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Assessment of Ligaments and Fibrocartilage Complex of Wrist Joint in Trauma – MRI Vs MR Arthrography

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Abstract: ***Injuries to the wrist may produce traumatic disruption of the triangular ulnar fibrocartilage(TFC), which is a well recognized cause of ulnar wrist pain. MRI is a useful tool in the imaging of the wrist, because of its superior soft tissue contrast and multiplanar capability. MR arthrography has emerged as an important technique in the assessment of TFCC injuries. We interpreted MR Images and the results of unenhanced MRI were compared with MRA. We also analysed the type of TFCC tear as per Palmer classification and appearances as described in the literature. Among the 37 clinically suspected TFCC tears 26 cases were confirmed to be tears by MRA. The sensitivity of MRI in diagnosing TFC tears to be only 57% (15/26). Direct MR arthrography as a diagnostic tool is strongly recommended if lesions of the triangular fibrocartilage are suspected.***

Keywords: Arthrography, fibrocartilage complex

1. Introduction

The triangular fibrocartilage complex is a complex anatomic and bio-mechanical structure (1). There is exclusion of the ulna from the carpel articulation with help of a ligamentous structure(2). Isolation of the ulna is necessary to create the rotational ability, needed for essential 'dart throwing' or 'brachiation' to cut the trees(3–5). The TFCC act as a cushion between the carpus and ulnar head during the ulnarflexion or darting movement of the wrist (6). TFCC may be injured in its horizontal portion, in its peripheral portion, or may be at its attachments(3). Injuries to the wrist may produce traumatic disruption of the triangular ulnar fibrocartilage(TFC), which is a well recognized cause of DRUJ instability and ulnar wrist pain(2,6). These injuries can lead to progressive instability with secondary deterioration of the wrist joint(6). Unlike bone fractures, TFCC and other ligament injuries of the wrist may often be initially overlooked as they are difficult to identify on radiographs.

Magnetic resonance (MR) imaging is certainly more useful that conventional arthrography in prospective evaluation of TFCC lesions(4,7,8).Previously it was difficult to see the extrinsic and intrinsic ligaments directly even with the MRI , but now withImprovement in MR imaging including development of thin section, volume acquisition sequences have enabled investigators to identify intrinsic and extrinsic ligaments of the wrist(8,9). Imaging the wrist have evolved from plain radiography and fluoroscopy to arthrography, computed tomography and MRI imaging(5,9). Various techniques for better visualisation of wrist anatomy have been developed in hopes that patients with wrist pain and instability can benefit from proper diagnoses(7).The most widespread technique, direct MR arthrography utilizing dilute gadolinium contrast agent has the advantage of consistent joint distension with contrast medium, markedly improved delineation of key intra-articular structures and consequently improved detection of pathology and thus obviating more invasive and expensive procedures such as diagnostic arthroscopy(4,8). MR arthrography has become an important diagnostic modality in the assessment of TFCC lesions (7,8).

The objective of this study is to
Evaluate and compare the performance of MRI and MR arthrography in the detection of traumatic tears and abnormalities of the wrist ligaments especially the TFCC complex.

1) To analyse the type of TFCC tear as per Palmer classification and appearances as described in the literature.
2) To compare the results of this study with other similar studies conducted in the past.
3) To study the limitation of MRI and MR arthrography in detection of traumatic injuries of the TFCC.

Arthrography of the wrist have been demonstrated to be useful in diagnosing the TFCC lesions (5,8). The anatomy of wrist is complex and its structures are small, with ligaments and cartilage measuring in the order of millimetres, necessitating high contrast and high resolution imaging. In recent years, MRI and MRA have greatly improved and proven effective for the diagnosis of soft tissue injuries of the wrist(4,7,9). MRI is a useful tool in the imaging of the wrist, because of its superior soft tissue contrast and multiplanar capability(5,10,11). Combining MRI with arthrography could increase the accuracy of diagnosing these injuries. Combination of the advantages of conventional arthrography with the direct visualization of structured on MR imaging made MRA the best modality for imaging for patients soft tissue injury of the wrist(4,5).

Hobby et al reviewed 11 published articles on the diagnostic performance of MRI and found that standard MRI without contrast imaging is highly specific but not sensitive, demonstrating an overall accuracy of 85 %, a sensitivity of 70% and a specificity of 90% if compared to gold standard arthroscopic evaluation(11). Their conclusion was that MRI without intra-articular contrast medium is unreliable in finding and locating the intrinsic ligaments tear(11). Moreover despite showing a high accuracy of 97% for

central and radial sided TFCC tears (palmers class IA, ID and class II tears), MRI is only 64% accurate for peripheral tears at the site of the ulnar attachment (Palmers class IB and IC)(12,13). The poor performance of MR for these tears is because of the presence of the high signal vascularised fibrous tissue in between the two ulnar attachments, which can mimic as a tear(13,14). The diagnostic performance of MR is improved by MRA making lesions better visualized when they are outlined by contrast material in a distended joint space. Braun et al. concluded that MRA was of equal value when compared to diagnostic arthroscopy in detecting complex defects of the SLL and LTL ligaments and has the potential to replace the diagnostic arthroscopy(13). It was helpful in detection of non communicating defects of the TFC, partial tears of the SLL, injury to the LTL, and injury of ECU tendon sheath and ulnar collateral ligament (UCL) (4,13). Zeev et al. Stated that joint distention by contrast injection into it, visualisation of contrast leakage allows better evaluation of subtle defects such as a partial ligamentous tear or cartilage defects(14).

The finding of a communicating defect through any of the ligaments of TFC could be either a symptomatic tear or an asymptomatic tearwhich can be result of degeneration. Several studies have indicated that communicating defects in the TFC and intrinsic ligaments can be frequently found on arthrography of asymptomatic wrists in 50- 80 % of people(14). Cadaveric , arthrographic studies have showed that TFC, SLL, and LTL defects are present in asymptomatic wrists as ageing process within the substance of the ligaments, as well as within the triangular fibrocartilage(13,14). Most people have wrist injuries at many times throughout their lives and asymptomatic wrist at times, and the examination cannot exclude that the wrist was previously traumatized or it is result of degeneration process. Moreover, there is little agreement in the literature if both traumatic and degenerative perforations of the intrinsic ligaments and TFC can be symptomatic(4,12,14).

Ruegger et al. found that non-communicating perforations of the ulnar attachment of the TFC on MRA are more likely to be symptomatic than even the communicating injuries on the radial or central aspects of the TFC(15). And attributing to this fact the differentiation of these peripheral tears of ulnar attachments of the TFC from central tears may be clinically important. Peripheral tears does not have a good vascular supply and can be associate with instability of the distal radioulnar joint (DRUJ) while central lesions are vascular(15). Interestingly, TFC lesions at their radial attachment considered to be traumatic by Palmer, while they were found to be commonly present in asymptomatic wrists and also frequently found in foetuses and in infants(14,16). TFC degeneration and perforation at the central or radial portion increase with age as a result of the senescence process (13,14). Tears of different portions of the SLL and LTT have been demonstrated to have varying clinical significance. The dorsal and volar portions of SLL and LTT are true ligaments, which consisting of closely packed dense collagen fibres(16). The dorsal portion of SLL and volar portion of LTL are the main contributors to stability of DRUJ (13,17). Degenerative perforations in the middle segment of the SLL and LTL are common, increase with age , are often asymptomatic, and correlate poorly with patients symptoms(2,16).Tears involving the tendon sheath of the extensor carpi ulnaris tendon and tears of ulnar collateral ligament are other issues which are only sparsely described in the literature. Machiels et al. described dorsal peripheral detachment of the TFCC as a tear located at the dorso-ulnar peripheral attachments of the TFCC which are extending into the floor of the ECU sheath(18). This tear can extend further into the ulnar collateral ligament and the disruption of the ECU Tendon sheath results in tendon instability of the joint. the authors concluded that in patients with a history of trauma and without rheumatoid arthritis who present with pain in the dorsal aspect of the wrist near the ulnar styloid along that trajectory of the ECU, contrast opacification of the tendon sheath, extravasation of contrast into the Dorsal ulnar and peristyloid soft tissue are pathognomonic features of dorsal Peripheral detachment of the TFCC. Interestingly, the UCL is a controversial topic in 1970, spinner and Kaplan defined the UCL as periosteum/ECU fibro-Osteous sheath(19).

Klienman described a vestigial ulnar collateral ligament(20).Buterbaugh defined UCL as the floor of the ECU tendon sheet(21). however, Osterman stated that there is no true UCL(22). Arons et al. described the defect of UCL distal to the intact TFC and exciting into the floor of the ECU tendon sheath(23). such cases of "ulnar capsular leak" described by palmers group on arthrography(24). Tears of the UCL without associated injury of the TFC or ulnar attachments of the TFC could be seen with and without ECU tenosynovitis. repair of these disruptions at Surgery leads to disappearance of the symptoms. In our series, no isolated regions of the UCL or ECU tendon sheath were seen. All UCL tears and partial tear of ECU tendon were associated with tears of LTL. Tear of the extensor carpi ulnaris tendon sheath was associated with communicating tears of the ulnar attachments of the TFC.

2. Single versus multiple compartment photography

There is no consensus exist related to single versus multiple compartment injections of the contrast dye on MRA. Each of the technique has its own pros and cons.Mann et al. concluded that the first injection of three-compartment arthrography shows unidirectional communications (25). Amrami(26)considered the single compartment arthrography to be more informative and that the conclusion of the multi-compartment injections on the static MRI images obtained after arthrography is complex and difficult to interpret, since there is no available "subtraction" technique and it can be hard to sort out which ligaments are completely and which are partially torn and what is the direction of contrast flow has been(24,26,27). Amrami(26) preferred a single compartment injection planned with the referring surgeon, performing a single injection in the most clinically relevant compartment and then after adding some additional injections if a tear is not seen on the conventional arthrogram preceding the MRI examination.

3. Palmer classification of the TFCC tears

Zanetti et al. and Ruegger et al. consider non-communicating defects of ulnar attachments of TFC to be frequently symptomatic,to diagnose these tears, the authors suggested including an injection of contrast material into the DRUJ in wrists (15,28). They reported an accuracy of 80% and a sensitivity of 85% for peripheral TFC tears with this.

Khouri et al suggested tailoring the examination to a one or two compartment injection when there is spontaneous intercompartmental communication and/or when the clinical relevance is accurate (E.g., are DRUJ injection is limited if there are no ulnar-sided symptoms)(29).In patients with chronic pain of unclear origin or instability of the wrist, Cerez et al. recommended performing triple compartment MRA (30). In cases of suspected TFCC or any Intrinsic ligament lesions with the given history of trauma or relevant clinical examination, the authors use conventional MR imaging with radiocarpal MRA. If a lesion of the ulnar attachment of the TFC is suspected at conventional MR imaging, they perform two-compartment (radiocarpal and DRUJ) MRA(24,27,30–32).

Palmer proposed a classification system (1,19,27,32)for TFCC lesions, which was based on a review of the literature and a retrospective study of patients with wrist pain. he classified lesions into two major groups astraumatic (class I) or degenerative (class II) on the broad basis of etiology of the lesion. Further subdivision serves to clarify the locus of injury and traumatic lesions and the cumulative derangement of the TFC in degenerating lesions. This classification is useful in determining the mechanics of injury and directing towards the clinical management of particular injury(1,5,24,29).

Degenerative changes follows a sequence as a result of repetitive loading from ulnocarpal abutment affecting the horizontal portion of the TFCC, the ulnar head and Lunate , and the lunotriquetral ligament(2,13,22).The frequency of TFC perforations increases progressively with age, increasing from 7% in the third decade to 53% inpatients more than 60 years old (19).The frequency and the extent of attritional changes in the TFC ligament or interosseous ligament is not related to handedness or sex. The thickness of the TFC is inversely proportional to ulnar length(10,19,24); hence, patients with positive Ulnar variance have a thinner disc and thus they have comparatively a higher prevalence of TFC tears. There is increased probability of lunotriquetral ligament tear in patients with already torn TFC.

The biomechanical forces occurring on the ulnar surface of the TFC during the pronation and supination are stronger than the forces sustained by the gliding motion of the carpal bones on the radial side, which probably accounts for the more number of degenerative lesions occurring on the ulnar side of the TFC. Degenerative lesions are frequently more common in patients with positive or neutral Ulnar variance, and they result from repetitive loading on the ulnar side of the wrist (Ulnar impaction).Manaster and colleagues , however, were not able to find a significant correlation between Ulnar variance and TFC tears. Only a smaller number of patients in their series were more than 35 years old, suggesting that most tears were traumatic rather than degenerative which occur in older population group(24,33) .The perforations associated with degenerative tears occur closer to the ulna than those of the traumatic tears(4,12,14,33). the tears may extend to the articular surface of the lunate bone, the ulnar head, and the lunatotriquetral ligament, eventually resulting in degenerative arthritis of the ulnocarpal and distal radioulnar joints. Many of the post-traumatic tears are located within 1 to 2 mm of the radial origin of the TFC, where the thick collagen bundles connect the avascular portion of the TFC to the radius(12,14,30).Bednar et al. studied the microvascular anatomy of the TFC and concluded that ulnar side or peripheral tears had the ability to heal, whereas the centrally or radially located tears did notattributing to their relative difference of the vascularity(1,34).

4. Methodology

This is primarily a record based study. This study is a retrospective analysis of Cases taken from the medical record department from September 2013 to November 2015. MR Images were interpreted and the results of unenhanced MRI were compared with MRA.

The study population contained 20 male patients and 17 female patients 15-50 years old. Exclusion criteria were patients above 50 years of age as degenerative change in TFCC are more common In this age group and with rheumatoid arthritis.

MRI was performed with a 1.5- T system (Magnetom Avanto, Siemens Medical Solutions) with a flex extremity coil. The patients were scanned in the supine position, with the arms alongside the body and the dorsum of the hand parallel to the coronal plane of the magnet. After completion of the MRI study, patients were directed to the fluoroscopy room, and the dorsal aspect of the wrist was prepared using an aseptic technique. A 1:1 solution of 300 mg I/mL iopamidal and 2.5 mmol/L DOTA- gadolinium was mixed. Radiocarpal injection: The needle was advanced 0.5 cm distal to Lister's tubercle at the dorsum of the radius, either the needle was angulated 10-15 degrees to avoid striking the dorsal lip of the radius, or the joint was flexed over a sponge, and the needle was advanced perpendicular to the joint. Three to four millilitre of contrast mixture was injected into the mid carpal compartment, until the patient felt some pressure in the joint, then radio carpal injection was done using 4-5 ml or more if communication with the distal radioulnar joint (DRUJ) was established.

Protocol of MR imaging

	TR	TE	FOV (cm)	SL (mm)
TI_SE_COR	614	20	9	3
TI_SE_COR_FS	469	20	9	3
T2_TSE_COR	3200	72	9	3
T2_TSE_COR_FS	3200	72	9	3
T1_SE_SAG	737	20	9	3
T2_TSE_TRA	4310	74	9	2.5
T2_F13D_COR (GRE)	27	9	15	1

Preliminary scout localizers in axial, coronal and sagittal planes were done.

Protocol of MRA

	TR	TE	FOV (cm)	SL (mm)
TI_SE_COR_FS	614	20	9	3
TI_SE_TRA_FS	511	20	9	3
T1_SE_SAG_FS	527	20	9	3
T2_F13D_COR	27	9	15	1

5. Results

The study included a total of 37 patients of which 20 were males and 17 were females. Od the 37 patients 12 had left wrist pain while 25 complained of right wrist pain. 26 of 37 patients showed tears of the TFC, 3 showed abnormalities other than that related to the TFCC, while 8 cases showed no abnormality.

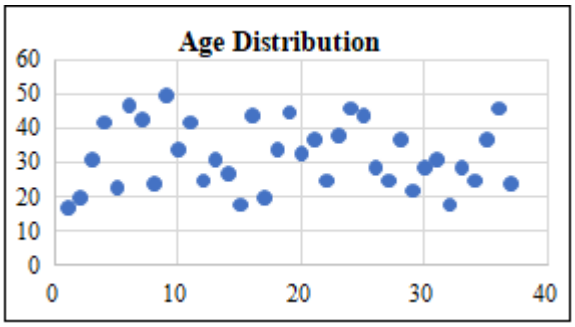

Figure 1: This study included patients in the age group between 15 to 50 years with history of trauma, mostly fall on outstretched hand.

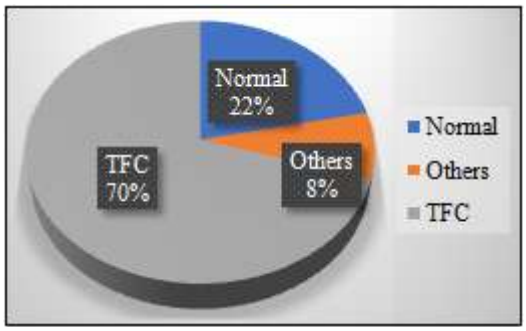

Figure 2: 26 of 37 patients showed tears of the TFC, 3 showed abnormalities other than that related to the TFCC, while 8 cases showed no abnormality.

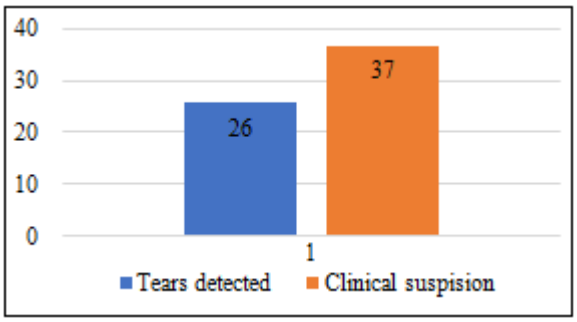

Figure 3: Among the 37 clinically suspected TFCC tears 26 cases were confirmed to be tears by MRI and MRA.

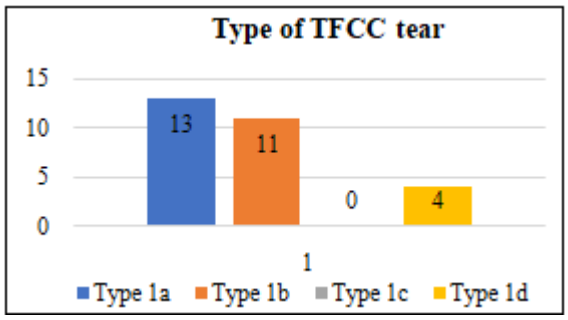

Figure 4: Of the total 26 TFCC tears detected, the highest number was that of type 1a lesions followed by 1b and 1c.

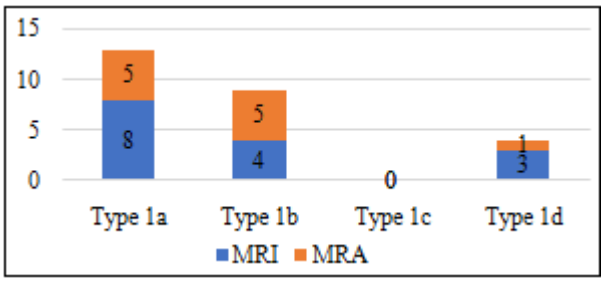

Figure 5: The above chart shows tears which were picked up by MRI and MRA. All these tears were picked up by MRI and MRA. All the tears were picked up by MRA. The below table 1. summarizes the same findings.

	Type 1a	Type 1b	Type 1c	Type 1d
MRI	8	4	0	3
MRA*	5	5	0	1

(*Lesion noticed MRA not seen on plan MRI)

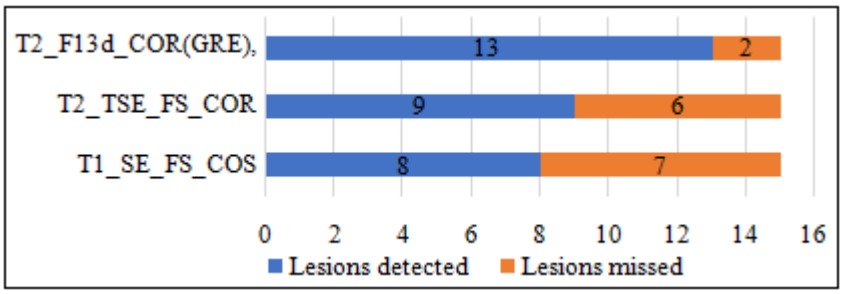

Figure 6: The above chart compares the performance of the three best MRI sequences for detection of TFC tears. The **T1_SE_FS_COS** sequence detected a total of 8 out of 15 lesion detected on plain MRI. The **T2_TSE_FS_COR** sequence detected 9 of 15 while **T2_F13d_COR(GRE)**, sequence detected 13 of 15 lesions making it the most sensitive of the three sequences.

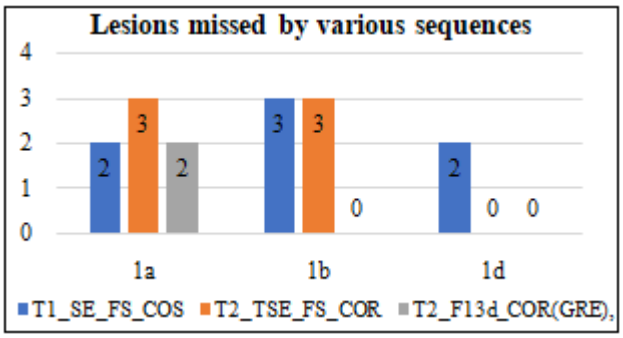

Figure 7: The above chart shows the lesion types missed by these sequences which were subsequently detected following arthrography.

Findings are summarized in the following table 2.

	1a	1b	1c	1d
T1_SE_FS_COS	2	3	-----	2
T2_TSE_FS_COR	3	3	-----	0
T2_F13d_COR(GRE),	2	0	-----	0

On Comparing the performance of MRI and MRA in arthroscopically confirmed cases of class 1a tears, the finding of MRA were found to be accurate in 26 cases while MRI picked up only 15 of the cases confirmed.

MRA was found to be performing well in the diagnosis of class 1a and 1d lesions, however was less sensitive for class 1b tears. This limitation has been demonstrated in literature and is postulated to high vascularity of the TFC at its ulnar attachment site.

The Plain MRI is known to perform best when there is associated joint effusion. Among the various sequences used in plain MRI in diagnosis of TFCC tears, the performance of T2_F13d_COR(GRE), T2_TSE_FS_COR and T1_SE_FS_COS sequences are the best.

T2-FI3D-COR sequence performs the best owing to its 1mm thin sections and ability to detect small fluid pocket (being 1 T2 weighted sequence) and thus demonstrating communicating tears better than other sequences.

6. Discussion

The study comprised of 37 patients, males, and females, in the age group of 15- 50 years old. Left and right wrists were scanned. Initially a MRI was performed using the above specified protocol followed by MR arthrography. Abnormalities of TFCC were detected in 26 of the 37 cases. The imaging findings confirmed the initial clinical diagnosis in 72% of the cases. This result is consistent with previous arthrography by Moser et al(35).

A few studies however emphasize a poor correlation between location of pain and articular communication. Most communications observed in this study were probably related to degenerated lesions. Inadequate recruitment of subjects also may account for such findings. In contradiction our study included young and homogenous population with predominantly traumatic lesions.

The tears were then classified as per description by Palmer et al(1). We found the type 1a tears to be most frequent followed by type 1b and type 1d. No cases were detected of type 1c.

We also found the sensitivity of MRI in diagnosing TFC tears to be only 57% (15/26). This is significantly less as compared to sensitivity of 70% reported by Hobby et al in their review of more than 10 studies(11). Among the various MR sequences used, the performance of T2_F13d_COR(GRE), T2_TSE_FS_COR and T1_SE_FS_COS sequences were the best. Among these the T2_F13d_COR(GRE) performed the best picking up 12 of the 15 lesions detected on the plain MRI.

MRA picked up all the 26 lesions. No abnormality was identified in 8 cases. However, there was a strong suspicion of TFCC injuries in these cases. The MRA findings were found to be accurate on arthroscopic findings in 26 patients while MRI picked up 15 of the cases.

7. Conclusion

The present diagnostic results of the MR arthrography are superior to the results of un-enhanced MRI. Direct MR arthrography as a diagnostic tool is strongly recommended if lesions of the triangular fibrocartilage are suspected. Direct MR arthrography imaging is well suited for detecting intra-articular lesions of the wrist. MR arthrography cannot replace arthroscopy, however it could be a potent additional tool for wrist imaging. It can facilitate the diagnosis and the indication for surgery of the wrist and help to reduce arthroscopic intervention for purely diagnostic purposes and therapeutic consequences.

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