Comparative study between the magnetic resonance imaging and cone beam computed tomography in the evaluation of temporomandibular joint involvement in rheumatoid arthritis patients

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Abstract: Aim: The aim of this study was to compare the diagnostic performance of magnetic resonance imaging (MRI) with cone beam computed tomography (CBCT) for the assessment of temporomandibular joint (TMJ) involvement in rheumatoid arthritis (RA). **Patients and methods:** CBCT and MRI were used to examine 40 TMJs from 20 RA patients who had TMJ complain. All CBCT and MRI images were evaluated separately by two experienced oral radiologists with regard to the presence or absence of osseous abnormalities; the radiologists were blinded to the clinical symptoms and prior TMJ disease. The following joint abnormalities were noted, bone erosion, flattening of the articular surfaces, sub-cortical and generalized sclerosis, sub-cortical cyst, osteophyte, joint space reduction and abnormal position of the condylar head within the temporal fossa. All these findings were tabulated, analyzed and by using CBCT findings as the reference standard, the diagnostic performance of MRI for detecting various types of osseous abnormalities was evaluated by calculating its sensitivity and specificity. **Results:** CBCT was clearly depicted the morphology of the condyle and the surrounding bone structure in all of the cases. The frequency of each osseous abnormality ranged from 72.5% for condylar head erosion to 10% for loose joint body. On the other hand, MRI clearly detected all joint abnormalities the most frequent osseous abnormality was condylar head erosion 52.5% and the least frequent was loose joint body 5%. With the CBCT as a reference standard, MRI had low sensitivity, but high specificity in diagnosis of most of the osseous abnormalities.

Conclusion: Although the high specificity that was obtained with MRI, this modality showed relatively low sensitivity for detecting osseous abnormalities of the TMJ, so value of MRI for the detection of TMJ osseous abnormalities is considered to be limited.

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1. Introduction:

Rheumatoid arthritis (RA) is an autoimmune disease resulting in persistent inflammatory synovitis, usually involving peripheral joints with a symmetric distribution [(1)]. Temporomandibular joint (TMJ) is a seldom joint to be affected first in the disease course [(2)].

The TMJ is an important organ that is closely associated with masticatory and swallowing functions, and TMJ damage severely reduces the quality of life of patients [(3)].

RA affecting the TMJ presents as a diagnostic challenge to the dentist in the initial stages of disease course [(1)]. Accordingly, the importance of imaging diagnosis of RA in the TMJs should be emphasized, similar to that of other joints [(3)]. Several imaging techniques have been used for the evaluation of the TMJ. Among them, MRI has great advantages over other techniques in its ability to depict soft tissue changes of the TMJ [(4-7)]. However, its diagnostic value for the detection of TMJ osseous abnormalities is still controversial [(4-8)].

Recently, cone beam CT (CBCT) has become widely used for the diagnosis of abnormalities of the dental region, and its reliability for detecting osseous abnormalities of the TMJ has been reported by several authors [(9-14)].

Thus, the aim of this study was to investigate the diagnostic performance of MRI for the assessment of osseous abnormalities of the TMJ using CBCT as a reference standard.

2. Patients and Methods:

Patients

Twenty RA patients (forty TMJs), 17 females and 3 males were randomly selected from the outpatient clinic of rheumatology department, Sohag University hospital, who had signs and/or symptoms of TMJ involvement (TMJ sounds, pain, joint stiffness, and inability to open mouth or open bite). With the mean age of 35.3±3.8 years (range 29.0–42.0

years). The mean duration of the disease prior to inclusion was 7.9±4.1 years (range from 1.0–16.0 years). All of the entire patients had signed a standardized informed consent laid down by research ethics committee (REC) of faculty of dentistry, Minia University.

CBCT examination

- CBCT images were obtained using a Promax 3D unit (PlanmecaOy, Helsinki, Finland), operating at 84 kVp, 9–14 mA, with a 0.16 mm voxel size, an exposure time of 6 seconds and a field of view of 8 cm.

- CBCT scans were saved and viewed into Romexis 4.4.2.r. software (PlanmecaOy, Helsinki, Finland). Examinations were performed through 360 degrees of rotation with the patient in an occlusal position. After scanning, contiguous sectional images in three orientations, i.e. parasagittal sections (vertical to the long axis of the condylar head), coronal sections (parallel to the long axis of the condylar head) and horizontal sections, were reconstructed from the data with a slice width of 1 mm using dedicated CBCT software.

MRI examination

Patients were scanned with 1.5 Tesla superconductive magnet (Siemens). Examination was performed at (Dar Sohag radiology center) using a head coil with the following imaging parameters: number of slices = 14, slice thickness = 3mm, interstice gap = 1mm, FOV = 150*1.2, Echo = 1/1, Flip angle = 20, TR = 443 and TE = 23.

Various sequences were performed: initial scanning was done to obtain three scout images; one each plane: axial, coronal and sagittal.

On the axial cuts, a slice was selected on which the condyles of both sides were well depicted. On the sagittal scout, axial cuts were planned parallel to the orbita- meatal line at the level of auditory canal and sagittal cuts were perpendicular on the parasagittal plane (horizontal long axis of each condyle) and the condyles were included inside the planned slices. Two pulse sequences in the parasagittal plane were taken while the patient was occluding in centric relation in (Closed mouth scans) and placing a 7 pieces of wooden tongue depressors in the patients mouth with its long axis perpendicular to the mid-sagittal plane in (Open mouth scans) as follow: T2 weighted (T2WI) and Proton density spin echo (PDWI) images were obtained.

Evaluation of images

1. CBCT images were evaluated independently by two oral radiologists with at least 2 years of experience, they were evaluated for the presence or absence of each osseous abnormality.
2. Two experienced oral radiologists who had no previous knowledge of the CBCT finding were asked to evaluate all MRI images independently and to record the findings on a specific evaluation sheet. In cases of disagreement, a second evaluation was performed by the two observers simultaneously without knowledge of the preceding recorded findings.

The images were evaluated for the presence or absence of each osseous abnormality on a CRT monitor using the installed DICOM (Digital Imaging and Communications in Medicine) image viewer.

The radiologists were blinded to the clinical symptoms and prior TMJ disease history.

The following osseous abnormalities were noted: condylar flattening, condylar sclerosis (sub-cortical & generalized), condylar erosion, condylar osteophyte, ankylosis, loose joint body, sub-cortical cyst, condylar head position, joint space reduction & The temporal fossa was evaluated for the presence of flattening, sclerosis & erosion.

Statistical analysis

The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 22.0, IBM Corp., Chicago, USA, 2013.

The sensitivity and specificity of MRI for detecting each osseous abnormality were calculated using the CBCT findings as a reference standard.

3. Results:

Table (1): Osseousfindings among the studied cases (By CBCT)

Findings		N	%
Condyles			
TMJs with detectable abnormalities		36	90.0
Flattening		17	42.5
Sclerosis	Normal	15	37.5
	Subcortical	15	37.5
	Generalized	10	25.0
Erosion		29	72.5
Osteophytes		7	17.5
Ankylosis		5	12.5
Loose joint body		4	10.0
Subcortical cyst		18	45.0
Head position	Normal	29	72.5
	Anterior	5	12.5
	Posterior	6	15.0
Joint space reduction		16	40.0
Temporal eminence/fossa			
TMJs with detectable abnormalities		33	82.5
Flattening		19	47.5
Sclerosis		20	50.0
		11	27.5
		9	22.5
Erosion		28	70.0

CBCT was clearly depicted the morphology of the condyle and the surrounding bone structure in all of the cases. Based on CBCT images, the frequency of each osseous abnormality ranged from 72.5% for condylar head erosion to 10% for loose joint body table (1).

MRI could also detect all osseous abnormalities with the most frequent abnormality was condylar head erosion 52.5% and the least frequent was loose joint body 5% table (2).

According to the Sensitivity test that was used to measure the agreement between CBCT and MRI in detecting the probability of radiographic signs of osseous abnormalities in the TMJs of RA patients.

MRI had low sensitivity, but high specificity in diagnosis of most of the osseous abnormalities, the mean sensitivity of MRI was 25%-90.9%, and the mean specificity was 70.8%-97.2%. MRI was most sensitive for detecting condyle abnormal position, and least sensitive for detecting loose joint body. Representative CBCT and MRI images are shown in figures (1, 2 and 3).

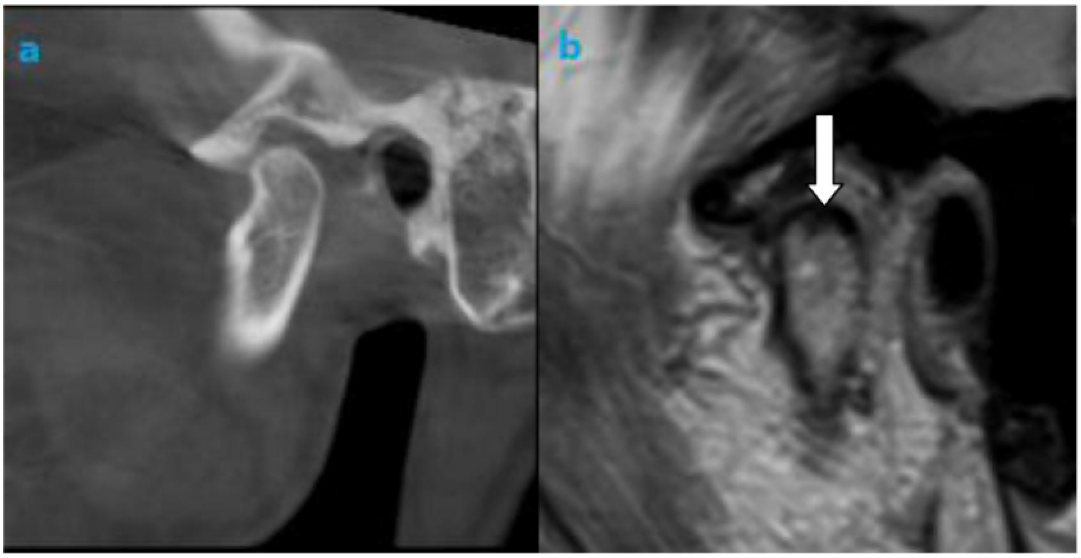

Figure (1): A 41-year-old woman with chief complaints of crepitus, pain and limited mouth opening. (a) Cone beam CT revealed no abnormality of the left condylar head, whereas (b) erosion was suspected on the corresponding sagittal proton density-weighted MR image (arrow).

Figure (2): A 30-year-old woman with a history of rheumatoid arthritis for 7 years and a chief complaint of clicking of the left TMJ, (a) the cone beam CT image revealed osteophyte in the left condylar head (arrow), whereas (b) while on the corresponding coronal T2-weighted MR image no abnormality was noted (arrow).

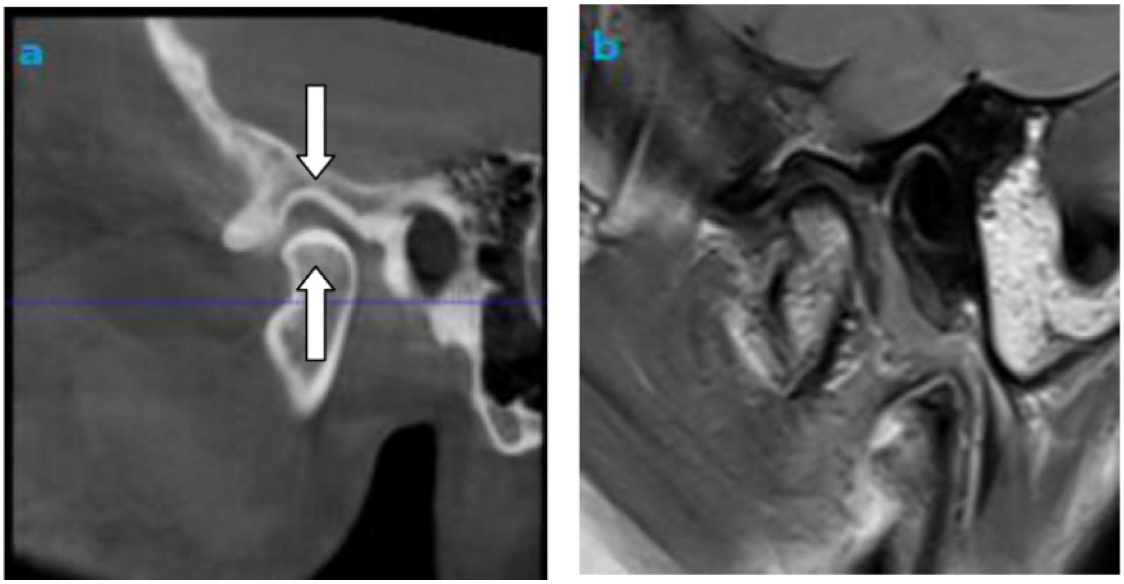

Figure (3): A 40-year-old woman with chief complain of bilateral TMJ clicking and limited mouth opening. (a) The cone beam CT image revealed sclerosis of the right condylar head and temporal fossa (arrows); whereas, (b) sclerosis was evident only in the temporal fossa and not clear in the condylar head on the sagittal proton density-weighted (arrow)

Table (2): Osseous findings among the studied cases (By MRI)

Findings		**N**	**%**
Condyles			
TMJs with detectable abnormalities		27	67.5
Flattening		6	15.0
Sclerosis	**Normal**	28	70.0
	Subcortical	6	15.0
	Generalized	6	15.0
Erosion		21	52.5
Osteophytes		8	20.0
Ankylosis		3	7.5
Loose joint body		2	5.0
Subcortical cyst		15	37.5
Head position	**Normal**	28	70.0
	Anterior	5	12.5
	Posterior	7	17.5
Joint space reduction		13	32.5
Temporal eminence/fossa			
TMJs with detectable abnormalities		22	55.0
Flattening		13	32.5
Sclerosis	**Normal**	27	67.5
	Subcortical	5	12.5
	Generalized	8	20.0
Erosion		20	50.0

4. Discussion:

Among the imaging modalities for the examination of the TMJ, MRI is the most useful technique because it has great advantages in the assessment of the soft tissue components of the joint [15]. In our study, MRI was done to 20 RA patients (40 TMJs). The MRI technique that we used was similar to the standard imaging protocol for the TMJ [16]. The use of the dual surface coil technique for simultaneous imaging of the right and left TMJs has been of great value because the examination time can be significantly shortened for bilateral TMJ imaging.

Osseous changes in the condyle and articular eminence and fossa were frequently observed in the RA group, in our study, MRI could detect all osseous abnormalities. As shown in table (2), these osseous changes were reported by other investigators [17, 18], Ardic et al. in 2006 [19] reported that the radiological changes of TMJ include cortical erosion, decreased joint space, deossification, sharpen pencil head or spiked deformity of the condylar head or mouth piece of flute deformity of condylar head, and subcortical cysts. Pritesh et al in 2014 [20] were agreed with these finding except for subcortical cysts.

In our study there were 12 (30%) from our patients have TMJ complain at 1 year after the onset of the disease, and this is consistent with a study by Redlund-Johnell [21], in which they evaluated 56 adult RA patients clinically and radiographically, they reported that some of RA patients (29.6%) in their study developed TMJ symptoms shortly (within 1 year) after the onset of the generalized disease. Aside from this, 18.5% noted TMJ symptoms before the generalized disease. Therefore, the early onset of TMD in RA patients implies that early diagnosis and prompt treatment may be beneficial.

According to our finding, the osseous abnormalities were observed in the condyle more than in the articular eminence and fossa, which is consistent to a study by Hirahara et al [22], in which they reported that osseous changes of the mandibular condyle were observed in approximately 83% of TMJs and erosion of the articular eminence and glenoid fossa was observed in approximately 10%.

Our results refer to the most common osseous abnormality detected by MRI either in the condyle or in the articular eminence and /fossa was erosion. And these results are ongoing with many studies as Abhijeet and Shirish in 2010 [23] reported that in patients with RA, the predominant finding was erosion of condyle (85%) followed by condylar sclerosis similar to study by Gynther and Tronje [24], Goupille et al. [25], and Voog et al. [26] Sclerosis is a sign of healing of joint in contrast to erosion, which indicated active bone disease.

Zhao et al [27] recently reported imaging findings of 711 patients some of them with osteoarthritis (OA) and others with RA of the TMJ. According to their report, osseous changes in RA patients are mostly bone erosion or destruction, whereas those in OA are mostly deformations due to osteophytes, flattening and/or osteosclerosis [28]. Goupille et al [25], in 1992 reported that erosive lesions might indicate acute or early changes whereas flattening and osteophyte formation may indicate late changes in TMJ.

CT has been considered the best modality for imaging the osseous components of the TMJ [29, 30]. Recently, CBCT for dental use has become widely available. Several researchers [31, 32] have reported the excellent ability of CBCT to evaluate osseous abnormalities of the TMJ. According to a study by Honey et al [31] using dry mandibles, the mean diagnostic accuracy of CBCT for detecting cortical erosive defects in the TMJ was 95%. Honda et al [10] compared the diagnostic accuracy of CBCT with that of MDCT in detecting osseous abnormalities of the TMJ and concluded that CBCT was similar to MDCT and that both modalities were highly reliable. Katakami et al [33] performed a similar comparison and showed that CBCT was superior to the other in detecting osseous changes in the TMJ. Other studies [34, 35] compared image quality after using both modalities to assess alveolar bone and tooth structure and concluded that CBCT was superior or at least similar to MDCT. Owing to the high reliability of CBCT demonstrated by these studies, we considered that CBCT, like MDCT, could be used as a reference standard in evaluating osseous changes and decided to perform this study.

Our results demonstrated that MRI has low sensitivity and high specificity in detecting most of osseous abnormalities. There have been other studies that evaluated the diagnostic ability of MRI to detect osseous abnormalities of the TMJ using cadaver specimens. Westesson et al [29] evaluated sagittal T1 weighted images of 15 joints and reported that the sensitivity and specificity of MRI were 50% and 71%, respectively. Similarly, Katzberg et al [36] evaluated coronal T1 weighted images of 18 joints and reported that the sensitivity and specificity were 83%and 100%, respectively. Tasaki et al [37] evaluated coronal and sagittal images of proton density and T2 weighted sequences of a relatively large number of subjects (55 joints) and reported that the sensitivity and specificity were 87% and 100%, respectively. Alkader et al [15], evaluated 106 TMJs by CBCT and MRI and they reported low sensitivity (30-82%) but high specificity (84-90%) of MRI for detecting osseous abnormalities of the TMJ. This last study and the first one are consistent with our results as they demonstrated low sensitivity and high specificity of MRI in detecting osseous abnormalities.

Alkader et al [15], explained this discrepancy is mostly due to differences between study evaluation methods. Specifically, the previous studies evaluated all osseous changes together and did not consider sclerosis or ankylosis, whereas they evaluated the sensitivity of MRI for each TMJ osseous change as we did. Differences between the reference standard are also considered to be attributed to the discrepancy because the CBCT findings may not be completely consistent with direct observations of cadaver specimens. In addition, as indicated in the previous studies, [29, 37] MR images obtained using cadavers may not be equivalent to those obtained in clinical settings, as the latter are affected by artifacts caused by jaw motion and the pulsation of arteries.

The low sensitivity of MRI in detecting osseous abnormalities may be due to the limited spatial resolution of MRI; [15] the slice thickness of MRI is 3 mm or more for clinical use, which may be too thick to detect subtle osseous changes. Other problems include the presence of fibrous tissues inside the TMJ and the attachment of the lateral pterygoid muscle in close proximity to the articular surface of the condyle, which can be interpreted as either an osseous abnormality or as a disc, and may result in false-positive or false-negative results. [38, 39] In addition, when detecting osseous abnormalities in the articular fossa and eminence, difficulties sometimes arise due to magnetic susceptibility artifacts.

For better MRI evaluation of normal and pathological conditions affecting the TMJ, a recent study [40] recommended the use of a 3 T MRI scanner because of its high signal-to-noise ratio at half the slice thickness, which results in better spatial resolution.

5. Conclusion:

Although high specificity was obtained with MRI, it showed a relatively low sensitivity for detecting osseous abnormalities of the TMJ. Thus, the value of MRI for the detection of TMJ osseous abnormalities is considered limited.

Therefore, we recommend further studies evaluating TMJ osseous changes using the latest 3 T scanner.

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