2012

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DENTOMAXILLOFACIAL RADIOLOGY, LONDON, v. 41, n. 5, pp. 367-372, JUL, 2012
http://www.producao.usp.br/handle/BDPI/42383

Dentomaxillofacial Radiology (2012) 41, 367–372

http://dmfr.birjournals.org

RESEARCH

MRI analysis of the relationship between bone changes in the temporomandibular joint and articular disc position in symptomatic patients

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Objectives: The aim of this study was to investigate bone changes in the condyle, articular eminence and glenoid fossa in relation to the position of the articular disc.
Methods: 148 temporomandibular joints (TMJs) of 74 symptomatic patients who underwent MRI were evaluated. The position of the disc was classified as either normal (N), disc displacement with reduction (DDwR), disc displacement without reduction (DDwoR) and posterior displacement (PD). Bone changes were investigated in the condyle and temporal components of the TMJ and classified as osteophytosis, sclerosis or erosion.
Results: There were no bone changes in the glenoid fossa of the temporal bone. Of the total number of TMJs studied, 94 (63.5%) were N, 34 (23%) presented DDwoR, 19 (12.8%) presented DDwR and 1 (0.7%) presented PD. The bone changes in the condyle and posterior aspect of the articular eminence were associated with the position of the disc. The bone changes in the anterior aspect of the articular eminence were not associated with the position of the disc.
Conclusion: In cases of DDwoR, bone changes in the condyles were more common. The combination of erosion and osteophytosis in the condyle and the bone changes of the posterior aspect of the articular eminence were associated with disc position.
Dentomaxillofacial Radiology (2012) **41,** 367–372. doi: 10.1259/dmfr/79317853

Keywords: magnetic resonance imaging; temporomandibular joint; disc displacement; bone changes

Introduction

Temporomandibular joint (TMJ) disorders are common and affect up to one-third of all adults at some stage.[1] The correlation between the images and clinical findings has led to a better understanding of the pathophysiology of temporomandibular disorders (TMD).[2]

Mechanisms such as internal derangement and osteoarthritis, which play an important role in the aetiology of TMD, have been the focus of various studies. Emshoff et al[3] studied the relationship between pain and internal derangement and the results showed that pain has a strong relationship with internal derangement. Another study about TMJ derangements, imaging techniques and internal derangement diagnosis revealed that clinical and imaging findings were statistically significant in patients with internal derangement and osteoarthritis was the most prevalent change.[4] Emshoff et al[5] investigated the relationship between pain and imaging findings as internal derangement and osteoarthritis in symptomatic patients. The results confirm the relationship between internal derangement and osteoarthritis. Emshoff et al[6] evaluated the relationship between clinical and imaging diagnosis of internal derangement and the results confirmed that clinical diagnosis is not a reliable tool when compared with imaging findings.

Many imaging techniques can be used to examine the TMJ. MRI is currently considered the most appropriate method for TMJ examination. MRI is a non-invasive imaging technique with superior soft-tissue resolution and it has been widely used as the gold standard for the examination of TMJ disc displacement.[1]

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Received 20 September 2010; revised 11 March 2011; accepted 11 April 2011

The aim of this study was to evaluate the relationship between TMJ disc position and bone changes in the condyle, glenoid fossa and articular eminence of the temporal bone. Given that the association of the variables used in this study have not been previously shown, it seems relevant to discuss these findings.

Materials and methods

Sagittal proton density-weighted and T_2 weighted MRI scans of 74 symptomatic patients were made as recommended by their doctors or dentists (or both). The images of 148 TMJs were evaluated by 2 experienced radiologists (a doctor and a dentist) and the results were used in this study.

All scans were performed at the same institution on the same MRI scanner (Signa® 1.5 T, GE Healthcare, Little Chalfont, UK) using the same surface coils (double surface coil 20 cm in diameter) and scanning protocols. The images were submitted to digital manipulation in a workstation (Easyvision; Philips Medical Systems, Best, Netherlands) and recorded in digital imaging and communications in medicine (DICOM) format.

The inclusion criterion was that the patient must have at least one sign or symptom of TMD (or a combination of the two) during clinical examination. Patients presenting with systemic rheumatic diseases were excluded.

We evaluated the chief complaint, the presumed area of pain, the presence of articular sounds (clicking, popping and/or grinding noises) and secondary factors, such as trauma and occlusal interference, which patients considered important to mention.

The TMJs were assessed bilaterally, in the sagittal plane, in the closed-mouth position (maximum intercuspal position) and with intermediate apertures of 10 mm, 20 mm and 30 mm. These measurements were made with the aid of a mouth prop and a plastic calliper.

The position of the TMJ disc was classified as follows:

- Normal state (N): the posterior band of the disc is centred in relation to the condyle and the bottom of the glenoid fossa.
- Disc displacement with reduction (DDwR): the disc is anterior to the condyle in the closed-mouth position and returns to its normal position when the jaw is opened (Figure 1a,b).
- Disc displacement without reduction (DDwoR): the disc is anterior to the condyle in the closed-mouth position and does not return to its normal position when the jaw is opened (Figure 1c,d).
- Posterior displacement (PD): the posterior band of the disc is in apparent contact with the bilaminar zone and its anterior band is at a 2 o'clock or 3 o'clock position (Figure 1e).

Bone changes in the condyle and temporal bone were investigated and classified as osteophytosis, sclerosis or erosion (Figure 2a–c).

Information regarding gender, disc position, bone changes in the condyle, bone changes in the anterior aspect of the articular eminence, bone changes in the posterior aspect of the articular eminence and bone changes in the glenoid fossa of the temporal bone were analysed by calculating the absolute and relative frequencies.

Inferential analysis was performed to confirm or refute the evidence found in the descriptive analysis. An extension of Fisher's exact test was used to determine whether bone changes in the condyle, anterior aspect of the articular eminence, posterior aspect of the articular eminence and glenoid fossa of the temporal bone were associated with the position of the disc. For all of the analyses, the level of significance was set at 5%.

Results

From the 74 patients (148 TMJs) evaluated, 51 (68.9%) were female and 23 (31.1%) were male. The mean age of female patients was 40.4 ± 14.5 years (range: 13–69 years). The mean age of male patients was 35.9 ± 11.2 years (range: 17–58 years).

Tables 1–3 show the distribution of the TMJs according to the position of the disc, the bone changes in the condyle, the bone changes in the anterior aspect of the articular and posterior aspect of the articular eminence, respectively. None of the patients presented with bone changes in the glenoid fossa of the temporal bone.

Tables 4–6 show the descriptive analysis of the association between disc position and bone changes in the condyle, posterior aspect of the articular eminence and anterior aspect of articular eminence, respectively.

The results of the statistical tests revealed that bone changes in the condyle and posterior aspect of the articular eminence were associated with the position of the disc ($p = 0.003$, $p < 0.001$, respectively). Bone changes in the anterior aspect of the articular eminence were not associated with the position of the disc ($p = 0.365$).

The TMJs classified as N, DDwR and DDwoR were statistically equal in terms of bone changes in the condyles, except for the combination of erosion and osteophytosis, which was more common in the condyles of the TMJs classified as DDwoR ($p = 0.335$) (Table 4).

The proportions of TMJs without bone changes in the posterior aspect of the articular eminence were statistically equal between the groups classified as N and DDwR ($p > 0.999$). As can be seen in Tables 5 and 6, the proportion of TMJs presenting erosion of the articular eminence was higher in the DDwoR group than in the DDwR and N groups put together ($p < 0.001$).

Discussion

MRI is considered the method of choice for the evaluation of the soft tissue components of joints, as well as for the evaluation of the amount of joint fluid,

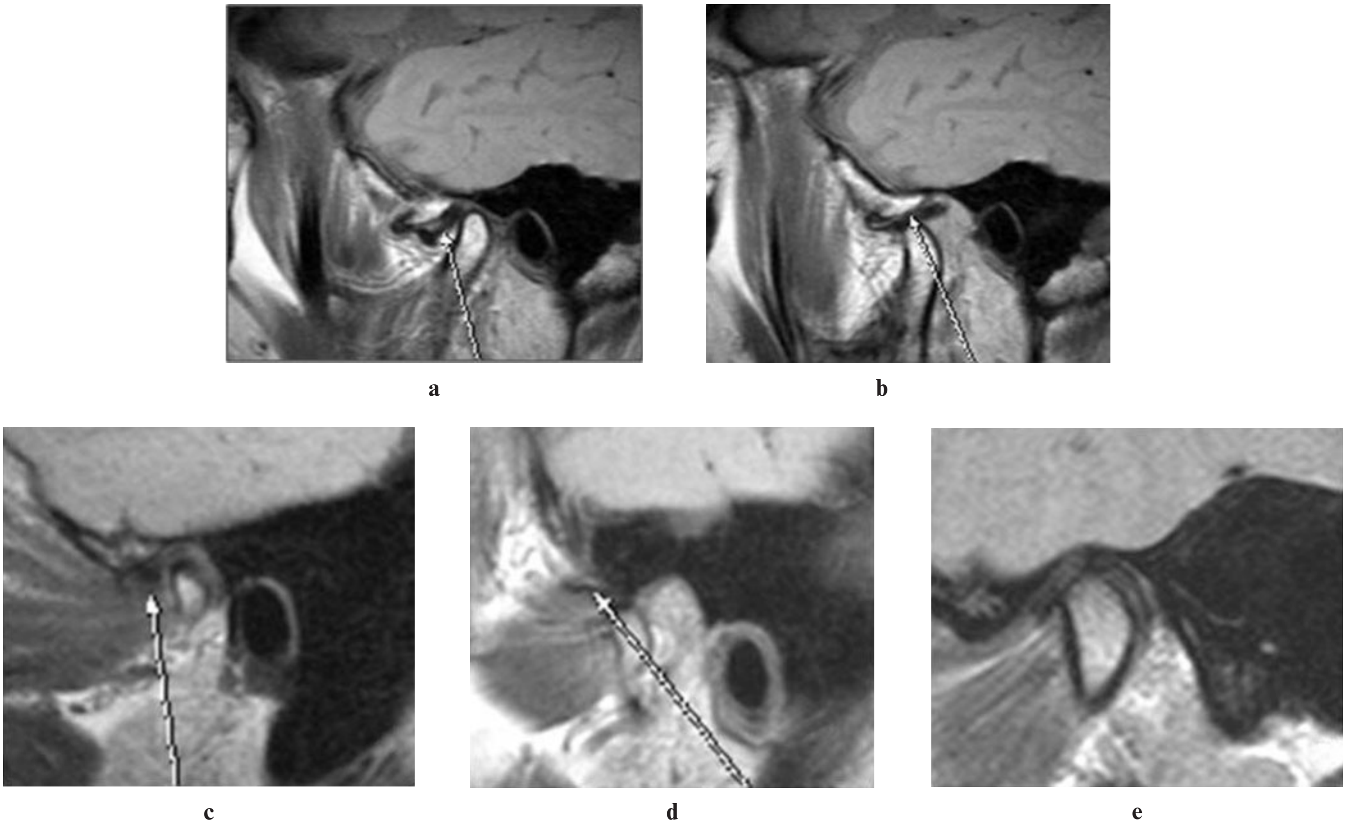

Figure 1 MRI sagittal view. (a) and (b) disc displacement with reduction, (a) closed mouth, (b) open mouth; (c) and (d) disc displacement without reduction, (c) closed mouth, (d) open mouth; (e) posterior displacement, closed mouth

whereas CT is considered the best method for the study of bone changes in the TMJ.[7] Although the radiation dose in CT is a disadvantage, one group of authors has reported that CT is a more suitable method for examining osteophytes and erosions.[8]

Although CT has greater specificity and sensitivity for detecting bone changes than MRI, Liu et al[1] found that the accuracy of MRI in determining the position and morphology of the disc and in assessing bone changes was 95% and 93%, respectively. Various studies have used MRI to examine bone changes resulting from the position of the articular disc. The diagnosis of osteoarthritis should be established by evaluation of MR images in association with clinical examination,[9] considering that the most common condylar pathology found was articular surface degeneration indicative of osteoarthrosis. This study showed that osteoarthrosis and internal derangement were found to co-exist in the same joint in about one-third of cases.[10] TMJ-related pain is correlated with TMJ-related MRI diagnoses of internal derangement and osteoarthrosis.[5,11–13] In the present study, we used MRI to evaluate bone changes in the TMJ and we studied bone changes resulting from the position of the articular disc.

The inclusion criterion adopted for the present study was that patients must have reported TMJ pain or pain in adjacent regions. The aetiology of TMJ pain has yet to be fully understood; however, TMJ pain is a rather common finding in cases of internal derangement.[3,5,9,11,12,14–19] Nevertheless, the absence of TMD signs has been associated with high rates of internal derangement, which confirms that a clinical diagnosis of internal derangement is not a reliable tool to predict an imaging diagnosis of internal derangement.[6]

From the 148 TMJs studied, 94 (63.5%) presented N, 34 (23%) presented DDwoR, 19 (12.8%) presented DDwR and 1 (0.7%) presented PD (Table 1). Based on these data, only 36.48% of the study sample was classified as presenting internal derangement, which is in disagreement with the findings of Emshoff et al[16] who reported a strong correlation between pain and internal derangement (64.4%). The proportion found in the present study was closer to that found among asymptomatic individuals, which is in agreement with the findings of Sano et al[14] who reported that osteoarthritis and related entities can reflect the clinical symptoms of TMJ problems although the discrepancy between imaging findings and symptoms can complicate the clinical management. Our data showed that pain is not a reliable predictor of internal derangement, which is in agreement with the findings of other studies.[4,6,11]

Regarding the type of disc displacement observed in the present study, the proportion of DDwoR was higher than that of DDwR (23% *vs* 12.8%) which is in agreement with the findings of Emshoff et al[12,16] but in disagreement with the findings of another study where 82.5% of cases had disc displacement, of

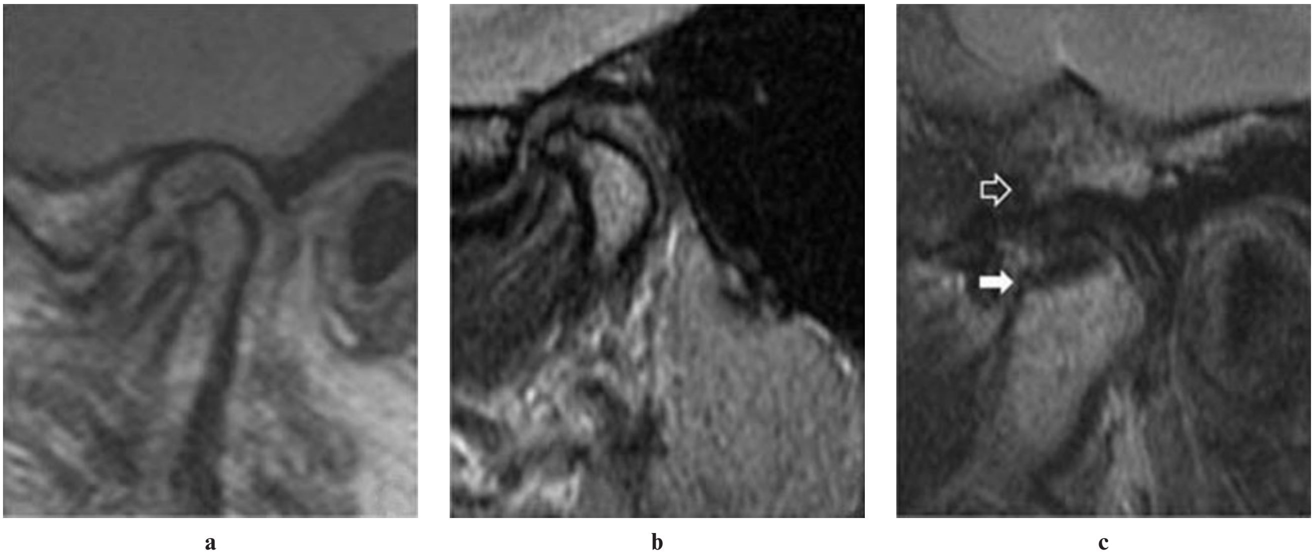

Figure 2 MRI sagittal view. (A) osteophytosis; (B) erosion and sclerosis; (C) erosion of mandibular condyle (white arrow) and articular eminence (black arrow)

which 59.5% demonstrated reduction with opening and 40.5% did not reduce. Anterior disc displacement is common (44%) and sideways displacement is rare (4%). Anterolateral displacement was the second most common type of displacement (29%) which is probably related to the weakness of the lateral disc attachment.[20]

The results of the present study revealed that bone changes were more common in the condyle than in the articular eminence. None of the patients presented bone changes in the glenoid fossa of the temporal bone.

The bone changes in the condyles of the TMJs classified as N, DDwR and DDwoR were statistically identical ($p = 0.335$). Another study has reported the same statistical result.[5]

The fact that the changes in the condyles of the TMJs classified as N, DDwR and DDwoR were statistically identical allowed us to conclude that, when changes in the condyle were analysed as a whole (*i.e.* without taking into consideration the subdivisions according to the type of change), there was no association between bone changes and the position of the disc. However, as can be seen in Table 4, the combination of erosion and osteophytosis was extremely common in the DDwoR group which allowed us to infer that only this type of change was associated with the position of the articular disc.

As can be seen in Table 2, there was a combination of bone changes (erosion + sclerosis, erosion + sclerosis + osteophytosis, erosion + osteophytosis or sclerosis + osteophytosis) in half of the condyles that presented some type of abnormality, whereas in the other half there was only one type of change (erosion, sclerosis or osteophytosis).

In the present study, the proportion of erosion and osteophytosis in the condyle was high, which is in agreement with the findings of Campos et al,[9] Güler et al[17] and Yamada et al[21] who also reported a high proportion of osteophytosis and erosion in the condyle.

Regarding the articular eminence, the posterior aspect was the site that was most commonly affected, erosion being the most common of the bone changes observed (Table 3). There is controversy regarding the causes of changes in the articular eminence. Studies have suggested that bone changes in the articular eminence can be caused by bone changes in the condyle,[21] disc displacement[22] or disc perforation.[23] It has also been suggested that bone changes in the articular eminence are a predisposing factor for disc displacement.[24]

The statistical tests performed in the present study revealed a significant relationship between bone changes in the anterior and posterior aspect of the articular eminence and disc position (Tables 5 and 6), a finding that was quite

Table 1 Distribution of the temporomandibular joints according to the position of the articular disc

Position of the disc	*Frequency (n)*	*Percentage (%)*
DDwR	19	12.8
DDwoR	34	23.0
PD	1	0.7
N	94	63.5
Total	148	100.0

DDwoR, disc displacement without reduction; DDwR, disc displacement with reduction; N, normal; PD, posterior displacement.

Table 2 Distribution of the temporomandibular joints according to the bone changes in the condyle

Bone changes in the condyle	*Frequency (n)*	*Percentage (%)*
E	1	0.7
E+S	5	3.4
E+S+O	6	4.1
E+O	8	5.4
S	8	5.4
S+O	3	2.0
N	104	70.3
O	13	8.8
Total	148	100.0

E, erosion; E+O, erosion and osteophytosis; E+S, erosion and sclerosis; E+S+O, erosion, sclerosis and osteophytosis; N, no changes; O, osteophytosis; S, sclerosis; S+O, sclerosis and osteophytosis.

Table 3 Distribution of the temporomandibular joints according to the bone changes in the anterior and posterior aspects of the articular eminence

	Posterior aspect of the articular eminence		*Anterior aspect of the articular eminence*	
Bone changes	*Frequency (n)*	*Percentage (%)*	*Frequency (n)*	*Percentage (%)*
Erosion	12	8.1	1	0.7
No changes	136	91.9	147	99.3
Total	148	100.0	148	100.0

Table 4 Distribution of the temporomandibular joints according to the bone changes in the condyle and the position of the articular disc

	Position of the disc									
	DDwR		*DDwoR*		*PD*		*N*		*Total*	
Bone changes in the condyle	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*
E	—	—	1	2.9	—	—	—	—	1	0.7
E+S	—	—	1	2.9	—	—	4	4.3	5	3.4
E+S+O	1	5.3	2	5.9	—	—	3	3.2	6	4.1
E+O	—	—	7	20.6	—	—	1	1.1	8	5.4
NC	—	—	3	8.8	—	—	5	5.3	8	5.4
S+O	—	—	1	2.9	—	—	2	2.1	3	2.0
N	18	94.7	16	47.1	—	—	70	74.5	104	70.3
O	—	—	3	8.8	1	100.0	9	9.6	13	8.8
Total	19	100.0	34	100.0	1	100.0	94	100.0	148	100.0

DDwR, disc displacement with reduction; DDwoR, disc displacement without reduction; E, erosion; E+O, erosion and osteophytosis; E+S, erosion and sclerosis; E+S+O, erosion, sclerosis and osteophytosis; N, normal; NC, no changes; O, osteophytosis; PD, posterior displacement; S, sclerosis; S+O, sclerosis and osteophytosis.

similar to those of Major et al.[22] The statistical analysis also revealed that the proportion of TMJs that presented erosion of the anterior and posterior aspect of the articular eminence was higher among the TMJs classified as DDwoR than among those classified as DDwR and N put together ($p < 0.001$).

It is worth noting that bone changes in the articular eminence and the combination of erosion and osteophytosis in the condyle were associated with DDwoR which can be interpreted as a more advanced stage of internal derangement. This is in agreement with the findings of Costa et al[15] who argued that bone changes occur predominantly in more severe cases of internal derangement.

In conclusion, we found strong indications that bone changes were more common in the condyle than in the remaining bone components of the TMJ; that the most common bone change in the condyle was the combination of osteophytosis and erosion, whereas the most common bone change in the posterior aspect of the articular eminence was erosion; and that bone changes in the articular eminence and the combination of erosion and osteophytosis in the condyle were related to DDwoR.

Table 5 Distribution of the temporomandibular joints according to the bone changes in the posterior aspect of the articular eminence and the position of the articular disc

	Position of the disc									
	DDwR		*DDwoR*		*PD*		*N*		*Total*	
Bone changes: posterior aspect of the articular eminence	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*
Erosion	—	—	9	26.5	1	100.0	2	2.1	12	8.1
No changes	19	100.0	25	73.5	—	—	92	97.9	136	91.9
Total	19	100.0	34	100.0	1	100.0	94	100.0	148	100.0

DDwoR, disc displacement without reduction; DDwR, disc displacement with reduction; N, normal; PD, posterior displacement.

Table 6 Distribution of the temporomandibular joints according to the bone changes in the anterior aspect of the articular eminence and the position of the disc

	Position of the disc									
	DDwR		*DDwoR*		*PD*		*N*		*Total*	
Bone changes: anterior aspect of the articular eminence	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*	*Number (n)*	*Percentage (%)*
Erosion	—	—	1	2.9	—	—	—	—	1	0.7
No changes	19	100.0	33	97.1	1	100.0	94	100.0	147	99.3
Total	19	100.0	34	100.0	1	100.0	94	100.0	148	100.0

DDwoR, disc displacement without reduction; DDwR, disc displacement with reduction; N, normal; PD, posterior displacement.

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