Are temporomandibular joint disk displacements without reduction and osteoarthrosis important determinants of mandibular backward positioning and clockwise rotation?

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Objective. The aim of this study was to estimate whether, in patients with temporomandibular joint (TMJ) arthralgia, the magnetic resonance imaging (MRI) findings of bilateral TMJ disk displacement without reduction (DDwoR) and/or osteoarthrosis (OA) are determinants of mandibular backward positioning and/or clockwise rotation.

Study design. Bilateral MRI of the TMJ was performed in 50 consecutive TMJ arthralgia patients to identify individuals with bilateral TMJ DDwoR and/or OA. Linear and angular cephalometric measurements were taken to apply selected criteria of mandibular backward positioning (FH to Na-Pog <84°, Na-A-Pog >5°, and SNB >75°) and clockwise rotation (FH to OP >13°, MP to FH >35°, and S-Gn to FH >64°). Logistic regression analysis was used to estimate the association between selected MRI and cephalometric parameters.

Results. In the age- and gender-adjusted analyses, significant increases in risk of mandibular backward positioning and clockwise rotation occurred with bilateral DDwoR and OA (9.5:1; P = .040).

Conclusion. In patients with TMJ arthralgia the MRI parameters of DDwoR and OA seem to be important determinants of mandibular backward positioning and clockwise rotation. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:435-441)

The issue of structural characteristics in the diagnosis and assessment of temporomandibular joint (TMJ) disorders is important, given that so many clinicians base their diagnoses, etiologic hypotheses, and treatment regimens almost entirely on an assessment of the structural characteristics of a particular patient. With the rapid progress made in TMJ imaging techniques, many studies have focused on the importance of magnetic resonance imaging (MRI) findings of internal derangement (ID) and osteoarthrosis (OA) as the underlying mechanisms in the etiology of TMJ disorders. However, the question whether diagnoses of ID and/or OA are making a significant biologic contribution to the risk for changes in dentofacial morphology remains a point of controversy.

Several studies have described associations between MRI findings of TMJ ID and specific cephalometric parameters. Changes in dentofacial morphology, such as decreases in posterior facial and ramus height and backward rotations and retruded positions of the mandible, were described to become more severe as TMJ ID progressed to bilateral disk displacement without reduction (DDwoR). Few studies, however, have assessed the association between the radiographic and MRI depiction of osseous TMJ components and facial morphology in adolescents, and MRI studies considering TMJ disk displacement and OA simultaneously in their relationship to altered craniofacial morphology have not been performed. The purpose of the present study was to estimate whether MRI findings of bilateral TMJ DDwoR and/or OA are determinants of mandibular backward positioning and/or clockwise rotation.

MATERIAL AND METHODS

Subjects

Subjects were selected from a consecutive series of TMD patients who attended the Orofacial Pain and Temporomandibular Disorders (TMD) Unit in the Department of Oral and Maxillofacial Surgery at the Innsbruck Medical University between January 2008 and December 2009. A total of 50 patients, who were
recruited for a prospective cohort study of nonsurgical management for chronic TMD pain, were included. The TMJ pain group included 44 women and 6 men, with a mean age of 35.5 ± 13.2 years (range 17-49 years). The subjects were informed about the study procedure, and informed consent was received.

Criteria for including a TMD pain patient were: 1) the presence of a TMD diagnosis of unilateral arthralgia assigned according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD),21 i.e., pain during palpation associated with ≥1 self-reports of pain (pain in the region of the joint, pain in the joint during maximum unassisted opening, pain in the joint during assisted opening, or pain in the joint during lateral excursion); 2) presence of a TMD diagnosis of myofascial pain according to the RDC/TMD,21 i.e., pain to palpation of ≥3 muscle sites associated with report of pain or ache in the jaw, temples, face, preauricular area, or inside the ear at rest or during function; 3) age between 18 and 50 years; 4) caucasian race; 5) presence of all first mandibular molars; 6) ambulatory and able to be treated by as an outpatient; and 7) available for the study schedule. Criteria for excluding a TMD pain patient were: 1) acute infection or other significant disease of the teeth, ears, eyes, nose, or throat; 2) debilitating physical or mental illness; 3) presence of a collagen vascular disease; 4) history of trauma; 5) history of previous orthodontic treatment; 6) history of juvenile rheumatoid arthritis; and 7) congenital anomalies. The clinical evaluation consisted of the collection of basic demographic information, subject self-report measures, questions of history, and physical examination measures.21

To determine whether MRI diagnoses of bilateral TMJ DDwoR and/or OA are related to cephalometric parameters of mandibular backward positioning and clockwise rotation, the subjects underwent MRI investigation immediately after clinical and cephalometric evaluation. The MR images and lateral cephalograms were interpreted by the radiologist and orthodontist independently without knowledge of the results of the other investigation.

Cephalometric measurements

All study participants had lateral cephalograms with the teeth in centric occlusion position and with the Frankfort horizontal parallel to the floor. All cephalograms were taken on the same radiographic machine at the orthodontic clinic set for standardized exposure. A single investigator traced all cephalograms. The tracings were digitized with a digitizer interfaced with a desktop computer. Eleven landmarks were digitized on each radiograph, from which 6 variables were calculated. The positions of all the landmarks are shown in Fig. 1 and their measurements in Figs. 2 and 3. Duplicate determinations were performed on 20 cephalometric radiographs, from which the measurement error was calculated by intraclass correlation coefficient. The reliability of linear and angular measurements had intraclass correlation coefficients >0.91.

Magnetic resonance imaging

At MRI, the diagnoses of DD and OA were made by a single radiologist (A.R.). The MRI was carried out with a 1.5T MR scanner (Vision; Siemens, Erlangen, Germany) and a dedicated circular-polarized transmit-and-receive TMJ coil. The data were collected on a 252 × 256 matrix, with a field of view of 145 mm, giving a pixel size of 0.60 × 0.57 mm. With the patient in a supine position, 15 paracoronal and 8 parasagittal slices were obtained of each TMJ by using a turbo spin-echo proton density sequence (repetition time of 2,800 ms, echo time of 15 ms) and a turbo inversion recovery magnitude sequence (repetition time of 4,000 ms, echo time of 30 ms, inversion time of 150 ms) with thin slices of 3 mm. The MR images were corrected to the horizontal angulation of the long axis of the condyle.

Each subject received an individual nonferromagnetic intermaxillary device to obtain the different mouth opening positions. Sequential bilateral images were made at the closed-mouth and the respective max-
imum mouth opening positions. These images were selected for analysis of the disk-condyle relationship that depicted the disk, condyle, articular eminence, and glenoid fossa. The TMJs were classified as: 1) normal when the disk was located superior to the condyle; 2) disk displacement with reduction (DDwR) when the disk was displaced at the closed-mouth position and in the normal position in the open-mouth images; and 3) DDwoR when the disk was displaced in both the closed- and open-mouth positions.22,23

MRI diagnosis of OA was defined by the presence of flattening, subchondral sclerosis, surface irregularities, and erosion of the condyle or presence of condylar deformities associated with flattening, subchondral sclerosis, surface irregularities, erosion, and osteophyte.22,24

Statistics

Univariate analysis of variance and chi-squared analysis was used to control for possible differences in age and gender between the cephalometric variables. The MRI subgroups of “bilateral DDwoR,” “bilateral OA,” and “bilateral DDwoR and OA” were statistically assessed by chi-squared analysis.

Cephalometric variables needed to be transformed into polychotomous test items before carrying out the logistic regression analysis. Each variable of mandibular backward positioning and clockwise rotation was categorized based on its distributional properties and the sensibility of the cutoff points.11-14 The parameters selected for mandibular backward positioning were a facial plane angle (FH to Na-Pog) of <84°, an angle of convexity (Na-A-Pog) of >5°, and an SNB angle of >75°; those selected for mandibular clockwise rotation were a Frankfort occlusal plane angle (FH to OP) of >13°, a Frankfort mandibular plane angle (MP to FH) of >35°, and a Y-axis (S-Gn to FH) of >64°.11-14

Odds ratios were used to describe the proportionate risk that an individual with a certain MRI feature may belong to the predefined groups of mandibular backward positioning and/or clockwise rotation. A significant odds ratio was defined as an upper and lower 95% confidence limit not containing the value of one. For the odds ratio to be clinically relevant or even clinically noticable, it was assumed that it would need to be >2. Significance was set at $P < .05$. For all statistical analysis, the SPSS program (version 10.0 for Windows; SPSS, Chicago, IL) was used.

RESULTS

Application of the MRI criteria resulted in a study group of 16 patients with bilateral DDwoR, 17 with

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Fig. 2. Angular measurements used for mandibular backward positioning: facial plane angle (FH to Na-Pog), angle of convexity (Na-A-Pog), and SNB angle.

Fig. 3. Angular measurements used for mandibular clockwise rotation: Frankfort occlusal plane angle (FH to OP), Frankfort mandibular plane angle (MP to FH), and Y-axis (S-Gn to FH).
unilateral DDwoR, 17 with absence of DDwoR, 16 with bilateral OA, 15 with unilateral OA, 19 with absence of OA, 10 with bilateral DDwoR and OA, 17 with unilateral DDwoR and OA, and 23 with absence of DDwoR and OA (Tables I and II).

The distribution of age and gender among the subjects are presented in Tables I and II. There was no significant difference in age ($P = .05$) or gender ($P = .05$) between the cephalometric variables.

Analysis of cephalometric parameters selected for mandibular backward positioning and clockwise rotation showed a significant relationship between the MRI subgroup of bilateral DDwoR and the cephalometric variables of angle of convexity (Na-A-Pog) ($P = .022$) and Frankfort mandibular plane angle (MP to FH) ($P = .009$). There was a significant association between the MRI finding of bilateral OA and the cephalometric parameters of SNB angle ($P = .026$), Frankfort occlusal plane angle (FH to OP) ($P = .015$), and Frankfort mandibular plane angle (MP to FH) ($P = .001$). Furthermore, a significant association between the MRI subgroup of bilateral DDwoR and OA and the cephalometric variables of facial plane angle (Na-A-Pog) ($P = .010$) and Frankfort mandibular plane angle (MP to FH) ($P = .000$) was found (Tables I and II).

The odds ratios that an individual with an MRI finding of bilateral DDwoR and OA might belong to the backward positioning, clockwise rotation, or backward positioning and clockwise rotation group were strong (7.70:1, 7.68:1, and 9.50:1, respectively) and significant ($P = .014$, $P = .026$, and $P = .040$). There was no significant increase in the odds ratios to indicate that an individual with an MRI finding of bilateral DDwoR or bilateral OA would belong to the backward positioning (1.39:1 and 2.22:1, respectively), clockwise rotation (1.63:1 and 1.56:1, respectively), or backward positioning and clockwise rotation (1.75:1 and 1.67:1, respectively) group (Table III).

DISCUSSION
This study revealed a significant relationship between the MRI diagnoses of bilateral DDwoR and the cephalometric variables of angle of convexity (Na-A-Pog) and Frankfort mandibular plane angle (MP to FH); these findings suggest that the mandible of affected subjects may tend to retrude and rotate clockwise. However, given the fact that TMJ bilateral DDwoR was not always associated with the cephalometric parameters selected for mandibular backward positioning and clockwise rotation, more data may be necessary if
bilateral DDwoR are to become generally accepted as a significant contributing factor in the pathogenesis of altered craniofacial morphology. The results may be regarded as compatible with those of an earlier study reporting that subjects affected with an MRI finding of bilateral TMJ DDwoR may have a significantly smaller angle of convexity and a significantly greater Frankfort mandibular plane angle. However, the results may be not directly comparable, because that study was conducted without controlling for the presence of TMJ OA as a contributary factor in the etiology of altered craniofacial morphology. Further studies including a large

<table>
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<tr>
<th>Parameter</th>
<th>FH to OP &gt;13° (n = 14)</th>
<th>FH to OP ≤13° (n = 36)</th>
<th>P value</th>
<th>MP to FH &gt;35° (n = 18)</th>
<th>MP to FH ≤35° (n = 32)</th>
<th>P value</th>
<th>SG-N to FH &gt;64° (n = 11)</th>
<th>SG-N to FH ≤64° (n = 39)</th>
<th>P value</th>
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<td>Age (y)</td>
<td>34.5 ± 11.6</td>
<td>35.9 ± 13.9</td>
<td>.742</td>
<td>36.3 ± 10.3</td>
<td>35.1 ± 14.7</td>
<td>.758</td>
<td>35.9 ± 9.6</td>
<td>35.4 ± 14.1</td>
<td>.909</td>
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<td>Gender (% female)</td>
<td>85.7</td>
<td>88.9</td>
<td>.326</td>
<td>83.3</td>
<td>.609</td>
<td>72.7</td>
<td>92.3</td>
<td>.111</td>
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<tr>
<td>Bilateral DDwoR (%)</td>
<td>6 (42.9)</td>
<td>10 (27.8)</td>
<td>.528</td>
<td>10 (55.6)</td>
<td>6 (18.8)</td>
<td>.009*</td>
<td>5 (45.5)</td>
<td>11 (28.2)</td>
<td>.233</td>
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<td>Nonbilateral DDwoR (%)</td>
<td>8 (57.1)</td>
<td>26 (72.2)</td>
<td>.281</td>
<td>8 (44.4)</td>
<td>26 (81.3)</td>
<td>.281</td>
<td>6 (54.5)</td>
<td>28 (71.8)</td>
<td>.233</td>
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<tr>
<td>Unilateral DDwoR (%)</td>
<td>5 (62.5)</td>
<td>12 (46.2)</td>
<td>.375</td>
<td>3 (37.5)</td>
<td>14 (53.8)</td>
<td>1 (16.7)</td>
<td>16 (57.1)</td>
<td>.233</td>
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<td>Absence of DDwoR (%)</td>
<td>3 (37.5)</td>
<td>14 (53.8)</td>
<td>.625</td>
<td>5 (62.5)</td>
<td>12 (46.2)</td>
<td>5 (83.3)</td>
<td>12 (42.9)</td>
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<tr>
<td>Bilateral OA (%)</td>
<td>9 (64.3)</td>
<td>7 (19.4)</td>
<td>.015*</td>
<td>11 (61.1)</td>
<td>5 (15.6)</td>
<td>.001*</td>
<td>5 (45.5)</td>
<td>11 (28.2)</td>
<td>.233</td>
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<td>Nonbilateral OA (%)</td>
<td>5 (35.7)</td>
<td>29 (80.6)</td>
<td>.015*</td>
<td>7 (38.9)</td>
<td>27 (84.4)</td>
<td>.001*</td>
<td>6 (54.5)</td>
<td>28 (71.8)</td>
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<td>Unilateral OA (%)</td>
<td>3 (60.0)</td>
<td>12 (41.4)</td>
<td>.292</td>
<td>3 (42.9)</td>
<td>12 (44.4)</td>
<td>3 (50.0)</td>
<td>12 (42.9)</td>
<td>.233</td>
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<td>Absence of OA (%)</td>
<td>2 (40.0)</td>
<td>17 (58.6)</td>
<td>.571</td>
<td>4 (57.1)</td>
<td>15 (55.6)</td>
<td>3 (50.0)</td>
<td>16 (57.1)</td>
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<td>Bilateral DDwoR and OA (%)</td>
<td>5 (35.7)</td>
<td>15 (39.3)</td>
<td>.903</td>
<td>9 (50.0)</td>
<td>1 (3.1)</td>
<td>.403</td>
<td>4 (36.4)</td>
<td>6 (15.4)</td>
<td>.233</td>
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<td>Nonbilateral DDwoR and OA (%)</td>
<td>9 (64.3)</td>
<td>31 (86.1)</td>
<td>.093</td>
<td>9 (50.0)</td>
<td>31 (96.9)</td>
<td>.000*</td>
<td>7 (63.6)</td>
<td>33 (84.6)</td>
<td>.135</td>
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<td>Unilateral DDwoR and OA (%)</td>
<td>6 (66.7)</td>
<td>11 (35.5)</td>
<td>.333</td>
<td>3 (33.3)</td>
<td>14 (45.2)</td>
<td>2 (28.6)</td>
<td>15 (45.5)</td>
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<tr>
<td>Absence of DDwoR and OA (%)</td>
<td>3 (33.3)</td>
<td>20 (64.5)</td>
<td>.667</td>
<td>6 (66.7)</td>
<td>17 (54.8)</td>
<td>5 (71.4)</td>
<td>18 (54.5)</td>
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</table>

Abbreviations as in Table I.
*Significant difference with ANOVA.

Table III. Cephalometric by MRI variables (n = 50)

<table>
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<tr>
<th>Diagnostic variable</th>
<th>Estimate</th>
<th>Standard error</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>P value</th>
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<td>Backward positioning</td>
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<tr>
<td>Bilateral DDwoR</td>
<td>0.32</td>
<td>0.41</td>
<td>1.39</td>
<td>0.62-3.12</td>
<td>.424</td>
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<tr>
<td>Bilateral OA</td>
<td>0.79</td>
<td>0.42</td>
<td>2.22</td>
<td>0.96-5.10</td>
<td>.060</td>
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<tr>
<td>Bilateral DDwoR and OA</td>
<td>2.04</td>
<td>0.84</td>
<td>7.70</td>
<td>1.50-93.56</td>
<td>.014*</td>
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<td>Clockwise rotation</td>
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<tr>
<td>Bilateral DDwoR</td>
<td>0.48</td>
<td>0.44</td>
<td>1.63</td>
<td>0.69-3.86</td>
<td>.270</td>
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<td>Bilateral OA</td>
<td>0.46</td>
<td>0.44</td>
<td>1.56</td>
<td>0.58-3.15</td>
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<tr>
<td>Bilateral DDwoR and OA</td>
<td>2.04</td>
<td>0.91</td>
<td>7.68</td>
<td>1.28-45.97</td>
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<td>Backward positioning and clockwise rotation</td>
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<td>Bilateral DDwoR</td>
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<td>0.506</td>
<td>1.75</td>
<td>0.65-4.72</td>
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<td>Bilateral OA</td>
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<td>0.505</td>
<td>1.67</td>
<td>0.62-4.48</td>
<td>.312</td>
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<tr>
<td>Bilateral DDwoR and OA</td>
<td>2.25</td>
<td>1.10</td>
<td>9.50</td>
<td>1.11-81.47</td>
<td>.040*</td>
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</table>

CI, Confidence interval; other abbreviations as in Table I.
*FH to Na-Pog <84°, Na-A-Pog >5°, and SNB <75°.
*FH to OP >13°, MP to FH >35°, and SG-N to FH >64°.
*Significant difference with logistic regression analysis, adjusted for age and gender.
sample size of MRI-related TMJ DDwoR and TMJ non-DDwoR subjects are warranted to describe TMJ ID-specific data of craniofacial morphology.

The findings of a significant association between the MRI finding of bilateral OA and the cephalometric parameters of SNB angle, Frankfort occlusal plane angle (FH to OP), and Frankfort mandibular plane angle (MP to FH) are in agreement with those of Gidarakou et al., who compared symptomatic TMD patients with asymptomatic volunteers and described a significantly smaller SNB angle and a significantly greater Frankfort occlusal and mandibular plane angle in symptomatic patients with an MRI finding of bilateral TMJ OA. Dibbets et al. and Nebbe et al. have also reported a steeper mandibular plane in children and adolescents presenting with degenerative joint disease, and Nickerson and Moystad also found a steeper mandibular plane in their sample of patients with bilateral condylar remodeling. These reports correspond to the concept that as TMJ morphology progresses to osteoarthritic changes, a backward positioning and rotation of the mandible may occur. However, to identify which parameters may define mandibular backward positioning and clockwise rotation patients and “normals,” multiple-factor studies including additional morphological variables are necessary, and from a methodologic point of view, only a well controlled incidence study rather than a case-control study may clarify the etiologic contribution of TMJ OA to craniofacial morphology.

The present study provides a perspective to the contribution of MRI variables of DDwoR and OA to the presence of mandibular backward positioning and clockwise rotation. Although the MRI parameters of bilateral DDwoR and bilateral OA contributed only minor amounts to the change in risk, a clear definition of the mandibular backward positioning and clockwise rotation groups was only evident for the bilateral DDwoR and OA variable and involved only a few subjects. Therefore, based on this study, DDwoR and OA may not be considered to be the unique and dominant factors in the definition of mandibular backward positioning and clockwise rotation. However, the contribution of these variables was not zero. Combinations of 2 of these parameters contributed to tracking the change in risk for mandibular backward positioning and clockwise rotation, and the elevations in odds ratios indicate that they are probably making some contribution biologically. This concept corresponds with the reports of other authors who demonstrated that alterations of vertical and horizontal positions of the mandible relative to the cranial base and maxilla changed significantly as ID progressed from DDwoR to DDwoR. Although the cause-and-effect relationships were considered to be unclear, the authors hypothesized that the underlying mechanism of increasing changes in dentofacial morphology may be related to progressive osteoarthrotic changes occurring in subjects with TMJ DDwoR. Further investigations are necessary to answer the question of which additional TMJ- and non-TMJ-related features may have to be defined as “diagnostic for disorder” or “normal,” namely with or without significant elevated risk for mandibular backward positioning and clockwise rotation.

The present findings raise the question of whether the use of cephalometry-related diagnoses of craniofacial morphology may need to be supplemented by MRI to distinguish among subtypes of craniofacial morphology. From a methodologic point of view, etiology, prognostic statements, and implications for treatment are considered to be the main indicators for the utility of diagnostic classifications. Further research may be warranted to assess the diagnostic validity of MRI-related variables of TMJ ID and OA, and by determining how well these diagnoses may show decisive differences in the areas of pathogenesis, treatment, and/or prognosis.

CONCLUSION

In patients with TMJ arthralgia, the MRI parameters of DDwoR and OA seem to be important determinants of mandibular backward positioning and clockwise rotation.

REFERENCES


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