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ARTHROGRAPHIC EVALUATION OF 1ST COMPARTMENT INJURY OF THE WRIST JOINT BY MULTIDETECTOR CT AND MRI

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ABSTRACT
Objectives: To assess role of CT arthrography and MR arthrography in detecting scapholunate ligament, lunotriquetral ligaments and triangular fibrocartilage complex injuries. **Background**: Wrist trauma is a common problem. Ligament injuries can lead to progressive instability with secondary deterioration of wrist joint. CT and MR arthrography are excellent techniques for determining the localization and extent of pathologic lesions of the triangular fibrocartilage complex and intrinsic carpal ligaments of the wrist. **Patients and methods:** The study included 30 patients with unilateral painful wrist to do CT and MR arthrography for wrist joint. A contrast mixture formed from MRI contrast agent, saline, iodinated contrast and local anesthesia prepared and injected intra-articular by CT guidance. Comparative CT and MR scanning done. Results of the analysis performed by two principal observers were compared. Concordant findings were accepted as the reference. Four cases with discordant or equivocal findings were reviewed by a third observer. **Results:** Sensitivities for CT arthrography for the 1st observer was 100% for SLL, LTL and TFCC injuries. For MRA was 100%, 75%, 85% & 100% for complete SLL tears, partial SLL tears of, partial LTL tears & TFCC tears respectively. Sensitivities for 2nd observer was 100% for all injuries by both CT arthrography and MR arthrography. **Conclusion**: Both CT and MR arthrography have high accuracy and reliable in diagnosis of intrinsic ligaments tears especially complete tears. However, CT arthrography is superior in the diagnosis of partial tears while MR arthrography is superior in diagnosis of early degenerative changes of triangular fibrocartilage.

KEYWORDS: arthrography, magnetic resonance imaging, multidetector computed tomography, wrist joint, wrist Injuries.

INTRODUCTION
Disorders of the wrist include both partial and complete tears of ligaments as well as a spectrum of chronic overuse injuries involving inflammatory and degenerative changes within the ligaments and surrounding tissues that may cause wrist instability and chronic pain.[1],[2]

There are advantages of performing arthrographic CT (computed tomography) or MRI (magnetic resonance imaging) of the wrist joint through single joint (radio-carpal) approach. Contrast opacification of the midcarpal or distal radioulnar joint provide evidence of communication tear or perforation of the intrinsic carpal ligaments or the triangular fibrocartilage complex (TFCC), respectively.[3]

The wrist joint is separated into number of compartments by the ligaments that attach to the carpal bones. These compartments are of considerable significance for the interpretation of wrist imaging and for identifying various patterns of arthritic involvement. In daily clinical practice, the most important compartments are the radiocarpal, midcarpal and distal radioulnar compartments.[4]

In 1981, Palmer and Werner introduced the term ‘‘triangular fibrocartilage complex’’(TFCC) to describe the complex of soft tissues interposed between the distal part of the ulna and the carpal bones on ulnar side.[5] In most descriptions, the TFCC is composed of the triangular fibrocartilage proper (TFC), meniscus homologue (MH), ulnar collateral ligament (UCL), dorsal and volar radioulnar ligaments (RUL), subsheath of the extensor carpi ulnaris tendon and the ulnocarpal ligaments (ulno-lunate and ulno-triquetral).[6]

The scapholunate ligament (SLL) and lunotriquetral ligament (LTL) of the proximal carpal row are both C-shaped spanning the dorsal, proximal, and palmar margins of their respective joint spaces.[7] Their integrity is essential for maintenance of normal carpal kinematics. The thickest and strongest region of the scapholunate ligament is located dorsally, while that of the lunotriquetral ligament is located palmary.[8][9]

This construction seems to support the ‘‘balanced lunate’’ concept, meaning that the lunate is under the influence of two opposite movements (scaphoid flexion and triquetral extension) which counteract each other.[10]

Traumatic injuries of TFC are subdivided into four types based on the site of injury into class IA (Avascular disc central slit), class IB (Base of the ulnar styloid avulsion), class IC (Carpal avulsion), class ID (radial avulsion).[3]

Ulnar impaction syndrome (UIS), also known as ulnar abutment or ulnocarpal impaction, is a degenerative condition characterized by chronic impaction between the ulnar head, the TFCC and ulnar carpus and results in a spectrum of pathologic changes: TFC degenerative tear, chondromalacia of the lunate, triquetral and distal ulnar head, LT ligament instability or tear and finally osteoarthritis of the DRUJ and ulnocarpal joint.[11]

Ulno-carpal impaction (UCI) most commonly occurs with positive ulnar variance. The most common predisposing factors include congenital positive ulnar variance and malunion of the distal radius and premature physeal closure of the distal radius.[3]

The degenerative changes of the ulnar impaction syndrome are sub classified according palmar classification into several stages according to the degree of involvement of structures on the ulnar side, highlighting the progressive nature of these injuries.[3] Class II-A; TFC degeneration without perforation, class II-B; TFC degeneration with associated lunate or ulnar chondromalacia, class II-C; represent TFC perforated defect with lunate or ulnar chondromalacia, class II-D; TFC perforated defect in the central horizontal portion associated with lunate or ulnar chondromalacia and LTL perforation, class II-E; TFC perforated defect associated with lunate or ulnar chondromalacia, LT ligament perforation and additional ulnocarpal arthritis.[5]

Differentiation between stages of ulnocarpal impaction syndrome is important because treatment is completely different.[12]

Intrinsic ligament tear may be classified into complete (all three portions disrupted) and incomplete (one or two portions disrupted) (also referred to as “partial” by some authors) interosseous ligament tears.[13]

The most common ligament to be injured is the scapholunate ligament. An acute or previous fall on the dorsally extended hand is generally the traumatic cause.[5]

SLL injury could be traumatic or degenerative, degenerative lesions usually affect proximal (fibrocartilaginous) segment and palmar segment. Traumatic tears usually affect dorsal segment.[3]

With CT/MR arthrography, the exact location and extent of a tear are better seen, thereby helping to differentiate degenerative from traumatic lesions as well as partial from complete tears. A partial tear may be diagnosed when there is focal thinning or irregularity or high-signal intensity in a portion of the ligament.[5]

Complete tears appear as distinct areas of discontinuity within the ligament, or an absence, altogether, of the ligament with contrast leak from radiocarpal to mid-carpal joint space.[5]

Compared with SLL injuries, LTL injuries are quite uncommon. Frequently, either the injury is missed or is misdiagnosed as another ulnar-sided wrist lesion such as midcarpal instability or a TFCC injury.[14]

As in SLL the imaging modality of choice for visualizing the LTL is CT/MR arthrography because it allows accurate visualization of the size, location, and morphology of LT tears. This type of detailed information is necessary because communication across a small membranous perforation or deficiency of the membranous portion of the ligament may not be clinically significant if the volar and dorsal components of the ligament are intact. In complete tears of the ligament, the intra-articular contrast will demonstrate communication between the radiocarpal and midcarpal joints.[3]

MATERIALS AND METHODS

The study included 30 patients with unilateral painful wrist referred from the orthopedic surgeons to Nile scan diagnostic radiology center to do CT and MR wrist arthrography. They included 22 males and 8 females in the age range between 17 and 50 years, with a mean age of 31years. The study includes all patients had wrist pain and suspected clinically to have TFCC injury or ligamentous injury of wrist joint, both sexes are included with no age predilection. Exclusion criteria was patients have wrist tumors or inflammatory diseases.

After approval from the local institutional ethical committee of Nile scan diagnostic radiology center and obtaining oral consent from each patient, all patients included in this study were subjected to comparative CT and MRI scanning after radiocarpal intra-articular contrast injection by CT guidance. Midcarpal injection was done in one case only due to advanced degenerative changes with diminished radio scaphoid joint space. In four cases mid carpal injection is added to radiocarpal injection upon referring doctor request.

Patient preparation before intra-articular injection started by putting the patient in prone position with the wrist lying overhead in pronation and the dorsal aspect of the wrist disinfected using povidone-iodine (Betadine). Then the Contrast mixture prepared by using 0.1 ml of Gd-DTPA diluted in 10 ml saline in addition to 5 ml iodinated contrast and 5 ml of local anesthesia making a mixture of 20 ml.

The CT machine used was Philips, 16 slice scanner, Country of Origin is Netherlands (Holland). The examination protocol included axial cuts with 1 mm slice thickness with coronal and sagittal reconstruction.

After skin preparation, a 28-gauge needle is inserted under CT guidance directly through the skin from a dorsal approach into radiocarpal space. Small-bore needles (28-gauge) used for wrist arthrography have the advantage of minimizing tissue trauma and post injection leakage of joint fluid. The needle position is verified by taken CT cuts after needle insertion and before injection of the contrast mixture.

Then only 3-5 ml of this contrast mixture well be injected in radiocarpal joint space under CT guidance, we added 2 ml of contrast mixture in 7 cases that showed communication between radiocarpal & midcarpal compartments and in 5 cases that showed communication between radiocarpal & inferior radio-ulnar compartments.

In four cases which double injection was requested by referring doctor, mid carpal injection done with radiocarpal injection.

Then the patient transferred to MRI suit. The MRI machine used was Philips, Achieva 1.5 Tesla scanner, Country of Origin is Netherlands (Holland). The examination protocol included coronal, sagittal, and axial planes. Coronal, axial and sagittal fast spin-echo T1-weighted (TR/TE, 22/450), coronal, axial and sagittal fast spin-echo T1 weighted with fat saturation (TR/TE, 22/450), coronal T2-weighted (TR/TE, 12/1000) sequences. Slice thickness was 3 mm with 0.3 mm interslice gap and field of view 16 cm. Flexible (circular) coils placed over wrist and was secured by rubbery bands. patients were placed in prone position with the wrist lying overhead in pronation (Superman position).

Statistical analysis was done using IBM© SPSS© Statistics version 22 (IBM© Corp., Armonk, NY, USA).

Because our study was aimed at evaluating the performances of different imaging techniques for wrist ligament injuries, including those not amenable to surgery, our reference was defined from the imaging and clinical follow-up. Results of the analysis performed by two principal observers were compared with findings on conventional arthrographic images. Concordant findings were accepted as the reference. Four cases with discordant or equivocal findings were reviewed by a third observer who had long experience in musculoskeletal radiology.

Diagnostic accuracy, including sensitivity, specificity, positive predictive value, and negative predictive value, was determined for each technique and each observer for the diagnosis of tears of the scapholunate and lunotriquetral ligaments, TFCC tears and cartilage abnormalities. We also separately calculated the sensitivity of each technique in the diagnosis of partial and complete tears of the scapholunate and lunotriquetral ligaments and for central perforation 'degenerative and traumatic' and ulnar tears 'styloid and foveal ligaments' of the TFCC as well as tears of ulnar and radial collateral ligaments. Kappa test also was used to evaluate agreement between two diagnostic methods. All tests were two-tailed. A p-value < 0.05 was considered significant.

RESULTS

The study included 30 wrists with wrist pain acute or chronic with age ranging from 17 to 50 years (mean = 31.4) complained of post traumatic wrist pain with clinical suspicion of having TFCC or wrist ligament tears were involved in this study.

The study includes 48 pathologies diagnosed by CT and 47 pathologies diagnosed by MR.

About SLL sensitivity of complete tears by both observers was 100% for both CTA and MRA. For partial tears sensitivities of 1st observer was 100% & 75% for CTA & MRA respectively and for 2nd observer was 100% for both CTA & MRA (Table 1), (Figure 1,2).

Table 1: Diagnostic accuracy of MRI and CT arthrography in the diagnosis of Scapholunate Ligament tears.

Technique	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
CT arthrography					
Observer 1	100%	100%	100%	100%	100%
-Partial tears	100%				
-Complete tears	100%				
-Intact	100%				
-Observer 2	100%	100%	100%	100%	100%
-Partial tears	100%				
Complete tears	100%				
-Intact	100%				
-MRI arthrography					
-Observer 1	80%	100%	100%	96.20%	96.70%
-Partial tears	75%				
Complete tears	100%				
-Intact	100%				
-Observer 2	100%	100%	100%	100%	100%
-Partial tears	100%				
Complete tears	100%				
-Intact	100%				

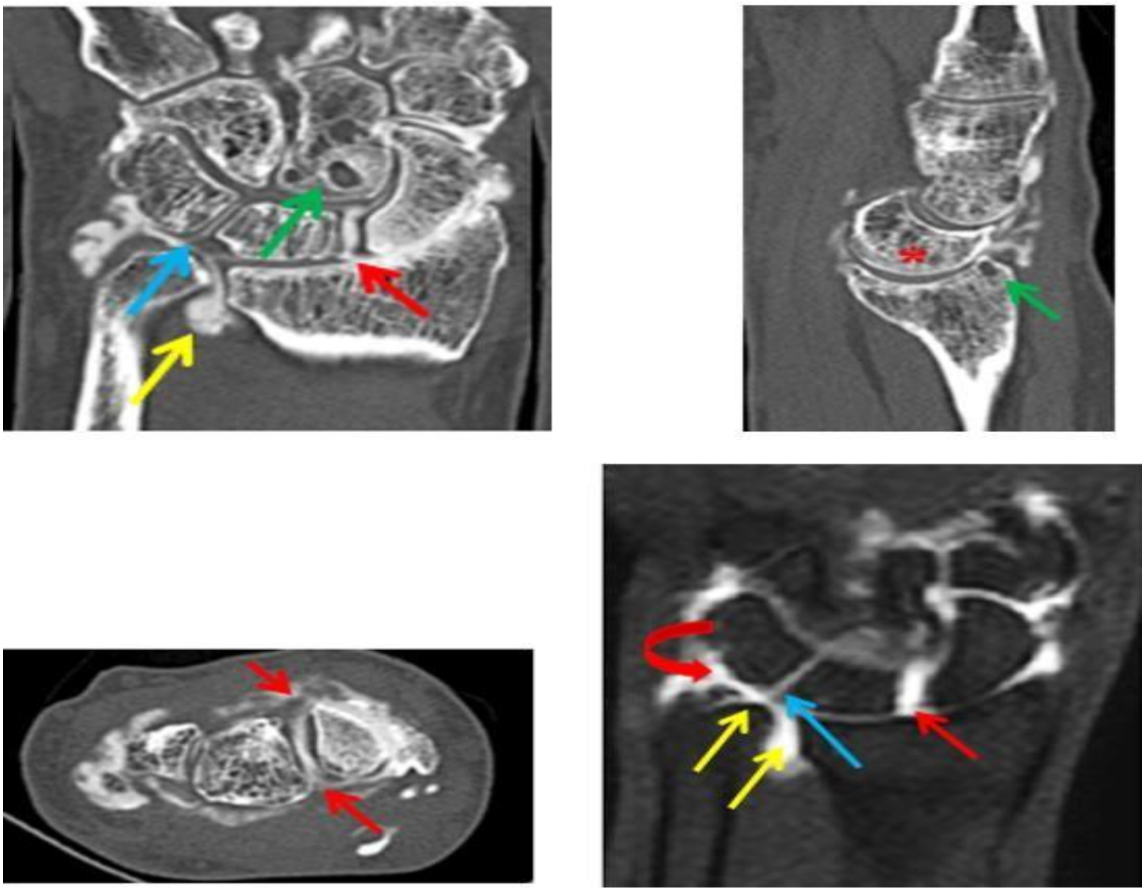

Figure 1: Male patient 50 years old complaining of chronic left wrist pain with previous history of falling in outstretched hand.

A. CTA Coronal reconstruction image.

B. CTA Sagittal reconstruction image.
C. CTA axial image.
D. MRA coronal T1 FS.

Images show torn SLL (red arrows), torn middle segment of LTL (blue arrows), degenerative tear of TFC with contrast leak at inferior radioulnar compartment (yellow arrows), osteoarthritic changes and pseudocyst formation of capitate and radial bones (green arrows), Dorsal malrotation of the lunate bone (red asterisk).

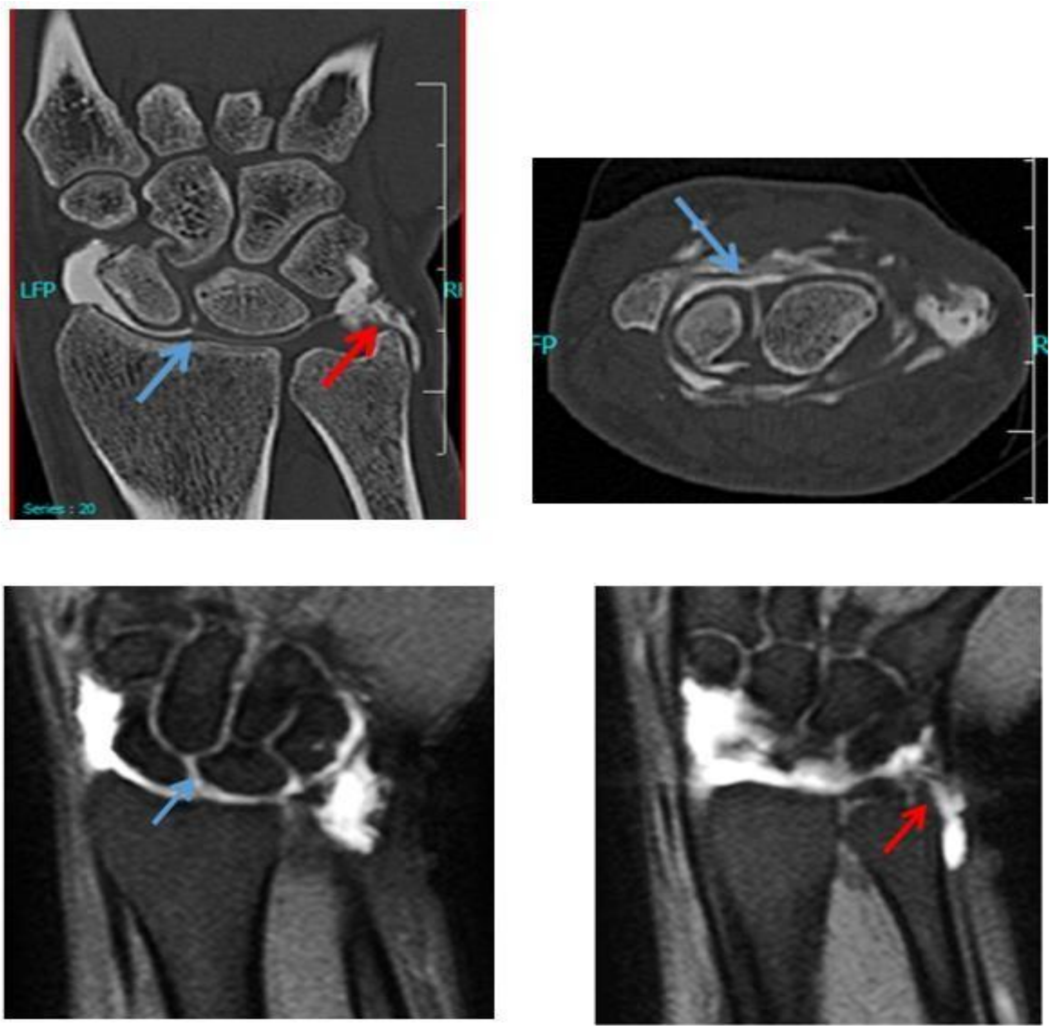

Figure 2: Male patient 30 years old complaining of post traumatic right wrist pain.

A. CTA coronal reconstruction image.
B. CTA axial image.
C. & D. MRA coronal T1 FS.

Images show partial tear of SLL (torn posterior segment) (blue arrows), torn UCL (red arrows).

Measure of agreement between CT and MR finding for SLL was 1.000 kappa with P value >0.001, that denoting almost perfect agreement.

About partial tears of LTL sensitivities of 1st observer was 100% & 85.7% for CTA & MRA respectively and for 2nd observer was 100% for both CTA & MRA (Table 2), (Figure 1).

Table 2: Diagnostic accuracy of MRI and CT arthrography in the diagnosis of Lunotriquetral Ligament tears.

Technique	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
CT arthrography					
Observer 1	87.5%	100%	100%	95.7%	96.7%
-Partial tears	100%				
-Intact	100%				
Observer 2	100%	100%	100%	100%	100%
-Partial tears	100%				
-Intact	100%	100%	100%	100%	100%
MRI arthrography					
Observer 1	71%	100%	100%	92%	93.3%
-Partial tears	85.7%				
-Intact	100%				
Observer 2	100%	100%	100%	100%	100%
-Partial tears	100%				
-Intact	100%				

Measure of agreement between CT and MR finding for LTL was 0.918 kappa with P value >0.001, that almost perfect agreement.

About TFC tears sensitivity for both CTA and MRA of 1st and 2nd observers were perfect (100%) for central and peripheral tear as well (Tables 3), (Figure 3).

Table 3: Diagnostic accuracy of MRI and CT arthrography in the diagnosis of Triangular fibrocartilage proper tears.

Technique	Sensitivit y	Specificit y	Positive predictive value	Negative predictive value	Accura cy
CT arthrography					
Observer 1	100%	100%	100%	100%	100%
-Central degenerative perforation	100%				
-Central traumatic perforation	100%				
-Degenerative changes					
-Intact	100%				
Observer 2	100%	100%	100%	100%	100%
-Central degenerative perforation	100%				
-Central traumatic perforation	100%				
-Degenerative changes					
-Intact	100%				
MRI arthrography					
Observer 1	100%	100%	100%	100%	100%
-Central degenerative perforation	100%				
-Central traumatic perforation	100%				
-Degenerative changes	100%				
-Intact	100%				
Observer 2	100%	95.7%	87.5%	100%	96.7%
-Central degenerative perforation	100%				
-Central traumatic perforation	100%				
-Degenerative changes	100%				
-Intact	100%				

Figure 3: Male patient 29 years old presented with left sided wrist pain. CT and MRI done after CT guided radiocarpal injection.

A. CTA coronal reconstruction image.
B. MRA coronal T1 FS.

Images show small central traumatic perforation of TFC with contrast leak in inferior radioulnar compartment (blue arrows) and partial tear of the radial collateral ligament (red arrows).

Measure of agreement between CT and MR finding for TFCC was 0.909 kappa with P value >0.001, that denoting almost perfect agreement.

DISCUSSION

The anatomy of the wrist is complex and its structures are small, with ligaments and cartilage measuring in the order of millimeters, necessitating high-contrast and high-resolution imaging.[15]

The purpose of our study was to evaluate MDCT arthrography and MR arthrography in the diagnosis of TFCC abnormalities as well as tears of the wrist ligaments.[13]

MRI and MR arthrography have been compared in several studies with conclusion that results of MR arthrography are superior to the results of unenhanced MR as in H.

A. Kamal et al.[15]
B. MDCT arthrography and MR arthrography have been compared in few studies.

In this study, we used a procedure combining MDCT arthrography and MR arthrography after one injection of contrast solution to avoid multiple articular injections.

In this study, we defined complete tears as involving the entire length of the ligament, in case of incomplete "partial" tear the segment torn is defined.

However, differentiation of complete and partial tears may differ slightly among authors and partially explain the discrepancy in results among articles.

Interobserver agreement was lower for MR arthrography, the 1st observer having the poorer performance. Our results showed similar accuracy between CT arthrography and MR arthrography for complete tears of SLL for both observers with sensitivity about 100%. This was as same as results of T. Moser et al 2007.[13]

In partial tears of SLL our results showed higher diagnostic accuracy of CT arthrography (100%) over MRI arthrography (75%) in diagnosis of partial tears of SLL for the 1st observer with sensitivity compared to 94% for CTA and 59% for MRA in T. Moser et al 2007.[13] For the 2nd observer sensitivity was better for CT arthrography (100%) and MR arthrography (100%) compared to 94% & 77% respectively in T. Moser et al 2007.[13]

A single case was diagnosed by the less-experienced observer in CTA as partial tear (posterior segment) and MRA missed the diagnosis. The more experienced observer detects the lesion by CTA and MRA.

About LTL, there was no complete tears in our study. In partial tears of LTL our results show higher diagnostic accuracy of CT arthrography (100%) over MRI arthrography (85.7%) in diagnosis of partial tears of LTL for the 11st observer with sensitivity compared to 100% for CTA and 56% for MRA in T. Moser et al 2007.[13] For the 2nd observer sensitivity was better for CT arthrography (100%) and MR arthrography (100%) compared to 89% & 44% respectively in T. Moser et al 2007.[13]

A single case was diagnosed by the 1st observer as middle segment tear of LTL by CTA and MRA while the 2nd observer diagnosed it as middle and anterior segment tear.

In another single case the 1st observer diagnose a middle segment tear of LTL by CTA but can't detect the lesion by MRA while the 2nd observer detect the middle segment tear by both CTA and MRA.

Almost perfect agreement between CTA and MRA findings was detected for SLL and LTL tears. About TFC tears sensitivity for both CTA and MRA of 1st and 2nd observers were perfect (100%) for central and peripheral tear as well. T. Moser et al 2007[13] results show 100% sensitivity for CTA for central and peripheral tears of TFC for both observers as well as ulnar tears for both observers by MRA. The sensitivity was less in central tears of TFC by MRA for both observers, 75% for the 1st and 64% for the 2nd.

In a single case the 2nd observer diagnosed TFC degeneration by MRA while it was intact by CTA and the 1st observer diagnosed it intact by CTA and MRA whichis agreed by the 3rd observer.

In another single case 1st and 2nd observers agreed in diagnosis of TFC degeneration by MRA which was not detected by CTA.

In this study, our results revealed perfect agreement between CTA and MRA with mild greater sensitivity of CTA for partial ligament tears of SLL and LTL particularly for the less-experienced observer.

This was agreed with T. Moser et al 2007 which state "Our results show for the first time to our knowledge that MDCT arthrography is more sensitive than MR arthrography in the diagnosis of wrist ligament tears. The greater sensitivity was particularly evident for partial tears of the scapholunate and lunotriquetral ligaments, which were frequently missed with MR arthrography".

CTA and MRA show perfect agreement in detection of central perforation of TFC as well as ulnar attachment tears including foveal and styloid ligaments tear while MRA was superior in detection of early degenerative changes of TFCC.

T. Moser et al 2007 stated that Central perforation of the TFCC was far better depicted with MDCT arthrography than with the other techniques. MDCT arthrography was more specific than MR arthrography in most cases.

Finally, both techniques CTA and MRA has perfect interobserver agreement, making both reliable. CTA has advantage that analysis of the images appears very straight forward specially for partial tears of intercarpal ligaments as well as in post-traumatic cases with suspected bone fractures.

MRA has advantage of detecting early degenerative changes of TFCC as well as extraarticular abnormalities as tendon injuries.

Finally, a major advantage of MDCT arthrography is that analysis of the images appears very straight forward, with almost perfect interobserver agreement, making this the technique preferred by surgeons at our institution.

CONCLUSION

In summary, we evaluated MDCT arthrography, and MR arthrography in the diagnosis of tears and TFCC abnormalities of the wrist ligaments in a series of patients. CT and MR arthrography show perfect agreement in diagnosis of abnormalities of wrist ligaments and TFCC especially in the diagnosis of complete tears of the scapholunate and lunotriquetral ligaments. MDCT arthrography, however, is superior in the diagnosis of partial tears of the scapholunate and lunotriquetral ligaments. MR arthrography is superior in diagnosis of early degenerative changes of TFCC. Because of perfect agreement between CT and MR arthrography accuracy and reliability, we propose that examination with one modality is usually diagnostic.

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