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Original Article

Triangular fibrocartilage and ligamentous injury of the wrist joint: Does MR arthrography improve diagnosis over standard MRI?

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ABSTRACT

Objective: To detect the added value of magnetic resonance arthrography (MRA) over MRI in different triangular fibrocartilage complex (TFCC) and intrinsic wrist ligament lesions.
Patients and methods: MRI and MRA were achieved in 57 patients presented with wrist pain. Another symptomless Ten control individuals with negative MRI and MRA findings were included. Images were assessed for the presence of TFCC, scapholunate ligament (SCL) and lunotriquetral ligament (LTL) lesions. Imaging findings were compared with arthroscopic findings in all cases.
Results: Out of fifty-seven patients, 38 males (66.6%) and 19 females (33.3%) (age range 19–61 years (mean = 34.3 years) were included in the study, The sensitivity, specificity and accuracy of MRI and MRA for TFCC peripheral tears were 79.16%, 100%, 85.29% and 91.66%, 100%, and 94.11% respectively, the sensitivity, specificity and accuracy of MRI and MRA for TFCC central tears were 60%, 100%, 80% and 90%, 100%, and 95% respectively. Sensitivity, specificity and accuracy of MRI and MRA for SCL partial tears were 63.15%, 100%, 75.86% and 94.73%, 100% and 96.55%, respectively. For LTL partial tears, the values were 20%, 100%, 73.33% and 80%, 100%, and 93.33% respectively.
Conclusion: MR arthrography is highly accurate for the evaluation of TFCC and ligamentous injury of the wrist joint.

1. Introduction

MRI is used to diagnose wrist joint lesions, such as triangular fibrocartilaginous complex (TFCC) and intrinsic ligaments injury. MRI is accurate for showing complete tears of the TFCC and intrinsic ligament [1–7]. When attention is required for evaluation of triangular fibrocartilage complex (TFCC), other ligamentous, or capsular injury, direct MR arthrography has become a progressively applied imaging modality, allowing for improved visualization of the closely related ligamentous structures following the direct injection of contrast [8–10]. Intra-articular contrast allows for visualization of contrast leakage/extravasation and has been shown to be useful in detection of partial TFCC and ligamentous tears [11–14]. The aim of this work was to detect the added value of MRA over MRI in detection of TFCC and ligamentous tears and to compare the results with arthroscopy as the gold standard.

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2. Patients and methods

57 patients with age ranging from 19 to 61 years (mean = 34.3) complained of wrist pain and/or instability with clinical suspicion of having TFCC or wrist ligament tears were involved in this study. The study was approved by the scientific and ethical committee of the hospital. Informed written consent was obtained from all patients. Forty patients complained of right wrist pain while seventeen of left wrist pain. There were 38 male (66.6%) and 19 female (33.3%) patients. Twenty-seven patients had a previous history of trauma. The right wrist was imaged in 40 (70.17%) cases and the left wrist in 17 (29.82%) cases.

Patients were subjected to full clinical history. Plain radiography of the wrist was done in the following positions: postero-anterior view, lateral view, and scaphoid view. Three main regions were examined: TFCC, SCL, and LT ligament tears using a combination of conventional MRI, MRA and arthroscopy as a gold standard. Arthroscopy was achieved within 2–3 weeks of MR arthrography.

All patients were examined by conventional MRI. The MRI machine used was Philips gyros can enteraT scanner. Using dedicated wrist coil the examination protocol included coronal, sagittal, and axial planes. Coronal and sagittal fast spin-echo T1-weighted (TR/TE, 400/15), coronal and axial fast spin-echo T2-weighted (TR/TE, 2000/60), coronal gradient (TR/TE, 450/20) and coronal STIR (TR/TE, 2000/65) sequences with a field of view of 12 cm were used. Slice thickness was 2.5 mm with 2 mm interslice gap. Coronal plane is the most important image for detecting ligament tears. Normal intrinsic ligaments, normal TFCC appearance and the corresponding coronal MRI appearance are mentioned in Figs. 1 and 2.

3. Technique

MR arthrography is performed with single-compartment radiocarpal joint arthrogram with intra-articular injection of diluted gadolinium under fluoroscopic guidance, and 2–5 ml solution from 0.1 ml of diluted gadolinium in 20 ml solution from the combined 15 ml of normal saline and 5 ml of iodinated contrast (diatrizoate meglumine) (370 mg iodine/ml) was used. If connection with midcarpal or distal radioulnar joint was noted, we added 2–3 ml of contrast. The mid carpal compartment was punctured, and the solution was injected. If the distal radioulnar joint did not fill spontaneously, an injection was administered only to this joint when a TFCC tear was suspected. In the absence of radiocarpal connection, an injection was administered to the radiocarpal compartment, and 5 ml of contrast solution was injected. Radiocarpal

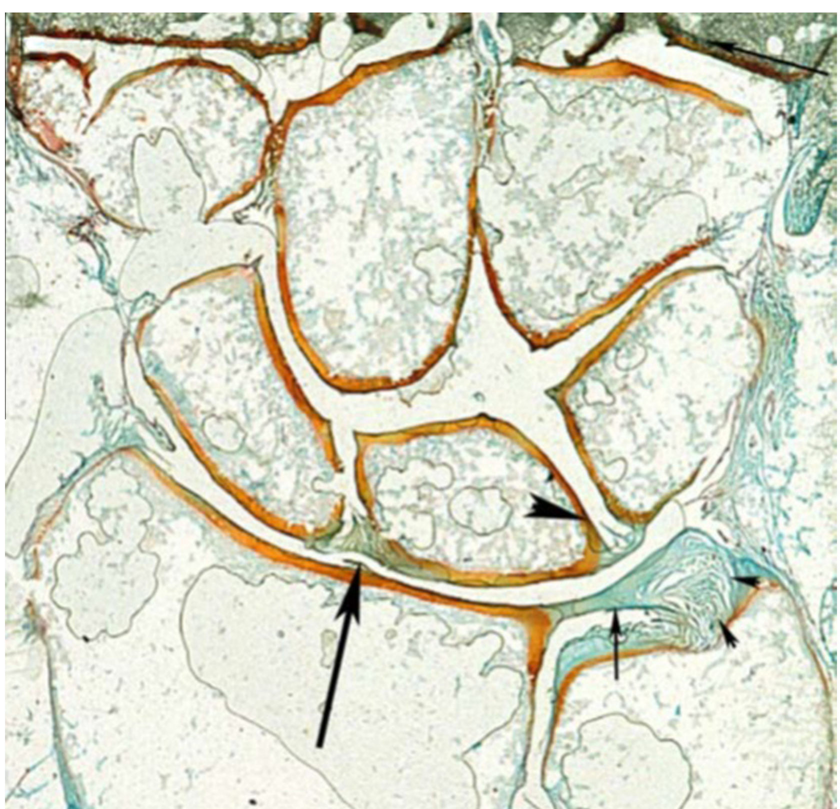

Fig. 1. Coronal section of normal anatomy of the scapholunate ligament (black arrow) and the lunate triquetral (arrowhead). The triangular fibrocartilage complex (TFCC), with the more fibrocartilage-like articular disk (small black arrow) and the more ligamentous-like peripheral ulnar attaching portion (smaller arrowheads) [32].

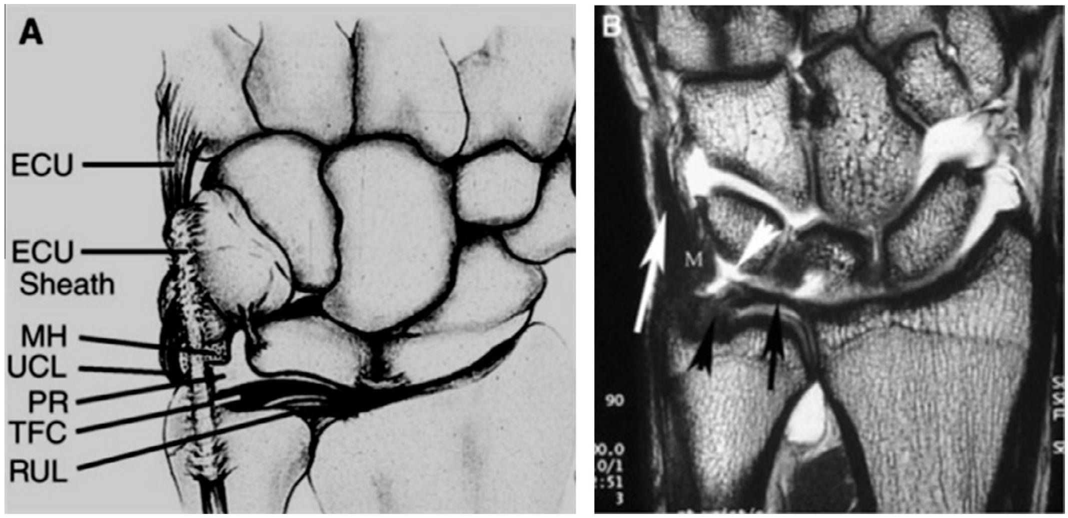

Fig. 2. Coronal section of TFCC anatomy. ECU, extensor carpi ulnaris tendon; MH, meniscus homolog; PR, prestyloid recess; RUL, radioulnar ligament; TFC, triangular fibrocartilage (articular disk); UCL, ulnar collateral ligament. (B) Correlative coronal MR arthrogram image provides a detailed view of the TFCC anatomy. The TFC (articular disk) reveals homogeneous low signal (black arrow); the ulnar portion is more intermediate in character, as it attaches to the ulnar styloid (arrowhead). Note the contrast outlining the region of the prestyloid recess (white arrowhead). ECU tendon (white arrow). M, meniscus homolog [32].

injection was performed in all cases, and associated mid carpal injection was performed in 15 cases.

Patient was shifted to MR gantry within half an hour of radiocarpal injection and active exercise of the joint is advised to ensure uniform distribution of contrast, to ensure similarity in the quality of sequences, the parameters such as field of view and acquisition number were kept the same for coronal axial and sagittal MR arthrography sequences. Arthroscopy was achieved regardless of normal or abnormal MR arthrography findings.

4. Statistical analysis

Statistical analysis between MRI and MRA in different TFCCs, and the ligamentous injury was compared in terms of sensitivity, specificity, PPV, NPV, accuracy and *P* value using Chi-square test. All statistical calculations were done using the computer program SPSS (Statistical Package for the Social Science: SPSS Inc., Chicago, IL, USA) version 16.

5. Results

Age of 57 patients ranging from 19 to 61 years (mean = 34.3), the main types of presentation was pain with or without wrist instability, the patients were clinically diagnosed as suspected tears of TFCC or wrist ligament, and the chief complaint was painful wrist (100%) plus other less common symptoms such as limitation of movement (30%), swellings (16.6%), tingling and numbness. History of trauma was recorded in 27 patients (48.21%), and 30 patients (51.78%) without history of trauma, another 10 control normal patients with no wrist pain are involved in our study with no positive findings in these cases.

In the 57 patients, MRI detected a total of 25 (43.8%) TFCC tears (19 peripheral and 6 central), TFCC degeneration (3), 17 (29.82%) SLL tears (12 partial and 5 complete), and 1 (1.75%) partial LTL tears, and 3 (5.26%) complete LTL tears, and other findings include bone marrow edema in 12 patients, tenosynovitis of ECU tendon in 12 patients, joint effusion in 19 patients, fracture radius in 11 patients, Kienbock's disease in 8 patients, DRUJ instability in 8 patients, and DISI in 5 patients (Table 1).

Comparative study between MRI and MRA results is mentioned in Table 2. MRA detected normal MR Arthrography study in 2 patients. A total of 31 (54.38%) TFCC tears (22 peripheral and 9 central), TFCC degeneration (5), 24 (42.1%) SLL tears (18 partial and 6 complete), and 4 (7.01%) partial LTL tears and 4 complete LTL tears were diagnosed in 57 patients. Concomittant lesions were present in 19 patients (36.84%) (Table 3).

In TFCC lesions according to palmer classification type 1 (traumatic tear) is detected in 15 and type 2 (degenerative

Table 1
Radiological abnormality in 57patients with painful wrist joint by MRI.

Radiological abnormality	Incidence	Percentage
TFCC tear	25	43.85%
TFCC degeneration	3	5.26%
Scapholunate ligament	17	29.82%
Lunotriquetral ligament	4	7.01%
Bone marrow edema	12	21.05%
Joint effusion	19	33.33%
Kienbock's disease	8	14.03%
Fracture distal radius	11	19.29%
Fracture scaphoid	6	10.52%
DISI	5	8.77%
DRUJ instability	8	14.03%
Tenosynovitis of the ECU	12	21.05%

Table 2
Comparison between MRI and MRA findings in 57 patients with painful wrist joint.

	Pathology	MRI findings	MRA findings
TFCC (location)	TFCC tear (peripheral)	19	22
	TFCC tear (central)	6	9
	TFCC degeneration	3	5
Ligaments of the TFCC	Ulnotriquetral ligament	4	7
	Volar radioulnar ligament	9	11
	Dorsal radioulnar ligament	1	3
	Ulnar collaterals ligament	7	9
	Ulnolunate ligament	–	3
Intrinsic ligaments of the wrist	Scapholunate ligament partial tear	12	18
	Scapholunate ligament complete tear	5	6
	Lunotriquetral ligament (partial)	1	4
	Lunotriquetral ligament (complete)	3	4
	Lunolunate ligament	–	–

Table 3
Concomittant MR arthrogram findings.

Concomitant MR arthrogram findings	No. of patients	Percentage
TFCC and SL tears	10	17.54%
TFCC and LT tears	1	1.75%
SL and LT tears	1	1.75%
SL and UL tears	3	5.26%
SL and UT tears	2	3.5%
TFCC, SL and LT tears	2	3.5%

tear) in 13 patients, and in relation to the site, TFC tears were classified as central and peripheral. There were 9 (29.03%) central tears and 22 (70.96%) peripheral tears.

Regarding TFCC, ligamentous injury by MRA includes the ulnar collaterals ligaments 6 partial and 3 complete tears; the ulno-triquetral ligament, 4 partial and 3 complete tears; the volar radioulnar ligament, 3 partial tears, 8 complete tears; the dorsal radioulnar ligament, 2 partial and 1 complete tears; Arthroscopy revealed 34 TFCC lesions.

Other 26 ligament injuries include 18 partial and 6 complete scapholunate tears, and 4 partial tears and 4 complete tears of the lunotriquetral ligament, and non-ligamentous injury includes tenosynovitis of the extensor carpi ulnaris tendon detected in 12. Arthroscopy revealed 2 additional partial tears of SCL and LTL.

Compared to MRI, MRA detected additional SCL partial tear ($n = 6$), complete tear of SCL ($n = 1$), LT partial tear ($n = 3$), complete tear of LT ($n = 1$), TFCC central tear ($n = 3$), and peripheral tear ($n = 3$).

No statistically significant differences between MRI and MRA findings were detected in all TFCC and intrinsic ligament injury lesions except for lunotriquetral lesions where the P value = 0.006 and X2 = 7.06.

Following arthroscopy, two patients with negative MRA study were found to have a1 partial lunotriquetral ligament injury, and 1 with small peripheral tear of TFCC confirmed on arthroscopy (2 false). 4 patients had additional injuries which were not diagnosed on the MRA (2 peripheral TFCCs and 1 partial scapholunate and 1 ulnolunate ligament) (Table 4).

Table 4
Correlation between MR arthrography and arthroscopy results.

Correlation between MR arthrography and arthroscopy	No of patients
Normal MR arthrographic findings; injury identified at arthroscopy	5
Abnormal MR arthrographic findings; additional injury noted at arthroscopy	2

The overall sensitivity, specificity, Positive predictive value, Negative predictive value, and accuracy of MRI and MRA results are mentioned in Table 6.

6. Discussion

Chronic wrist pain is often a challenging problem for the treating surgeon. Several imaging modalities have been used to improve diagnostic accuracy, and magnetic resonance imaging gained approval because of better soft-tissue contrast and multiplanar capability [15,16]. In our study MRI detected other lesions rather than cartilaginous or ligamentous injury such as Bone marrow edema, Joint effusion, avascular necrosis, fracture, instability and tendinopathy of the surrounding tendons.

The accuracy of MRI was acceptable in the diagnosis of complete tears, but partial cartilaginous or ligamentous tears were frequently overlooked. Decreased accuracy of MRI was also found for TFCC tear. The latter finding contrasts with previous findings [17–19] suggesting good performances of MRI in the diagnosis of TFCC tears. MRI findings rarely allowed definite diagnosis of tears because of the absence of intrinsic fluid [19].

Non-contrast MRI is inaccurate in diagnosing tears of the intrinsic ligaments and TFCC. The dual use of conventional arthrography with the direct visualization of structures on magnetic resonance (MR) imaging accentuates not only visualization of TFCC and the intrinsic ligaments, but also lesions more evident and noticeable [20,21].

In our study injection was done through a Single radiocarpal joint injection. If connection with mid carpal or distal radioulnar joint was noted, we added 2–3 ml of contrast

Table 5
Sensitivity, specificity, PPV, NPV and accuracy of MRI and MRA results in TFCC, SCL, LTL Tears.

Pathology	Imaging modality	Sensitivity (%)	Specificity (%)	PPV(%)	NPV (%)	Accuracy (%)
TFCC (peripheral)	MRI	79.16	100	100	66.66	85.29
	MRA	91.66	100	100	83.33	94.11
TFCC (central)	MRI	60	100	100	71.42	80
	MRA	90	100	100	90.90	95
TFCC (degeneration)	MRI	60	100	100	71.42	80
	MRA	90	100	100	90.90	95
SCL (partial tear)	MRI	63.15	100	100	58.82	75.86
	MRA	94.73	100	100	90.90	96.55
SCL (complete tear)	MRI	83.33	100	100	90.90	93.75
	MRA	100	100	100	100	100
LTL (partial tear)	MRI	20	100	100	71.42	73.33
	MRA	80	100	100	90.90	93.33
LTL (complete tear)	MRI	75	100	100	90.90	92.85
	MRA	100	100	100	100	100

Table 6
Overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of MRI and MRA results.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
MRI	84.21	100	100	52.63	88.15
MRA	92.98	100	100	71.42	94.36

additional mid carpal injection was performed in 20 cases, and fifteen patients showed leakage into the distal radioulnar joint (DRUJ) after radio carpal injection, denoting indirectly an existing defect within the TFC. We did not inject directly in the DRUJ to avoid patient‘s discomfort. However, it may have a disadvantage of obscuring non - communicating proximal ulnar tear of the TFCC.

Central tears of the TFC appear as a linear band of increased signal intensity on short TR/TE and proton density-weighted spin echo (SE) or gradient echo (GRE) images. With complete tears the signal extends to proximal and distal articular surface (Figs. 3 and 4). In partial tears, the signal will extend only to one articular surface, usually the proximal surface (DRUJ) [22]. Fluid collecting in the DRUJ is an important secondary sign (Figs. 3C and 4B) but the presence of fluid signal alone is not indicative of a tear of the triangular fibrocartilage [23].

MRI does not adequately detect the peripheral attachment of the triangular fibrocartilage complex [16]. This is partly in line with our results regarding peripheral TFCC tears, but we detected in addition three missed central cases by MRI and diagnosed by MRA. The poor sensitivity was attributed to the presence of the striated fascicles at the periphery of the TFCC, which were believed to be difficult to be evaluated by MR imaging [24]. Findings that correlate with these types of tears include altered morphology of the ulnar attachments of the TFC (Figs. 5C, 6A, and 7A), excessive fluid localizing to this region (especially if it extends below the expected location of the prestyloid recess) (Fig. 5B). MR arthrography may also help outline

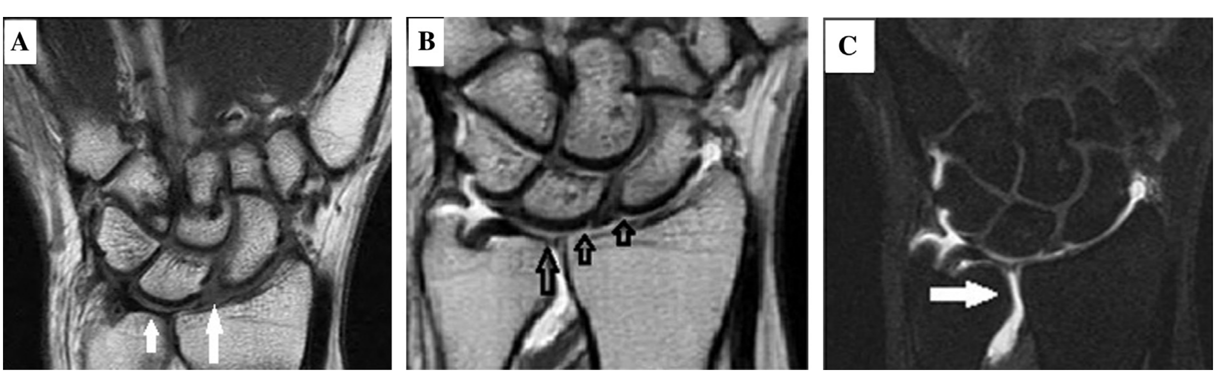

Fig. 3. Case of central perforation of the triangular fibrocartilage with partial tear of the scapholunate ligament: Fig 1. (A) Pre-contrast MRA Coronal T1 WI with indistinct appearance of the central tear of the TFCC and the partial tear of the SCL (arrows) and (B and C) post-contrast MRA. Coronal T1, T1 Fat suppression Intra-articular injection of diluted gadolinium under fluoroscopic **guidance** into the radiocarpal joint compartment, and leakage of contrast material (CM) into the distal radio-ulnar compartment was noted (arrow in c). Perforation of the central aspect of the triangular fibrocartilage articular disk (long arrow in B) with partial tear of the scapholunate ligament (short arrows in B).

Fig. 4. Case of central perforation of the TFC. Comminuted fracture of the distal radius with bone marrow edema/contusion, mild DRUJ effusion, (A) pre contrast MRA coronal T1 WI with fracture line at the distal end of the right radius (arrow), with indistinct appearance of the central tear of the TFCC and (B and C) post-MRA Coronal T1 and Axial T1 WI intra-articular injection of diluted gadolinium under fluoroscopic guidance into the radiocarpal joint compartment shows central defect of the TFC (arrow in b). Mild DRUJ effusion (arrow in C).

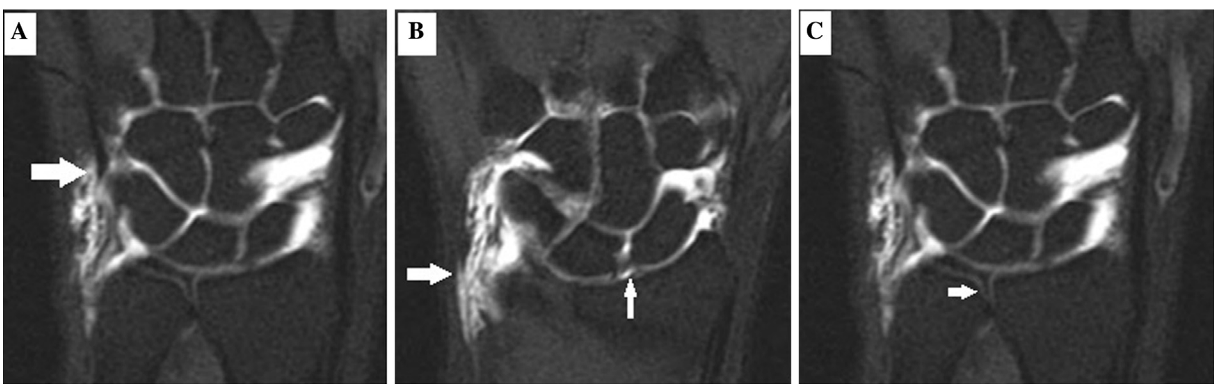

Fig. 5. A complete tear of the ulno-carpal collateral denoting Class 1b Palmer peripheral TFCC tear. Extensor Carpi Ulnaris tenosynovitis with associated partial tear of SCL: (A and B) Post-contrast MR arthrography Coronal T1 Fat suppression with intra-articular injection of diluted gadolinium under fluoroscopic guidance into the radiocarpal joint compartment shows the following: mild thickening of the extensor carpi ulnaris tendon with faint bright signal of its synovial sheath (arrow in A), disrupted ulno-carpal collateral ligament (arrow in B) with subsequent leakage of contrast material into the extra articular pre styloid space, leaking contrast in the scapholunate interval denoting partial tear (vertical arrow in B), and (C) coronal T1 Fat suppression post-MRA: Defect in the volar radioulnar ligament (arrow).

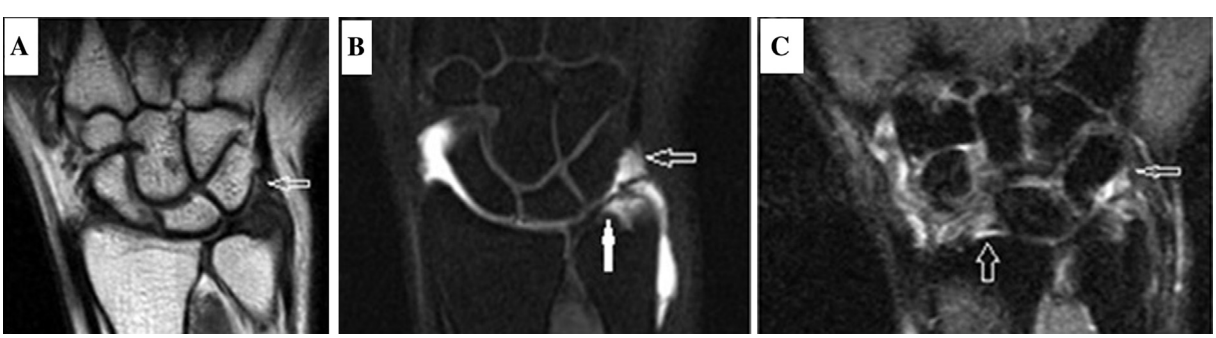

Fig. 6. Case of split tear of the ulnotriquetral ligaments with peripheral tear of the TFC. Partial tear (grade I injury) of the scapholunate ligament: (A) Coronal T1 Pre-contrast MRI with suspected tear of the ulno triquetral ligament (arrow in A) and (B and C) post-contrast MR arthrography Coronal T1 Fat suppression intra-articular injection of diluted gadolinium was performed under fluoroscopic guidance into the radiocarpal joint compartment shows Focal longitudinal split tear of the ulno-triquetral ligament near its triquetral attachment (horizontal arrow in B and C) with degenerative peripheral tear of the palmar aspect of the triangular fibrocartilage (vertical arrow in B). Partial thickness tear at the base of the scapholunate ligament adjacent to the lunate bone (grade I ligament injury) (vertical arrow in c).

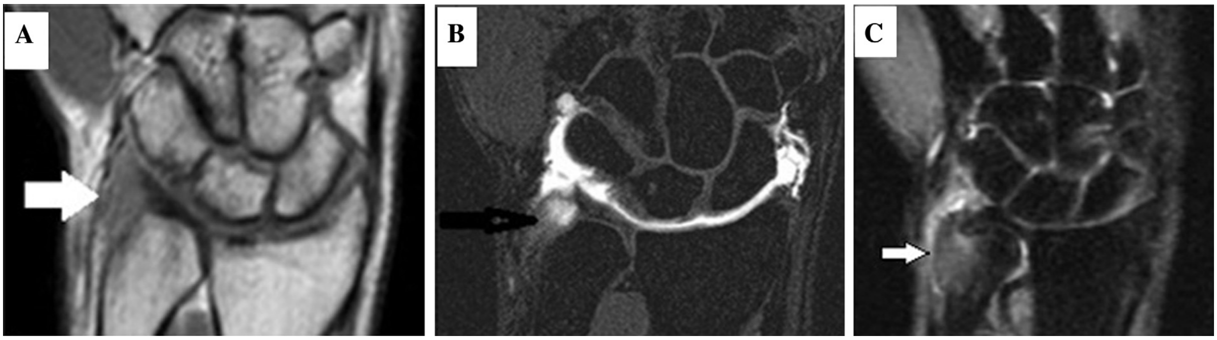

Fig. 7. Case of tear of the ulnar collateral ligament with marrow edema of the distal ulna: (A) Precontrast coronal T1 shows thickened UCL with intermediate signal intensity (arrow in A) and postcontrast MR arthrography coronal T1 Fat suppression (B and C) with intra-articular injection of diluted gadolinium was performed under fluoroscopic guidance into the radiocarpal joint compartment shows the following: Avulsed ulnar attachment of the ulnar collateral ligament (arrow in b) with ligamentous sprain. Focal cortical interruption and underlying patchy area of marrow edema of distal ulna (arrow in c).

such tears by revealing contrast extending directly into the defect [4].

Depending on palmer classification of TFCC [21], we detected type 1 (traumatic tear) in [15]. And type 2 (degenerative tear) was detected in 16 patients, and in relation to the site, TFC tears were categorized as central and peripheral. There were 9 (29.03%) central tears (Figs. 3 and 4), and 22 (70.96%) peripheral tears (Figs. 5 and 6).

MR arthrography was found to have a high positive predictive value [25]. This is in line with our results as all our cases have no false positive cases. The specificity and the PPV were 100%, (Table 5). Negative MR arthrography findings in patients with TFCC tears when clinically suspected should be interpreted with caution. As in our study three negative cases by MRA are found to have two peripheral tears and 1 central tear by arthroscopy, and regarding TFCC we detected a total of 31 (45.3%) TFCC tears, 22 peripheral tears and 9 central tears, 6 out of 22 peripheral tears and 4 out of 9 central tears are associated with intrinsic ligament tears.

In our study peripheral tears are associated with ligamentous and tendinous injury such as Volar radioulnar, dorsal radioulnar, ulnotriquetral ligament tear (Fig. 6), ulnar collateral ligamentous injury (Fig. 7), and tenosynovitis of the extensor carpi ulnaris (Fig. 5).

The degenerative type is reflected by progressive stages of ulnocarpal impaction. Five types of degenerative lesions were detailed. Class 2A is TFC wear from the undersurface, occurring in the central horizontal portion, without perforation. Class B is TFC wear with ulnolunate malacia (Fig. 9b). The cartilage changes occur on the inferomedial aspect of the lunate or on the more radial portion of the head of the ulna [26]. We also detected 3 cases of TFCC degeneration by MRI and 5 cases by MRA, 2 of them with ulnolunate impingement syndrome ch.ch by focal chondromalacia and subchondral erosion of the ulnar side of the proximal lunate (Fig. 9).

In our study cases with TFCC tears were more clearly illustrated by MRA images, even though cases with apparently normal or inconspicuous TFCC lesions by MRI proved to be with pathological tears of TFCC by MRA, and similar findings were found with other intrinsic ligaments, in a previous study [16] regarding central and peripheral TFCC tears; sensitivity, specificity, PPV, and NPV of MRI and MRA respectively for TFCC central tears were 38%, 100%, 100%, and 85% and 63%, 100%, 100%, and 94%, and sensitivity,

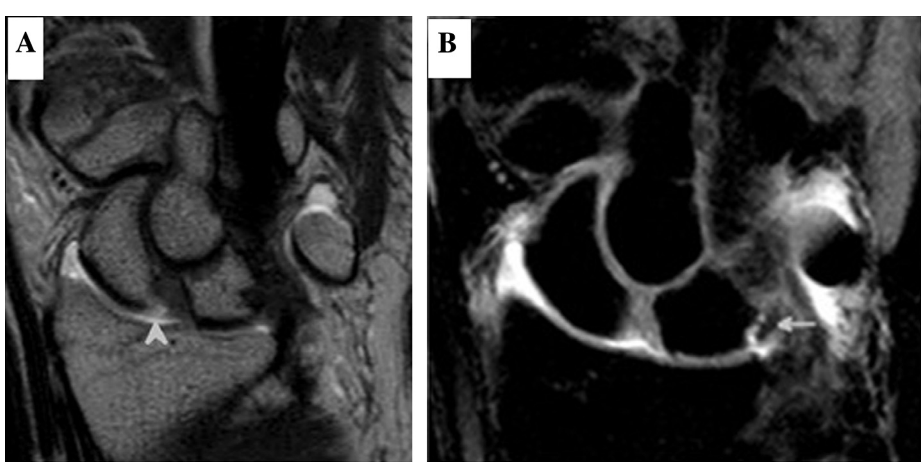

Fig. 8. Case of partial tear of the scapholunate and ulnolunate ligaments: (A and B) Post-MR arthrography Coronal T1 and T1 Fat suppression intra-articular injection of diluted gadolinium was performed under fluoroscopic guidance into the radiocarpal joint compartment shows partial tear (grade I injury) of the scapholunate ligament (arrowhead) (A). Subtle avulsion of the ulno-lunate ligament (thin arrow) (B).

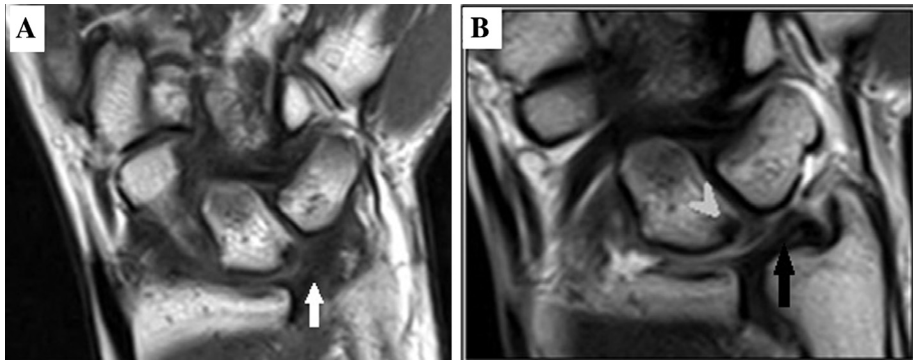

Fig. 9. Case of ulnolunate impaction syndrome: complex wear, lunate chondromalacia: precontrast Coronal T1 (A) shows suspected signal intensity of the triangular fibrocartilage, and post-contrast Coronal T1 (B), with intra- articular injection of diluted gadolinium under fluoroscopic guidance into the radiocarpal joint compartment, Findings are mild superficial wearing of the central aspect of the triangular fibrocartilage (black arrow). Focal chondromalacia and subchondral erosion of the ulnar side of the proximal lunate (*arrow* head in b).

specificity, PPV, and NPV of MRI and MRA respectively for TFCC peripheral tears were 67%, 100%, 100%, and 85% and 100%, 100%, 100%, and 94%. Our results are higher as in our study sensitivity, specificity, PPV, NPV, and accuracy of MRI and MRA respectively for TFCC central tears was 60%, 100%, 100%, 71.42%, and 80% and 90%, 100%, 100%, 90.90%, and 95%; sensitivity, specificity, PPV, NPV, and accuracy of MRI and MRA respectively for TFCC peripheral tears were 79.16%, 100%, 100%, 66.66%, and 85.29% and 91.66%, 100%, 100%, 83.33%, and 94.11% (Table 5).

Tears of this ligament may be partial or complete. On MR imaging examination, complete tears appear as distinct areas of discontinuity within the ligament with increased signal intensity on images with T2-type contrast, or the complete absence of the ligament. Severe distortion of the morphology of ligament fraying, thinning, or irregularity may be reflective of ligamentous injury, and coursing the central portion of the ligament in a direction other than horizontal may be considered abnormal. MR imaging arthrography may aid in revealing contrast extravasation through a complete defect [27] (Figs. 5B and 6A) or help to outline the aforementioned morphologic alterations. Fluid in the midcarpal joint is a sensitive but nonspecific finding of ligament tears. In more advanced cases, widening of the scapholunate ligament articulation may be evident, particularly if at least two portions of the ligament are involved in fluid pooling around a ligament and concomitant bone injury is other clue to injury. Ganglion cysts can also be a secondary finding of ligament derangement [27].

A partial tear may be diagnosed when there is focal thinning or irregularity or fluid signal in a portion of the ligament (Fig. 8A and B), more commonly in the volar portion where the weakest ligamentous attachments are located [28].

MR arthrography may yield an increased sensitivity to scapholunate tears over MR imaging alone and conventional arthrography, especially for more subtle injuries (see Ref. [29]). This includes partial tears, which may show contrast leak or imbibitions into a portion of an injured ligament (Figs. 3B, 5B) or better outline morphologic alterations or stretching. MR arthrography may help outline the surfaces of the ligament and improve the detectability of this lesion. Tears of the lunatotriquetral ligament are more difficult to detect than tears of the scapholunate ligament as it is a smaller ligament, and these lesions are less common. The lunate triquetral ligament may be less reliably observed on MR imaging than the scapholunate ligament, although thin-section, high signal contrast with MR arthrography may outline a defect in the lunate triquetral ligament as well [29].

Regarding SCL tear in a study [27], sensitivity, specificity, PPV, and NPV of MRI and MRA respectively for SCL partial tear were 71%, 83%, 81%, and 79% and 77%, 87%, 85%, and 80% ; sensitivity, specificity, PPV, and NPV of MRI and MRA respectively for SCL complete tear were 100%, 83%, 81%, and 79% and 100% 87%, 85%, and 80%. This in line with our study as sensitivity, specificity, PPV, NPV, and accuracy of MRI and MRA respectively for SCL partial tears (Fig. 8A) were 63.15%, 100%, 100%, 58.82%, and 75.86% and 94.73%, 100%, 100%, 90.90%, and 96.55%. Sensitivity, specificity, PPV, NPV, and accuracy of MRI and MRA respectively for SCL complete tear were 83.33%, 100%, 100%, 90.90%, and 93.75% and 100% 100%, 100%, 100%, and 100%.

Regarding LTL tear in a study [27], sensitivity, specificity, PPV, and NPV of MRI and MRA respectively for LTL partial tear were 22%, 94%, 60%, and 83% and 56%, 97%, 86%, and 89%, and for LTL complete tear they were 56%, 97%, 86%, and 89% and 63% 100%, 100%, and 94%. Our results are higher as in our study sensitivity, specificity, PPV, NPV, and accuracy of MRI and MRA respectively for LTL partial tear were 20%, 100%, 100%, 71.42%, and 73.33% and 80%, 100%, 100%, 90.90%, and 93.33%, and for LTL complete tear they were 75%, 100%, 100%, 90.90%, and 92.85% and 100% 100%, 100%, 100%, and 100%, Statistical significance is detected between MRI and MRA in partial and complete tears of LTL tears (P value = 0.007), and in our study we detected the LTL is relatively a small structure of only 2 mm wide; therefore, high spatial resolution MRA is required for better assessment.

Statistical analysis of our data revealed insignificant P value in all lesions using Qui square test except for the lunotriquetral ligament ($P = 0.007$).

Our results are comparable to the study by Mahmood et al. [30] who stated that regarding results of concomitant findings, TFCC and SL tears were $n = 5$, TFCC and LT tears $n = 1$, TFCC, SCL and LT tears $n = 2$, and SCL and LT tears $n = 1$, and in our study (Table 3) TFCC and SL tears were $n = 10$ (Figs. 3 and 4), TFCC and LT tears $n = 1$, TFCC, SCL and LT tears $n = 2$, SCL and LT $n = 1$, SCL and UL $n = 3$ (Fig. 8), and SCL and UT $n = 2$.

We agree with the study [31] that concluded that a neutralizing MRA cannot omit wrist pathology because in our study two negative MR arthrography cases proved to have positive findings at arthroscopy.

Based on our results it can be judged that MRA is highly accurate for the evaluation of TFCC and ligamentous injury of the wrist joint. We suggest that in cases in which there is doubt or uncertainty about the diagnosis and subsequent management of patients with chronic wrist pain, the use of MRA is essential in preference to standard MRI to establish a diagnosis. MR arthrography should be a fundamental part of the imaging protocol when wrist ligament injuries are suspected, as it achieves the highest level of diagnostic confidence especially for inconclusive cases, and also accurately delineates the location and type of the tear in conclusive ones.

A limitation of our study was there was an average time gap of 15 days to 1 month between the MR arthrography and the arthroscopy. Arthroscopic results may have been influenced due to the prior knowledge of the radiological diagnosis, and also we could not differentiate traumatic from degenerative tears unless there are other signs of injury.

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