 17 peripheral, even if they were partial and not full thickness tears. No false positives were identified by MRA (specificity 100%). The overall accuracy of MRA was calculated to be 97%.



Fig. 2. 33 year old man with wrist pain. Ulnar collateral ligament tear.

a. 3D coronal MRI image is suggestive of peripheral TFCC tear at its ulnar attachment.

b. Coronal T1 image arthrogram obtained with fat saturation reveals a normal ulnar TFCC attachment and ulnar collateral ligament tear.

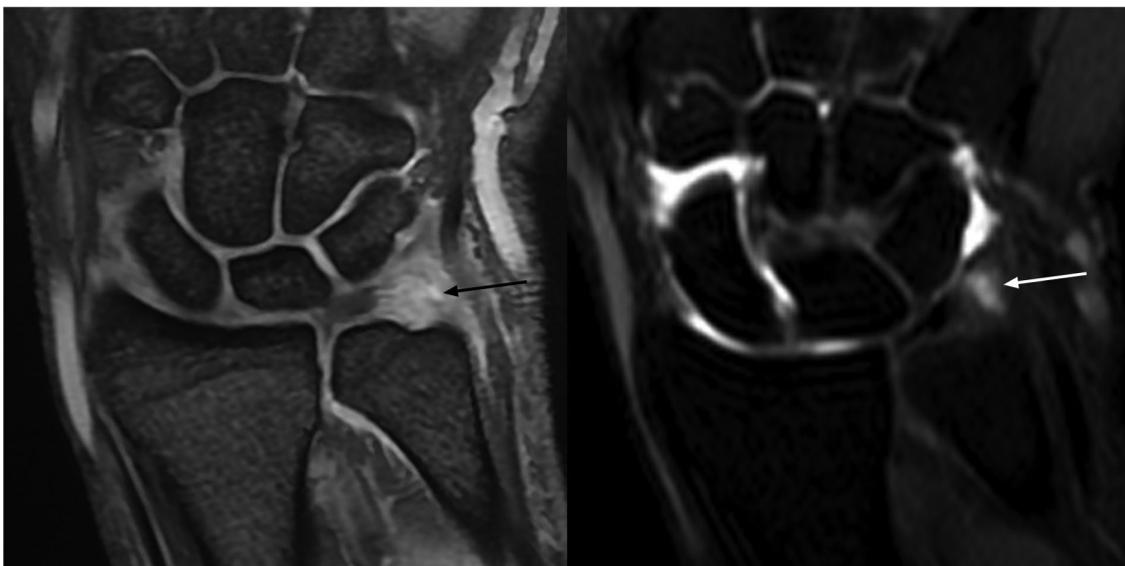


Fig. 3. 26 year old man with wrist pain.

a. 3D coronal MRI image is highly suggestive of peripheral TFCC tear.

b. Coronal T1 image arthrogram obtained with fat saturation shows that the TFCC ulnar attachment is intact and there is no abnormal communication between the radiocarpal and the distal radioulnar joint. Contrast fills the prestyloid recess.

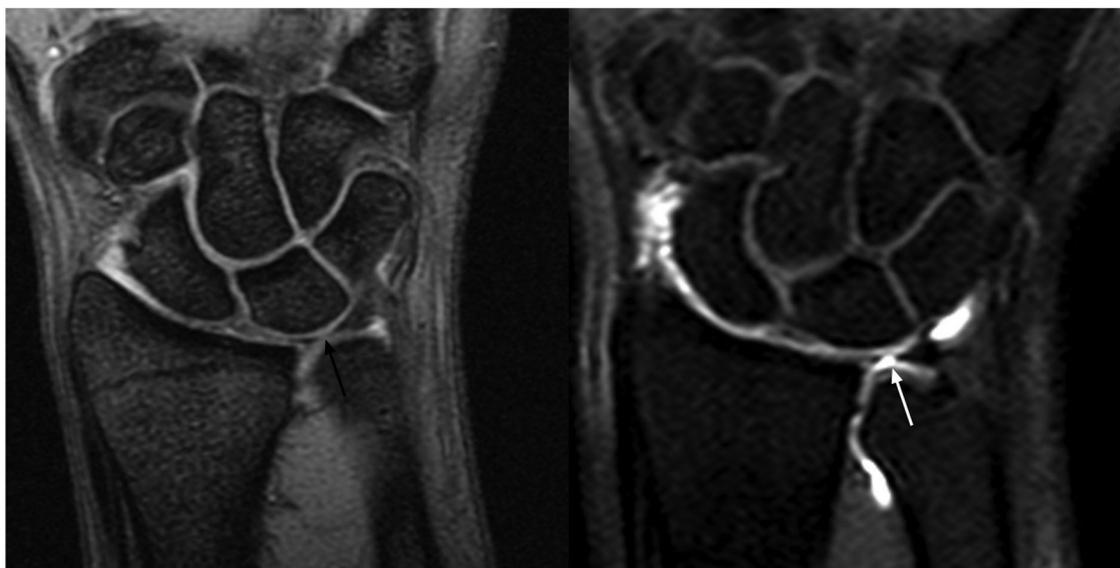


Fig. 4. 24 year old man with wrist pain. Central TFCC tear proven arthroscopically.
 a. 3D coronal MRI image reveals thinning of the central part of the TFCC but with no signs of tear.
 b. Coronal T1 image arthrogram obtained with fat saturation shows a central TFCC tear with contrast leakage into the distal radioulnar joint.

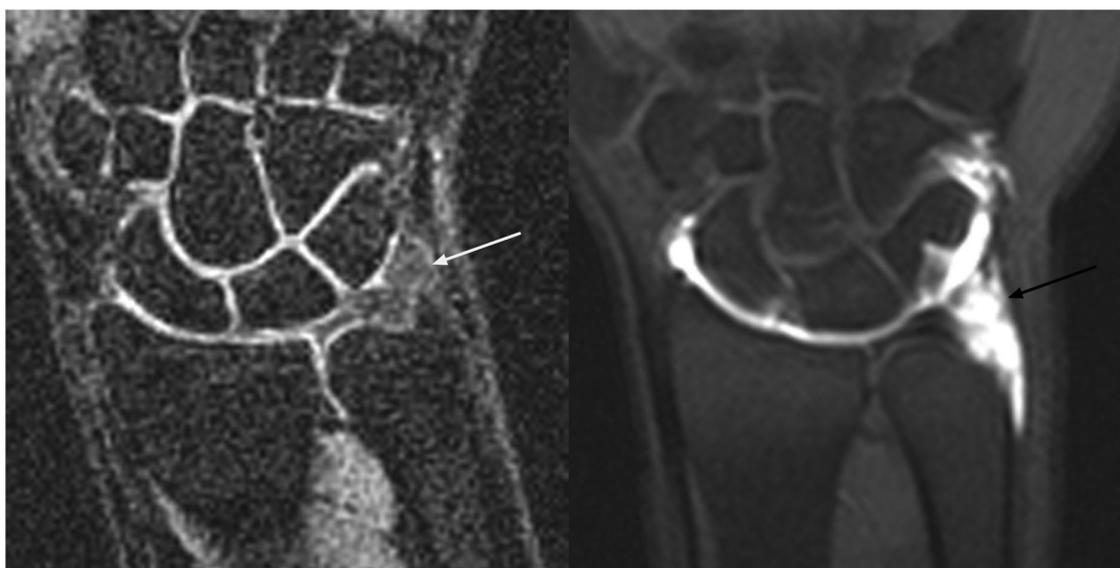


Fig. 5. 23 year old woman with ulnar sided wrist pain.
 a. 3D coronal MRI image shows an intact TFCC.
 b. Coronal MRA image shows a defect in the meniscal homologue.

Conventional MRI identified 26/40 tears (sensitivity 68%) and had 8 false positive and 13 false negative results (specificity 60%). Most of the tears not revealed by conventional MRI were peripheral. The overall accuracy of MRI was calculated to be 65%.

Conventional MRI was able to detect 6/19 and MRA detected 17/19 of the peripheral tears (Figs. 1 and 2). MRI had 6 false positive (Fig. 3) and 5 false negative results regarding peripheral tears

(Figs. 4 and 5). MRA detected 7/9 of the peripheral non communicating tears, while MRI detected none.

In two cases that there was a strong clinical suggestion of a TFCC tear, a two compartment arthrography was performed in the midcarpal and radioulnar joint, which revealed peripheral non communicating tears, (Table 1).

Discussion

Ulnar sided wrist pain and carpal instability are common clinical problems which are many times difficult to address because of the complexity of the anatomical structures involved. Common causes of ulnar sided wrist pain include damage to the intrinsic ligaments of the wrist especially the scapholunate, the lunotriquetral and the TFCC.

Table 1
 Diagnostic accuracy of MRI and MRA in the diagnosis of tears of the TFCC.

	MRI			MRA			Arthroscopy Tears
	Sen (%)	Spe (%)	Acc	Sen (%)	Spe (%)	Acc	
TFCC Peripheral	31.6	63.1	50	89.5	100	94.9	19
TFCC Central	95.2	92.3	96.9	100	100	100	21

The TFCC is also the main stabilizer of the distal radioulnar joint transmitting axial load from carpus to ulna [11–13].

Central TFCC tears are usually degenerative and most of the time asymptomatic. On the contrary, peripheral tears are mostly traumatic and symptomatic. The central part of the TFCC is avascular while the peripheral part has a good vascular supply. This is something that has to be differentiated because it affects the treatment strategy. Central tears are managed with debridement while peripheral tears can be repaired [14,15,30].

According to orthopaedic hand surgeons the gold standard for assessing lesions of the intrinsic ligaments of the wrist is arthroscopy as allows the direct visualization of the wrist joint [36–38], although recent studies claim that wrist diagnostic arthroscopy is not so reliable and should be reconsidered as a reference diagnostic tool [39]. As a method is invasive and costly, therefore diagnostic arthroscopy is reserved for patients with unequivocal or negative imaging studies with a history, symptoms and clinical examination consistent with intra articular pathology [16,17].

MRI is routinely used for assessing patients with TFCC abnormalities. The diagnostic values of this modality range from 71 to 100% for central and radial tears of the TFCC [35]. On the contrary, the diagnostic performance of conventional MRI in detecting peripheral tears is reported to only be 17% [10]. The poor performance of MR for these tears was attributed to the presence of high-signal vascularized fibrous tissue between the two ulnar attachments, which can mimic a tear.

The diagnostic accuracy of MRI is increased as the fields go stronger (3 T), with coil technology and pulse sequencing [9,27,29]. Anderson et al concluded that sensitivity, specificity and accuracy of 3 T wrist MRI for the TFCC is consistently higher compared with those of 1, 5 T wrist MRI, but there was no comparison between MRA and MRI even in different magnetic fields [9]. Magee in 2009 compared MRI to MRA using a 3 T magnetic field and concluded that MRA has a sensitivity of 100% in detecting TFCC lesions, much higher compared to MRI [27].

Lee et al compared 3D-THRIVE MRA and MRI at 3 T magnetic field and reported that MRA has better diagnostic performance than MRI in the depiction of intrinsic ligaments and TFCC tears, central and peripheral [41].

Smith et al in a meta-analysis that included 21 studies with 982 wrists reported sensitivity of conventional MRI in detecting TFCC full thickness tears 75% and specificity 81%, with stronger fields achieving better diagnostic performance [8]. There were no results regarding partial tears. On the contrary, they reported a sensitivity of MRA 84% and specificity of 95% in detecting full thickness TFCC tears and therefore prove MRA's higher diagnostic performance compared to conventional MRI. Their meta-analysis recommended that MRA should be preferred over MRI in order to assess TFCC pathology and patients with ulnar sided wrist pain. MRA even in lower magnetic fields has greater diagnostic performance compared to MRI in higher fields in detecting TFCC lesions.

In a more recent meta-analysis Treiser et al included 28 studies and concluded that MRA is more sensitive and specific than MRI in detecting TFCC lesions. The diagnostic accuracy of the two methods was higher for central tears [40].

Thomas et al reported higher accuracy of MRA compared to MRI even in detecting peripheral TFCC tears. They used one or two compartment injection in the midcarpal and distal radioulnar joint if TFCC abnormality was suspected [20].

Ruegger et al reported a sensitivity of 85% and specificity of 76% of MRA in detecting peripheral communicating or non-communicated TFCC tears with the contrast solution injected in the distal radioulnar joint [21].

Arthrography has played a vital role in the diagnosis of ligamentous lesions of the wrist. MR arthrography combines the advantages of the classical arthrography with the advantages of

MRI scans revealing the exact point of the tear and all the important information regarding soft tissue and bony structures.

MR arthrography exploits the natural advantages gained by joint effusion which causes joint extension and reveals intra articular structures and pathologies [18,19].

The major advantage of this method is that it enables the discovery of abnormalities not detected by other methods and that it does not involve exposure to ionizing radiation.

However, MRA being an invasive procedure may cause wrist pain and discomfort lasting up to 72 h after the intraarticular contrast injection. The pain is attributed to irritation of the synovium by the contrast medium [32]. In rare cases, severe complications as infection can occur [33].

Recently, a new MRA technique with traction of the wrist has been advocated as having better results in diagnosing TFCC tear because of the improved visibility of the articular cartilage and the detection and visibility of tears of the TFCC and intrinsic ligaments [28].

In the present study we confirmed the results of previous studies that showed MRA as having much greater sensitivity and specificity compared to conventional MRI; MRI's performance was much lower in detecting peripheral tears with the increased signal of the vascularized fibrous tissue leading to diagnostic pitfalls.

Limitations of this study include the small number of TFCC tears and the fact that the imaging findings of MRI and MRA as well as the results of diagnostic arthroscopy depend on the personal experience of the diagnostic radiologists and the orthopaedic surgeon.

The advantage of this study is that while all previous studies focused on central full thickness tears, our study went a step further by displaying the diagnostic superiority of MRA in detecting small peripheral tears which have the most clinical significance.

We recommend that in cases where there is a strong clinical suspicion of a TFCC tear, even in the presence of negative, MRA and MRI findings, the examination protocol should include injection of contrast also in the midcarpal and distal radioulnar joint as described in previous studies [21].

Patients with negative imaging findings whose clinical symptoms don't subside after conservative treatment should always be referred to orthopaedic surgeons for diagnostic arthroscopy.

The findings of our study illustrate the superiority of MRA compared to conventional MRI in assessing TFCC pathology. MRA is useful in detecting not only central full thickness tears but also the peripheral partial tears, which have high clinical significance. Conventional MRI has a poor diagnostic performance regarding these tears. Therefore, the evaluation of patients with suspected TFCC lesion should include MRA following the initial plain radiographs.

Declaration of Competing Interest

None.

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