Original Article

Comparison of Magnetic Resonance Arthrography and Wrist Arthroscopy in the Evaluation of Chronic Wrist Pain in Indian Population

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Abstract

Background: The purpose of our study was to compare magnetic resonance arthrography (MRA) as a diagnostic modality against the gold standard of wrist arthroscopy in the evaluation of chronic wrist pain. **Materials and Methods:** Thirty three patients with chronic wrist pain suspected to have ligament injuries of the wrist were prospectively recruited. They underwent MRA examinations followed by wrist arthroscopy. Arthroscopic findings were compared with radiological findings focusing on three important structures – triangular fibrocartilage complex (TFCC), scapholunate ligament (SLL), and lunotriquetral ligament (LTL). **Results:** For the 17 patients with TFCC tears/perforations on arthroscopy, MRA gave a sensitivity (SEN) = 88%, specificity (SPE) = 87.5%, positive predictive value (PPV) = 88%, and negative predictive value (NPV) = 87.5%. For the 13 patients with SLL tears on arthroscopy, MRA gave SEN = 77%, SPE = 100%, PPV = 100%, and NPV = 87%. For the 7 patients with LTL tears on arthroscopy, MRA gave SEN = 29%, SPE = 100%, PPV = 100%, and NPV = 84%. A composite correlation between findings on MRA and wrist arthroscopy revealed an overall SEN = 73%, SPE = 96%, PPV = 93%, and NPV = 85% for MRA, with overall accuracy = 88%. **Conclusions:** The presented diagnostic results of MRA are superior to those of magnetic resonance imaging quoted in literature. MRA is a potent tool for evaluating chronic wrist pain but tends to miss lesions of intrinsic carpal ligaments (SLL and LTL) more than TFCC. Wrist arthroscopy may be recommended when the clinical suspicion is strong.

Keywords: *Lunotriquetral ligament, scapholunate ligament, triangular fibrocartilage complex, wrist arthroscopy, wrist pain*

Introduction

Chronic wrist pain has been referred to as "low back pain of the hand."[1] The etiology may not be clear cut in most cases, and the determination of the cause of chronic wrist pain is frequently a diagnostic challenge. Triangular fibrocartilage complex (TFCC), scapholunate ligament (SLL), and lunotriquetral ligament (LTL) are critical to the stability of the wrist joint. Damage to these ligaments disrupts normal bone alignment – creating an altered motion pattern, producing pain, and eventually leading to osteoarthritis. These three ligaments are the most frequently involved entities in patients presenting with "undiagnosed" wrist pain.[2,3]

A better understanding of wrist anatomy and kinematics over the years has established physical examination as the basic tool in the formulation of a differential diagnosis.[4] Imaging studies can confirm or exclude a clinically presumptive diagnosis and help frame a treatment plan. Plain radiographs are often employed as the first imaging investigation. Arthrography has been successfully used in the past; however, various authors have noted communication between different wrist compartments, even in the absence of trauma or disease.[5,6]

Magnetic resonance imaging (MRI) makes it possible to directly visualize the ligamentous components of the wrist. Magnetic resonance arthrography (MRA) offers several advantages but is expensive and invasive and necessitates a complex and time-consuming technique. Wrist arthroscopy has been described as the "gold standard" in diagnosing TFCC or intercarpal ligament injuries.[7,8] Ever since its first use and description by Chen,[9] wrist arthroscopy has evolved as an essential diagnostic and therapeutic tool. Studies which compare wrist arthroscopy with the best possible

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imaging investigation – MRA – are still few and lacking. The primary objective of this study was to compare MRA as a diagnostic modality with wrist arthroscopy in the evaluation of chronic wrist pain when they are performed using standardized protocol and techniques. The secondary objective was to compare our results with previously published literature.

Materials and Methods

Patients presenting to the outpatient department with chronic wrist pain (>6-week duration) that was affecting work, hobby, or activities of daily living between April 2014 and November 2015 were included in this prospective study. Patients who were clinically suspected to have injury/pathology of the ligamentous structures of the wrist with their plain radiographs not demonstrating a conclusive cause of chronic wrist pain were included. All patients were given and had no relief with a trial of conservative treatment (at least 6 weeks) before being recruited for the study. Patients with fractures, arthritis, or a clinical picture suggestive of an inflammatory pathology were excluded. Prior approval was taken from the Institutional Ethics Committee, and informed written consent was taken from each patient who was included in the study.

Single-compartment radiocarpal joint arthrogram was performed under fluoroscopic guidance on Philips Allura Xper FD20 or Siemens Axiom Iconos R200 (digital spot imaging 1000 MA) radiographic systems. Using a 23G needle, 2–5 mL solution of 0.1 mL gadolinium diluted in 20 mL solution composed of 15 mL of normal saline, and 5 mL of iodinated contrast (diatrizoate meglumine [370 mg iodine/mL] or iohexol [300 mg iodine/mL]) material was injected. MRA was performed within an hour after conventional arthrography on a 1.5T magnetic resonance (MR) scanner (Sonata/Avanto, Siemens, Erlangen, Germany) using a dedicated wrist coil. Six sequences were performed – T1-weighted turbo spin echo sequence in coronal, sagittal, and axial planes; proton density and T2-weighted sequence with fat saturation in coronal and axial planes; and three dimensional (3D) gradient echo T2-weighted multiecho data image combination in the coronal plane. The image assessment was done by a radiologist with interest and experience in the field of musculoskeletal radiology who was unaware of the history, clinical findings, or subsequent findings at surgery. On MR arthrogram, contrast outlining a defect in the ligament or contrast leakage from the radiocarpal joint into the midcarpal joint was taken as a definite tear. Severe distortion of the morphology (fraying, thinning, or irregularity) was considered as a probable tear. Both of these were taken as an affirmative for each ligament tear.

Arthroscopy was performed following MRA as a day-care procedure under General Anaesthesia (GA)/regional block by a trained wrist arthroscopy surgeon. The wrist arthroscope (small-bore 1.9 mm arthroscope with a 30° viewing angle – Karl Storz, Tuttlingen, Germany) was introduced through the 3–4 portals. The 4–5 and the 6R/6U portals were used as accessory portals, for instrumentation and visualization as needed. The midcarpal joint space was assessed using the midcarpal radial and the midcarpal ulnar portals.

We focused on three main areas of pathology – TFCC, SLL, and LTL. The arthroscopy and MR arthrographic findings were examined for correlation. Therapeutic interventions, where needed, were performed in the same setting.

Results

Thirty three patients were included in the study. The mean age was 31 years (range 16–52 years). There were 22 males and 11 females with 16 of them (48%) having a history of antecedent trauma. Twenty one patients had their dominant hand involved. The mean duration of symptoms at the time of presentation was 9.5 months (range 4–24 months).

In the 33 wrists that were examined, MRA recorded 29 tears (17 TFCC tears, 10 scapholunate tears, and 2 lunotriquetral tears). In the same set of patients, subsequent wrist arthroscopy detected 37 tears (17 TFCC tears, 13 scapholunate tears, and 7 lunotriquetral tears). Agreement between the results of MRA and wrist arthroscopy was seen in 23 patients (70%). The remaining 10 patients (30%) had an alteration in their diagnosis after the arthroscopy [Table 1].

The findings of MRA were compared to the findings on wrist arthroscopy with regard to:
i. The presence or absence of tear
ii. Location of the tear.

We present our results with respect to each of our objectives: (i) comparison of MRA and wrist arthroscopy for the detection of tears of the TFCC, SLL, and LTL and (ii) comparison of the findings of our study with similar studies previously published in the literature.

Table 1: Findings on magnetic resonance arthrography and wrist arthroscopy

Finding	MRA	Wrist arthroscopy
Isolated TFCC tear	15	12
Isolated scapholunate tear	7	5
Isolated lunotriquetral tear	0	1
TFCC + scapholunate tear	1	3
TFCC + lunotriquetral tear	0	1
Scapholunate + lunotriquetral tear	1	4
TFCC + scapholunate + lunotriquetral tear	1	1
“Negative” investigation	8	6
Total	33	33

TFCC=Triangular fibrocartilage complex, MRA=Magnetic resonance arthrography

Comparison of magnetic resonance arthrography and wrist arthroscopy with respect to tears of the triangular fibrocartilage complex, scapholunate ligament, and lunotriquetral ligament

Table 2 shows the correlation of MRA and wrist arthroscopy in the detection of tears of the TFCC [Figures 1a, b and 2]. There were 2 false positive results and 2 false negative results. Based on these results, MRA showed a sensitivity (SEN) = 0.88 (88%), specificity (SPE) = 0.875 (88%), positive predictive value (PPV) = 0.88 (88%), negative predictive value (NPV) = 0.875 (88%), and an accuracy = 0.878 (88%). According to the location, TFCC tears were categorized into central, ulnar, and radial tears. The strength of agreement with regard to delineating the location of TFCC tears was "almost perfect" (kappa = 1.000).

Table 3 shows the correlation of MRA and wrist arthroscopy in the detection of tears of the SLL [Figures 3a, b and 4a, b].

Table 2: Correlation between magnetic resonance arthrography and wrist arthroscopy for triangular fibrocartilage complex tears

TFCC	Arthroscopic diagnosis		Total
	Tear present	Tear absent	
MR arthrogram (+)	15	2	17
MR arthrogram (−)	2	14	16
Total	17	16	33

MR=Magnetic resonance, TFCC=Triangular fibrocartilage complex

Table 3: Correlation between magnetic resonance arthrography and wrist arthroscopy for scapholunate ligament tears

SLL tears	Arthroscopic diagnosis		Total
	Tear present	Tear absent	
MR arthrogram (+)	10	0	10
MR arthrogram (−)	3	20	23
Total	13	20	33

MR=Magnetic resonance, SLL=Scapholunate ligament

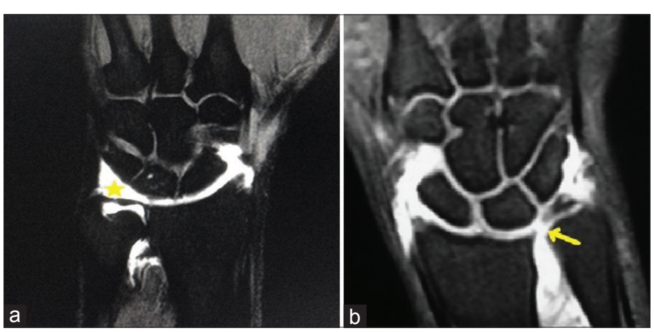

Figure 1: Triangular fibrocartilage complex tears on magnetic resonance arthrography, (a) triangular fibrocartilage complex central perforation (yellow star) – leak of contrast from radiocarpal joint to distal radioulnar joint is seen on a coronal T1-weighted fat saturation magnetic resonance arthrography image, (b) tear of the radial attachment of triangular fibrocartilage complex (yellow arrow) – as seen on coronal T1-weighted fat saturation magnetic resonance arthrography image

There were 3 false negative results. Based on these results, MRA showed a SEN = 0.77 (77%), SPE = 1.00 (100%), PPV = 1.00 (100%), NPV = 0.87 (87%), and an accuracy = 0.91 (91%). According to location, scapholunate tears were categorized into volar, dorsal, membranous, volar + membranous, dorsal + membranous, and complete tears. The strength of agreement with regard to delineating the location of TFCC tears was "strong" ($\kappa = 0.821$).

Table 4 shows the correlation of MRA and wrist arthroscopy in the detection of tears of the LTL. There were 5 false negative results. Based on these results, MRA showed a SEN = 0.29 (29%), SPE = 1.00 (100%), PPV = 1.00 (100%), NPV = 0.84 (84%), and an accuracy = 0.85 (85%). According to location, lunotriquetral tears were categorized into volar, dorsal, membranous, volar + membranous, dorsal + membranous, and complete tears. The strength of agreement with regard to delineating the location of TFCC tears was "almost perfect" ($\kappa = 1.000$).

Composite correlation for all ligament tears

Table 5 highlights the overall correlation between MRA and arthroscopy in diagnosing tears of the three major ligaments we sought to compare (TFCC, SLL, and LTL). Based on these results, MRA showed an overall SEN = 0.73 (73%), SPE = 0.96 (96%), PPV = 0.93 (93%), NPV = 0.85 (85%), and an accuracy = 0.88 (88%).

These results are summarized in Table 6.

Comparison to previously published literature

Our results are comparable to the previously reported studies comparing MRI/MRA and arthroscopy in the literature.[10-18]

Tables 7-9 show how our results compare to previously published studies with each of the three ligaments that we assessed.

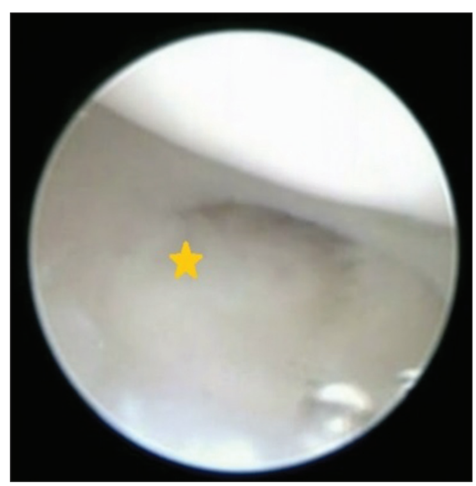

Figure 2: Triangular fibrocartilage complex tear on wrist arthroscopy, large central perforation (yellow star) of the triangular fibrocartilage complex. This patient was treated in the same sitting by shaving/debriding the edges of the perforation

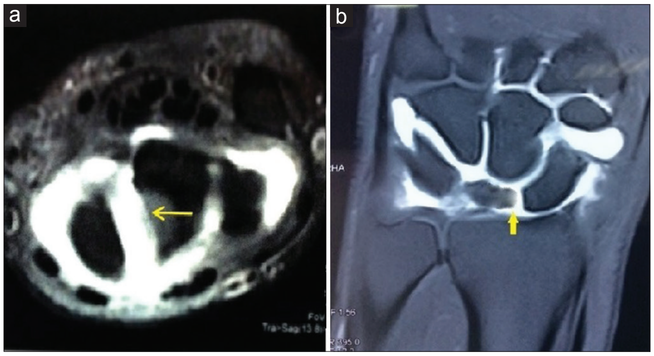

Figure 3: Scapholunate ligament tear on magnetic resonance arthrography, (a) complete scapholunate tear (yellow arrow) with contrast leak – axial T1-weighted fat saturation magnetic resonance arthrography, (b) complete scapholunate tear and diastasis (yellow arrow) with contrast leak into the midcarpal space – coronal T1-weighted fat saturation magnetic resonance arthrography

Table 4: Correlation between magnetic resonance arthrography and wrist arthroscopy for lunotriquetral ligament tears

LTL tears	Arthroscopic diagnosis		Total
	Tear present	Tear absent	
MR arthrogram (+)	2	0	2
MR arthrogram (−)	5	26	31
Total	7	26	33

MR=Magnetic resonance, LTL=Lunotriquetral ligament

Table 5: Correlation between magnetic resonance arthrogram and arthroscopy for all ligaments (triangular fibrocartilage complex, scapholunate ligament, and lunotriquetral ligament) in our study

Overall	Arthroscopic diagnosis		Total
	Tear present	Tear absent	
MR arthrogram (+)	27	2	29
MR arthrogram (−)	10	60	70
Total	37	62	99

MR=Magnetic resonance

Table 6: Summary of performance of magnetic resonance arthrography in comparison to wrist arthroscopy in our study

Parameter	TFCC (%)	SLL (%)	LTL (%)	Overall (%)
SEN	88	77	29	73
SPE	88	100	100	96
PPV	88	100	100	93
NPV	88	87	84	85
Accuracy	88	91	85	88

PPV=Positive predictive value, NPV=Negative predictive value, LTL=Lunotriquetral ligament, SLL=Scapholunate ligament, TFCC=Triangular fibrocartilage complex, SEN=Sensitivity, SPE=Specificity

Discussion

Chronic wrist pain is a common presenting symptom to hand surgeons, with many of these patients having normal radiographs. Whereas wrist arthroscopy remains the gold standard,[7,8] patients are frequently evaluated by wrist arthrography, computed tomography, noncontrast MRI, and MRA. In spite of these multiple imaging modalities, there is often a failure to clinch a clear, preoperative diagnosis. Diagnostic wrist arthroscopy has been claimed to have only a limited diagnostic value in the setting of an unclear diagnosis[19] and its precise advantages over MRA; currently, the favored diagnostic imaging modality to look for ligamentous injuries of small joints such as the wrist has still not been validated by enough evidence.

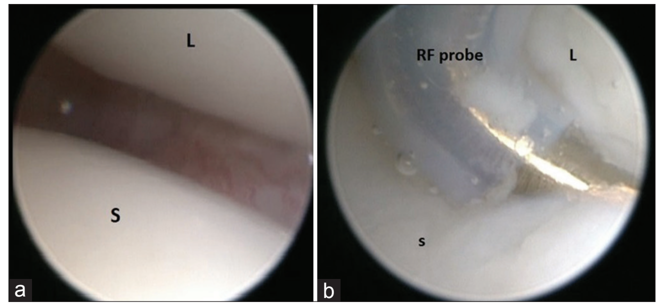

Figure 4: Scapholunate ligament tears on wrist arthroscopy, (a) increased gap between scaphoid and lunate suggestive of scapholunate tear (yellow star) (S = scaphoid and L = lunate), (b) radiofrequency ablation of a partial scapholunate tear with a radiofrequency probe S = scaphoid and L = Lunate

Our study population comprised predominantly younger adults with over half of the patients belonging to a single age group (21–30 years). Males and patients having a history of trauma featured prominently, suggesting that ligamentous injuries of the wrist are more common in young males with a history of trauma. Most of these patients had normal radiographs and yet MRA recorded 29 tears and arthroscopy revealed 37 tears. There is a paucity of literature comparing these two modalities, and existing studies suffer from a lack of standardization of the technique used for MRI and arthroscopy. Many of these studies are retrospective in nature, and important data have been missed out or inaccurately recorded. To our knowledge, no such study has been carried out in this part of the world.

There is a high rate of ligamentous injuries or tears in patients with hitherto undiagnosed chronic wrist pain.[3] Our study has further emphasized this finding. In our study, the most frequently affected structures were the TFCC (17 tears, 52%) and the SL ligament (13 tears, 39%) which is consistent with the literature.[2,3,20] Isolated TFCC injury causing ulnar-sided wrist pain was the most common presentation (12 isolated TFCC tears, 36%).

Our study showed an overall SEN of 73%, SPE of 96%, PPV of 93%, and NPV of 85% for MRA when compared to wrist arthroscopy as the gold standard with the overall accuracy being 88%. In a total of 33 wrists examined, there were 2 false positive and 10 false negative results. We believe that in some cases, the ligament edges could

Table 7: Results of magnetic resonance imaging/magnetic resonance arthrography compared with wrist arthroscopy for diagnosis of triangular fibrocartilage complex tears

Study	Year	Sample size	Imaging protocol	Performance statistics (SEN, SPE, PPV, and NPV)
MRI				
Zlatkin *et al*.[10]	1989	23	MRI, 1.0T	89%, 92%, N/A, N/A
Johnstone *et al*.[12]	1997	43	MRI, 0.5T	80%, 70%, N/A, N/A
Morley *et al*.[13]	2001	54	MRI, 1.5T	44%, 87%, N/A, N/A
MRA				
Schweitzer *et al*.[14]	1992	15	1.0T, MRA	52%, 91%, N/A, N/A
Scheck *et al*.[15]	1999	35	1.0T, MRA	90%, 100%, N/A, N/A
Meier *et al*.[16]	2005	125	1.5T, MRA	94%, 89%, 91%, 93%
Mahmood *et al*.[17]	2012	30	1.5T, MRA	90%, 75%, 85%, 80%
Asaad *et al*.[18]	2017	50	1.5T, MRA	83%, 80%, 91%, 67%
Our study		33	1.5T, MRA	88%, 88%, 88%, 88%

SEN=Sensitivity, SPE=Specificity, PPV=Positive predictive value, NPV=Negative predictive value, MRI=Magnetic resonance imaging, MRA=Magnetic resonance arthrography, N/A=Not available

Table 8: Results of magnetic resonance imaging/magnetic resonance arthrography compared with wrist arthroscopy for diagnosis of scapholunate ligament tears

Study	Year	Sample size	Imaging protocol	Performance statistics (SEN, SPE, PPV, and NPV)
MRI				
Zlatkin *et al*.[10]	1989	23	MRI, 1.0T	86%, 100%, N/A, N/A
Johnstone *et al*.[12]	1997	43	MRI, 0.5T	37%, 100%, N/A, N/A
Morley *et al*.[13]	2001	54	MRI, 1.5T	11%, 30%, N/A, N/A0
MRA				
Schweitzer *et al*.[14]	1992	15	1.0T, MRA	25%, 86%, N/A, N/A
Scheck *et al*.[15]	1999	35	1.0T, MRA	100%, 100%, N/A, N/A
Meier *et al*.[16]	2005	125	1.5T, MRA	72%, 100%, 100%, 92%
Mahmood *et al*.[17]	2012	30	1.5T, MRA	91%, 88%, 83%, 88%
Asaad *et al*.[18]	2017	50	1.5T, MRA	71%, 89%, 71%, 89%
Our study		33	1.5T, MRA	77%, 100%, 100%, 87%

SEN=Sensitivity, SPE=Specificity, PPV=Positive predictive value, NPV=Negative predictive value, MRI=Magnetic resonance imaging, MRA=Magnetic resonance arthrography, N/A=Not available

Table 9: Results of magnetic resonance imaging/magnetic resonance arthrography compared with wrist arthroscopy for diagnosis of lunotriquetral ligament tears

Study	Year	Sample size	Imaging protocol	Performance statistics (SEN, SPE, PPV, and NPV)
MRI				
Zlatkin *et al*.[10]	1989	23	MRI, 1.0T	50%, 100%, N/A, N/A
Johnstone *et al*.[12]	1997	43	MRI, 0.5T	0, 97%, N/A, N/A
Morley *et al*.[13]	2001	54	MRI, 1.5T	N/A
MRA				
Schweitzer *et al*.[14]	1992	15	1.0T, MRA	31%, 90%, N/A, N/A
Scheck *et al*.[15]	1999	35	1.0T, MRA	100%, 90%, N/A, N/A
Meier *et al*.[16]	2005	125	1.5T, MRA	25%, 99%, 50%, 98%
Mahmood *et al*.[17]	2012	30	1.5T, MRA	100%, 100%, 100%, 100%
Asaad *et al*.[18]	2017	50	1.5T, MRA	100%, 94%, 40%, 100%
Our study		33	1.5T, MRA	29%, 100%, 100%, 84%

SEN=Sensitivity, SPE=Specificity, PPV=Positive predictive value, NPV=Negative predictive value, MRI=Magnetic resonance imaging, MRA=Magnetic resonance arthrography, N/A=Not available

have coapted, simulating an intact ligament on MRA and possibly accounting for the false negative results. Magee[21] also described "microperforations" of the ligaments which allow the passage of contrast material from the radiocarpal joint space into the midcarpal joint space showing up as positive findings of tears on MRA. Such microperforations could have accounted for the false positive results. Differentiating peripheral and central tears of the TFCC is important as the mode of treatment is different in each condition. Injection of contrast in the distal radioulnar joint has been proposed to improve the diagnosis of peripheral ulnar-sided TFCC tears. Failure to do so can obscure the diagnosis of noncommunicating ulnar-sided tears of the proximal surface of the TFCC.[22] Lee *et al*. have employed a wrist traction device and finger traps to give axial traction at the time of performing MRA.[23] They reported improved opening of the joint spaces, more accurate tear detection rates, and better visibility of tears in the TFCC and the intrinsic carpal ligaments when MRA with traction was used. However, due to technical limitations and to maintain a standardized protocol, only single-compartment contrast injection into the radiocarpal joint without using wrist traction was done in our study.

When the diagnostic results of MRA for all the ligaments were taken together, our study showed a SEN of 73%, SPE of 96%, PPV of 93%, and NPV of 85%. In their study, Andersson *et al*.[24] considered the NPV – defined as the probability of an intact wrist ligament given a negative investigation – as the primary outcome measure. They proposed a value of at least 95% to be considered satisfactory from a clinical perspective for a particular diagnostic modality. This effectively meant finding out whether negative results of the test (in our case, MRA) were enough to safely discontinue further investigation with arthroscopy. In our study, the NPV of MRA in detecting each of the three ligaments that we assessed was less than the 95% cutoff. Thus, the negative results of MRA are unable to safely rule out the possibility of clinically relevant tears of the TFCC or the SLLs and LTLs, making a further evaluation with wrist arthroscopy necessary.

Our results illustrate the usefulness of MRA and its superiority over unenhanced MRI in assessing ligamentous pathology and suggest its use as the preferred imaging technique after plain radiography in evaluating patients with chronic wrist pain suspected to be due to an intercarpal ligament or TFCC injury. We also conclude that MRA is better for "ruling in" a ligament tear (high SPE) than for ruling it out (low SEN). The accuracy of MRA for detecting TFCC tears is satisfactory. MRA is a highly specific means of identifying tears of the intrinsic carpal ligaments but its SEN, particularly with respect to lunotriquetral tears, remains low.

Wrist arthroscopy is an effective tool in the exploration of the wrist joint and is relatively free of complications. Apt knowledge of its proper indications and limitations are required. A meticulous technique with care for the portals and intraarticular movements and using dynamic probing can avoid misdiagnosis. Arthroscopy is recommended as the method of choice when history and clinical examination support the possibility of a ligament tear, even if the imaging studies are negative and inconclusive. In future, the gold standard for diagnosing TFCC tears and SLL or LTL injuries may move toward MRI with high resolution, specific wrist coils, intraarticular contrast, thin slices, and a dedicated radiologist working closely with the hand surgeon, but at present, arthroscopy remains the gold standard.

Limitations and pitfalls

The sample size in our study was small. There was an inherent bias in our study as only symptomatic patients were included. To minimize the MRI examination time, single-compartment arthrography was used instead of the double or triple compartment recommended.[25] Another pitfall of our study was an inability to obtain a measure of interobserver reliability for MRA and arthroscopy. Both techniques are believed to be operator dependent and have significant intraobserver and interobserver variability. There was a delay of as much as 12 weeks between MRA and arthroscopy. During this delay, an incomplete tear can potentially turn into a complete one, or a tear seen through MRA can fill in with healing reaction tissue, making such a tear undetectable upon arthroscopy. Magee,[21] Saupe *et al*.,[26] and Lenk *et al*.[27] have compared MRI at a higher resolution (3T) with MRI at 1.5T and found superior results. More recently, 3T wrist MRA with a special 3D isotropic proton density-weighted fat-suppressed sequence has been used and reported to have better results.[28] However, in our study, we preferred to use MRI at 1.5T, believing that this is the type most readily available to orthopedic practitioners in our country.

Patient declaration statement

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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