Role of Direct Magnetic Resonance Arthrography in Evaluation of Wrist Joint Instability

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Abstract:

Background: Magnetic resonance imaging (MRI) is an effective method for helping determine the cause of wrist pain by demonstrating a broad spectrum of abnormalities, including those of bone, cartilage, ligaments, and tendons. **Aim:** To assess the role of direct MR arthrography imaging in the diagnosis of tear and cartilaginous abnormalities of the triangular fibrocartilage and intrinsic ligaments of the wrist joint. **Methods:** A prospective cohort study conducted on 50 patients with chronic refractory unexplained wrist pain. All patients underwent initially a conventional MRI exam followed by conventional arthrography then MR arthrography while 20 patients only with suspected TFCC or ligamentous injuries clinically and radiologically underwent to MR arthroscope. **Results:** We compared MRI, MRA and arthroscopic findings of 20 patients, there were high statistically significant differences between the groups in terms of distal avulsion and LT ligament tear. As regarding central and peripheral TFCC tears; sensitivity, specificity, PPV, and NPV of MRI and MRA respectively were 82.4%, 87.8%, 80.5%, and 84.2% and 63.2%, 66.7%, 71.1%, and 68.5%. **Conclusion:** 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.

Keywords: MRI; MR; arthrography; arthroscopy; wrist joint pain

Introduction

Pain of the wrist is a diagnostic challenge for hand surgeons and radiologists because of the small and complex anatomical structures involved, ligament injuries can lead to progressive instability with secondary deterioration of the wrist joint, these lesions most frequently involve the scapholunate, lunotriquetral ligaments, and the triangular fibrocartilaginous complex. Surgical techniques directed at specific injury patterns have been proposed, and precise preoperative diagnosis is necessary **(1).**

Magnetic resonance imaging is an effective method for helping determine the cause of wrist pain by demonstrating a broad spectrum of abnormalities, including those of bone, cartilage, ligaments, and tendons. MR imaging is useful in the detection, characterization, and staging of osseous injury and disease. MR imaging may demonstrate irregular cartilage loss, and its superior soft-tissue contrast makes it the method of choice for evaluating the synovial processes. Tendinitis, tenosynovitis, and anatomic variants can be diagnosed and accurately assessed with MR imaging **(2).**

Combination of the advantages of conventional arthrography with the direct visualization of structures on magnetic resonance (MR) imaging made magnetic resonance arthrography (MRA) the preferred modality for imaging patients with internal derangement of the wrist in some of the centers **(3).**

The diagnostic performance of MR is improved by MRA making lesions more conspicuous when they are outlined by contrast material in a distended joint space **(4).**

MR imaging should be initiated within 30 minutes following arthrography to minimize absorption of contrast solution and loss of capsular distention. The same dedicated coils and imaging planes are used similar to conventional MR imaging T1-weighted spin-echo pulse sequences, with or without fat suppression, maximize the signal intensity of contrast solution **(5).**

We aimed to assess the role of direct MR arthrography imaging in the diagnosis of tear and cartilaginous abnormalities of the triangular fibrocartilage and intrinsic ligaments of the wrist joint.

Patients and Methods

A prospective cohort study conducted at Radiology Department, Faculty of Medicine, Benha University and El-Sahal Teaching Hospital, Cairo, Egypt during the period from January 2015 to December 2020.

This study included 50 patients with chronic refractory unexplained wrist pain. All patients underwent initially a conventional MRI exam followed by conventional arthrography then MR arthrography while 20 patients only with suspected TFCC or ligamentous injuries clinically and radiologically underwent to MR arthroscope.

Informed written consents was taken from all participants in this study after explaining the aim for them, this study was approved by the Ethical Committee of Benha faculty of medicine.

Exclusion criteria:

- MRI or MRA performed with < 1.5 T.
- New trauma between MRI and arthroscope.
- TFCC surgery in the past.
- Interval between MRI or MRA and arthroscopy of more than 6 months.
- A systemic joint disease (i.e. gout or rheumatoid arthritis).

Methods:

All patients were subjected to full history, clinical examination and radiological investigations **(**Conventional unenhanced MRI, X-ray and conventional arthrography films and MR Arthrography).

Arthroscopy was done in 20 patients and the results were correlated with those of conventional MRI and MRA.

Magnetic Resonance Imaging:

All patients underwent MRI of the wrist in coronal, sagittal, and axial planes on a 1.5-T MRI scanner (General Electric Healthcare).

All patients were scanned in the prone position with the elbow extended overhead and with the pronated hand positioned in the center of the wrist coil at the scanner isocenter (Superman position) with the affected wrist extended into the MR scanner beyond the patient's head, using dedicated wrist coil, the examination protocol included coronal, sagittal, and axial planes, Coronal plane is the most important image for detecting ligament tears.

Protocol of conventional MR imaging

A coronal T1-weighted fast spin-echo was performed with TR/TE, 500/ 15; slice thickness 3 mm with gap 0.3 field of view100mm, matrix size 256x516.

A coronal T2* 3D was performed with TR/TE, 45/ 15,slice thickness 1.5 mm without gap, field of view 100 mm, matrix size 240x516.

A coronal PD fat saturated fast spin-echo was performed with TR/TE, 2700/ 30, slice thickness 3 mm with gap 0.3 field of view100mm, matrix size 256x516

Axial T2 FSE was performed with TR/TE, 2300/ 100, slice thickness 3 mm with gap 0.3 field of view100mm, matrix size 256x516

A Sagittal PD was performed with TR/TE, 2000/ 30; slice thickness 3 mm with gap 0.3 field of view100mm, matrix size 256x197

MR arthrography was performed using Two to four ml of contrast mixture (formed of Gadopentetate dimeglumine 0.1 ml added to 5 ml non-ionic contrast medium, 5 ml xylocaine, and sterile saline solution was added to form a mixture of 20 ml) was injected through the dorsal posterior approach into the radiocarpal compartment which was the only injected compartment. Introduction of the needle into the joint space was done underwent fluoroscopic-guided.

MRA was initiated within 30 min of the contrast injection and T1 fat saturated images were obtained in axial, sagittal and coronal planes (TR/TE, 550/20; slice thickness 3 mm with gap 0.3 mm field of view100mm, matrix size 256x516

Statistical analysis:

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software.

The data collected were tabulated and analyzed by SPSS (statistical package for social science) version 25 (Armonk, NY: IBM Corp) on IBM compatible computer. Data were statistically described in terms of range, mean ± standard deviation (± SD), frequencies (number of cases) and percentages when appropriate. Accuracy was represented using the terms sensitivity, specificity, +ve predictive value, -ve predictive value, and overall accuracy.

Results

Our results included 50 cases, their mean of age was (34.72 ±11.25 SD), with male predominance (58%), of traumatic nature (66%), on the right side (62%), and Limitation of movement was recorded in (22%).

As regard traumatic lesions, MRI and MRA showed that central perforation present in 22% vs 28%, peripheral ulnar tear/ulnar avulsion 24% vs 32%, distal avulsion 2% vs 4% and Radial tear/avulsion 2% vs 4%, respectively. Considering, Degenerative lesions, MRI and MRA showed that TFCC wear 6% vs 4%, TFCC wear with lunate and /or ulnar chondromalacia 6% vs 4%, TFCC perforation with lunate and /or ulnar chondromalacia 6% vs 8% and TFCC perforation with lunate and /or ulnar chondromalacia and LT ligament

Case 1: (Figure 1) Male patient 36 years old complaining of right sided ulnar wrist pain,he had history of fall in the right hand during playing football. Conventional MRI was done; **(A)**: coronal T2 WI image: suggest detachment of the peripheral attachment of the TFCC to the ulna (arrow). **(B)**: Radiocarpal injection with perforation 2% vs 4%, respectively (Table 1).

Intrinsic ligaments injury, SL ligament partial and complete tear in MRI & MRA were 10% vs 16% and 8% vs 12%, respectively. LT ligament partial and complete tear in MRI & MRA were 0% vs 6% and 6% vs 12%, respectively (Table 2).

We compared MRI, MRA and arthroscopic findings of 20 patients, there were high statistically significant differences between the groups in terms of distal avulsion and LT ligament tear (Table 3).

As regarding central and peripheral TFCC tears; sensitivity, specificity, PPV, and NPV of MRI and MRA respectively were 82.4%, 87.8%, 80.5% ,and 84.2% and 63.2%, 66.7%, 71.1%, and 68.5% (Table 4).

leakage of contrast in the distal radio ulnar joint (DRUJ) denoating underlying TFC tear. coronal T1 fat suppression MR arthrographic images **(C)** & **(D)** revealed: avulsion of the TFCC at the fovea attachement to the ulnar (arrow) with extension of the contrast to the distal radioulnar joint (short arrow), contrast extending in the soft tissue along the

medial aspect of distal ulna suggestive of injury to the ulnar colateral ligament. Arthroscopy confirmed the MRA findings with peripheral (ulnar) TFCC tear class I-B.

Case 2: (Figure 2) Female patient 45 years old, complaining of chronic ulnar side right wrist pain, history of old trauma. Conventional MRI was; Coronal T1 WI& PD FS **(A&B)** revealed attenuated central portion of the TFC with linear central defect within the TFC (arrow in B). MR Arthrography Coronal Fat suppressed T1 WI **(C)** & **(D)** images revealed: linear central defect within the TFC (arrow) which appear appears irregular and abnormal in signal with leakage of the injected contrast into the DRUJ(long arrow). Arthroscopy: confirmed the diagnosis of MRA of TFCC central perforation

Table 1: Distribution of patients regarding palmer classification of the different TFC lesions on MRI and after MRA.

	Cases (n=50)			
	MRI		MRA	
	No	*%*	*No*	*%*
Traumatic				
1A: Central perforation	11	22%	14	28%
1B: peripheral ulnar tear/ulnar avulsion	12	24%	16	32%
1C distal avulsion	1	2%	2	4%
1D:Radial tear/avulsion	1	2%	2	4%
Degenerative				
2A: TFCC wear	3	6%	2	4%
2B: TFCC wear with lunate and /or ulnar chondromalacia	3	6%	2	4%
2C: TFCC perforation with lunate and /or ulnar chondromalacia	3	6%	4	8%
2D:2C with LT ligament perforation	1	2%	2	4%
2E: 2D and Ulnocarpal arthritis	0	0%	0	0%
Total	35	70%	44	88%

Table 2: Distribution of patients regarding Intrinsic ligaments injury of the wrist in MRI and after MRA.

	Cases (n=50)			
	MRI		**MRA**	
	No	*%*	*No*	*%*
SL ligament tear				
Partial tear	5	10%	8	16%
Complete tear	4	8%	6	12%
Total	9	18%	14	28%
LT ligament tear				
Partial tear	0	0%	3	6%
Complete tear	3	6%	5	12%
Total	3	6%	8	16%

Table 3: Detailed MRI, MRA and arthroscopic findings of the 20 patients

		Cases (n=20)			***P value***
		MRI	MRA	Arthroscopy	
		o	*o*	*o*	
TFCC lesions	Central TFCC lesions	0%	5%	5%	0.353
	Peripheral ulnar TFCC lesions	0%	0%	5%	0.145
	Distal avulsion	%	0%	0%	**<0.001***
	Radial tear/avulsion	%	%	%	1
Ligamentous injuries	SLL lesions	0%	5%	5%	0.183
	LTL lesions	%	5%	5%	**<0.001***
Osseouss lesions	Lunate chondromalacia	5%	5%	5%	1
Miscellaneous	Ganglion cyst	0%	0%	0%	1

Table 4: Receiving operating characteristic analysis for MRI, MRA and arthroscopy

	AUC	Sensitivity	Specificity	NPV	PPV
MRI	0.682	82.4%	80.5%	63.2%	71.1%
MRA	0.781	87.8%	84.2%	66.7%	68.5%
Arthroscope	0.865	96.1%	87.5%	71.4%	75.2%

AUC: Area Under a Curve; NPV: Negative predictive value; PPV: Positive predictive value

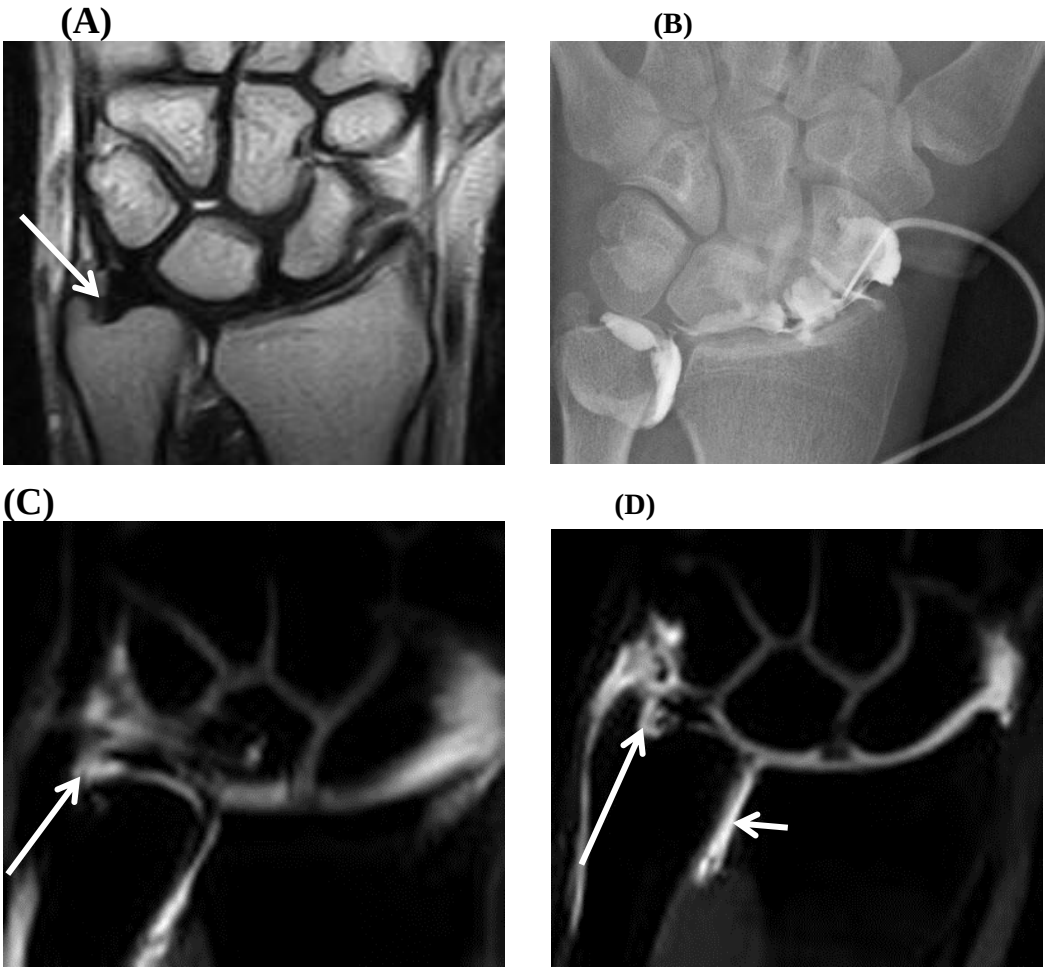

Figure (1): Case 1: Male patient 36 years old complaining of right sided ulnar wrist pain,he had history of fall in the right hand during playing football. Conventional MRI was done; **(A)**: coronal T2 WI image: suggest detachment of the peripheral attachment of the TFCC to the ulna (arrow). **(B)**: Radiocarpal injection with leakage of contrast in the distal radio ulnar joint (DRUJ) denoating underlying TFC tear. coronal T1 fat suppression MR arthrographic images **(C)** & **(D)** revealed: avulsion of the TFCC at the fovea attachement to the ulnar (arrow) with extension of the contrast to the distal radioulnar joint (short arrow), contrast extending in the soft tissue along the medial aspect of distal ulna suggestive of injury to the ulnar colateral ligament. Arthroscopy confirmed the MRA findings with peripheral (ulnar) TFCC tear class I-B.

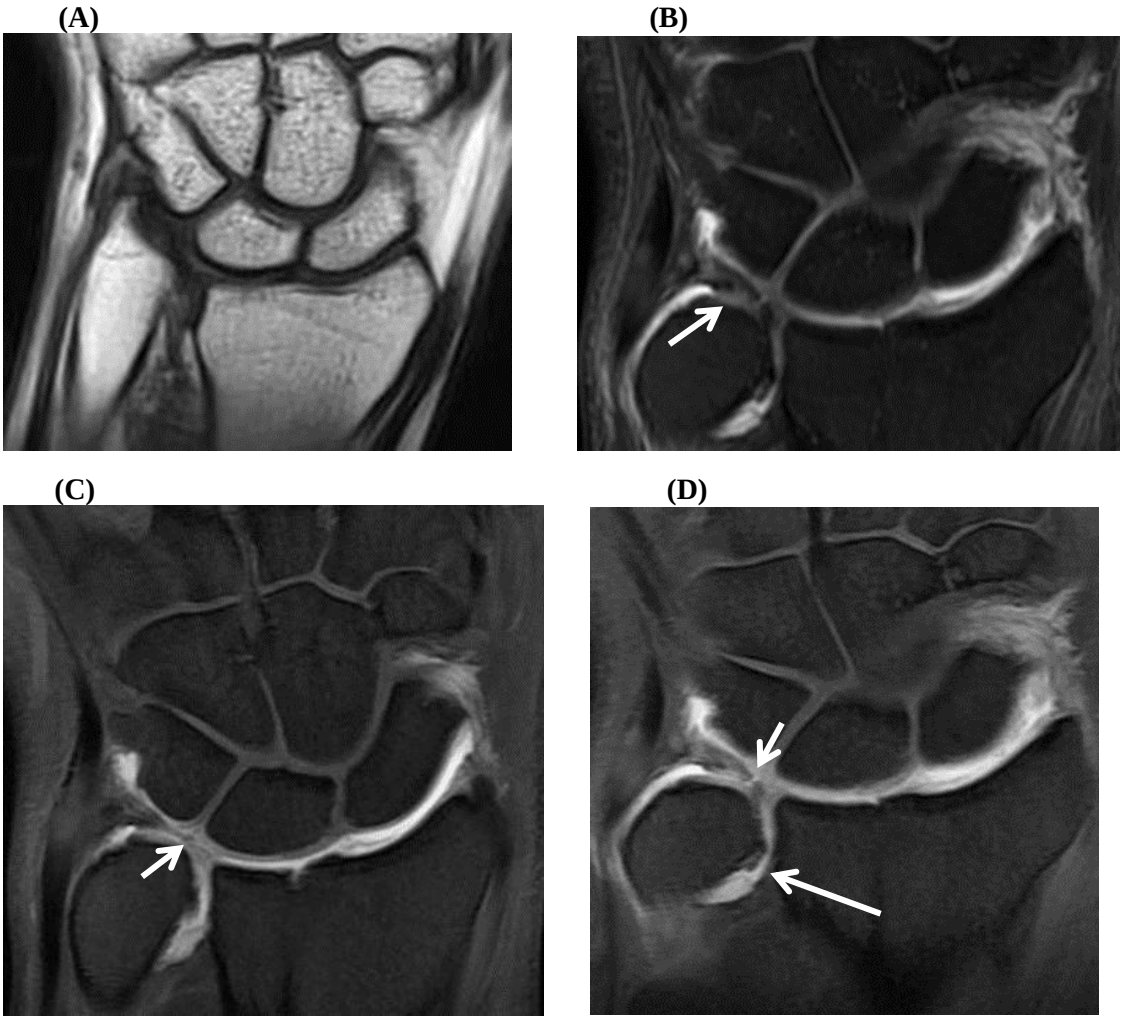

Figure (2): Case 2: Female patient 45 years old, complaining of chronic ulnar side right wrist pain,history of old truma. Conventional MRI was; Coronal T1 WI& PD FS **(A&B)** revealed attenuated central portion of the TFC with linear central defect within the TFC (arrow in B). MR Arthrographic Coronal Fat suppressed T1 WI **(C)** & **(D)** images revealed: linear central defect within the TFC (arrow) which appear appears irregular and abnormal in signal with leakage of the injected contrast into the DRUJ(long arrow). Arthroscopy: confirmed the diagnosis of MRA of TFCC central perforation

Discussion

Our choice of direct MRA over indirect MRA because this technique fully distends the joint cavity, outlines ligament defects and can depict the precise location of the ligamentous defect. Also, in term of cost effectiveness direct MRA needs very much lower concentration of contrast compared to indirect MRA. On the other hand indirect MRA is less invasive with a major advantage in detection of abnormalities other than the internal derangements as tenosynovitis **(6).** In the current study, the radiocarpal compartment was the only injected compartment. This is in agreement

with previous researchers ***(7)*** who supported sufficiency of single radiocarpal injection followed by fat suppressed gadolinium sensitive sequences.

Palmer classification for triangular fibrocartilage complex (TFCC) abnormalities is based on the cause, location, and degree of injury **(8)**. In our study, as regarding distribution of patients regarding palmer classification of the different TFC lesions on MRI and after MRA. Similar percentages were recorded by both modalities. Central perforation (22% by MRI and 28% by MRA), peripheral ulnar tear/ulnar avulsion (24% and 32%).

Similar results were reported by another study, ***(9),*** they concluded that MRA detected normal MR Arthrography in 2 patients. A total of 31 (54.38%) TFCC tears (22 peripheral and 9 central), TFCC degeneration, 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.

Concomitant lesions were present in 19 patients (36.84%). They also added that, In TFCC lesions according to palmer classification type 1 (traumatic tear) is detected in 15 and type 2 (degenerative 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.

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 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 **(10).**

In the study in our hand, we compared MRI, MRA and arthroscopic findings of 20 patients, there were high statistically significant differences between the groups in terms of distal avulsion and LT ligament tear.

The recent studies claim that wrist diagnostic arthroscopy is not so reliable and should be reconsidered as a reference diagnostic tool, **(11).** as it 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. **(12).**

In the current study, as regarding central and peripheral TFCC tears; sensitivity, specificity, PPV, and NPV of MRI and MRA respectively were 82.4%, 87.8%, 80.5% ,and 84.2% and 63.2%, 66.7%, 71.1%, and 68.5%.

There is wide variation in literature regarding the diagnostic accuracy of MRI and MRA **(13).** results of MRI for central TFCC lesions (showed sensitivity and specificity 87.5% & 100% respectively) are comparable with results of a recent study ***(14)*** that shows sensitivity and specificity of MRA being (83% & 100% (as their study didn`t encounter any peripheral ulnar TFCC lesions.

Conclusion

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.

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