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# Correlation between clinical variables and magnetic resonance imaging findings in symptomatic patients with chronic temporomandibular articular disc displacement with reduction: A retrospective analytical study

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**ABSTRACT**

**Objective:** To correlate the clinical aspects of symptomatic patients with chronic articular disc displacement with reduction with alterations in the articular disc (AD) morphology and sagittal position.

**Methods:** Records from 109 patients were selected that included data on AD morphology and sagittal position as determined by MRI. According to the MRI results, the sagittal position and AD morphology with opened and closed mouth were correlated with many clinical variables.

**Results:** More than half of the patients studied were female, and the biconcave and hemiconvex morphologies were most common. Thirty-four patients (31.3%) presented with restricted maximum interincisal distance (MID). The biplanar morphology was associated with eccentric bruxism and MID ($p < 0.05$). Visual analog scale (VAS) scores between 2 and 7 were shown to be risk factors ($p < 0.05$).

**Conclusion:** The mouth position can influence AD morphology and eccentric bruxism. VAS scores and unknown etiology were risk factors.

**KEYWORDS**
Temporomandibular joint; magnetic resonance imaging; diagnosis; temporomandibular joint syndrome; chronic articular disc displacement with reduction

## Introduction

The temporomandibular joint (TMJ), one of the most complex articulations in the human body, is formed by the mandibular condyle and the mandibular fossa located in the squamous portion of the temporal bone [1,2]. Between the mandibular condyle and the mandibular fossa is the articular disc (AD), which is a thin, oval plate of fibrocartilage that prevents the direct contact between the osseous surfaces and acts as an active component in mandibular movement [2,3]. Temporomandibular disorders (TMDs) affect 39% of the worldwide population [4]. The reported prevalence of TMD signs and symptoms in the population varies between 16 and 88% [5].

Articular disc displacement (ADD) is one of the most frequent TMD subtypes [4,6] and has been associated with clinical symptoms, such as pain, joint noise, and abnormal TMJ function [6,7]. ADD is defined as an abnormal relationship between the AD and the mandibular condyle, the articular surface of the mandibular fossa, and the articular tubercle [2,8,9]. Anterior ADD is more frequent than posterior and lateral/medial ADD [9]. Some studies have shown that ADD is more common between the second and fifth decades of life [4,10,11], and women are more frequently affected by the condition than men [4,11].

ADDs can occur with or without reduction, depending on whether the normal relationship between the AD and the mandible head is reestablished during mouth opening movement [2,9]. When the AD remains anteriorly displaced at the maximum mouth opening position, it is classified as disc displacement without reduction (DDWOR), whereas when the AD returns to its normal position when the mouth is open, it is classified as disc displacement with reduction (DDWR) [9]. In cases of DDWR, reciprocal clicks of the TMJ are commonly present [12], which may indicate a change from AD biconcave

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(physiological) morphology and can lead to a painful TMJ, due to mechanical overload [13].

TMD diagnosis is usually conducted through clinical analyses, in which the TMJ structural characteristics of each patient are investigated [12]. For some time, magnetic resonance imaging (MRI), a non-invasive, non-ionizing, and highly precise examination method, has also been employed in the investigation of TMJ-related problems and TMD diagnosis [2,4,8,9,11,13,14]. MRI has shown high sensitivity (80%), specificity (97%) [15], and accuracy in AD diagnosis (95%) and in detecting AD morphology and bone alterations (93%) [16]. The presence of pain is not always a pathognomonic sign of ADD. Previous MRI studies have reported a high prevalence of ADD in asymptomatic patients [17,18].

Therefore, the aim of this study was to correlate different clinical aspects of symptomatic patients with DDWR with changes in AD morphology and sagittal position using MRI scans acquired with the mouth open and closed. The null hypotheses tested are as follows: (I) no difference in AD morphology will be found with the mouth open or closed; and (II) the clinical variables will not be correlated with any particular AD morphology or sagittal position with the mouth closed or open.

## Materials and methods

This retrospective observational cross-sectional analytical study was approved by the Ethics Committee for the Research Involving Human Beings of the State University of Maringá, Maringá, Brazil (CAAE: 1.245.436 of 09/25/2015). This study was conducted according to the Strobe (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [19]. This study adhered to all 22 items of these guidelines except for the calculation of sample size. Due to the retrospective nature of this study, a signed informed consent was not required by the Committee.

### *Sample*

The sample comprised records from 109 patients who were diagnosed with DDWR and underwent MRI examination of the TMJ between January 2005 and January 2016. Individuals of both genders who were ≥18 years of age and presented with clinical signs and symptoms of intra-articular TMJ dysfunction, such as TMJ chronic pain (>three months), and/or mandibular deviation, and/or the presence of a restricted mouth opening, and/or joint noise while opening and closing the mouth, were selected for the study. Patients with rheumatoid arthritis, agenesis, hyperplasia, hypoplasia and/or malignant neoplasm of the condyle, bone ankylosis, removable dental prostheses, previous TMJ and/or neck and head surgery, or individuals who for some reason could not undergo MRI at the time of data collection were excluded from the study. All patients underwent a clinical assessment and diagnosis conducted by the same dentist, a TMD and orofacial pain specialist, at the Orofacial Pain and Deformity Center (CENDDOR) in Porto Alegre, Brazil.

The following clinical information was collected from the medical records of each patient: age; gender; maximum interincisal distance (MID); joint noise; trauma; eccentric and centric bruxism; unknown etiology, when it was not possible to find an associated etiological factor; and pain level, which was obtained with the visual analog scale (VAS). VAS was used as a one-dimensional evaluation measure [20]. Clinical TMD diagnosis was conducted according to previously established clinical diagnostic criteria for TMD [15,21]. Eccentric and centric bruxism were diagnosed based on the patient's clinical history, self-account, or accounts from relatives, such as spouses. In addition, pain when waking up or associated with canine wear, as observed during the clinical examination, was considered in eccentric and centric bruxism diagnoses. A stethoscope was used to detect TMJ noises.

### *MRI examination*

Magnetic resonance imaging (MRI) examination was based on the criteria defined by Brooks et al. [22]; MRI scans were obtained with a 1.5 tesla (T) magnetic field apparatus (General Electric Signa HDX) at the Diagnostic Investigation Service (SIDI), Porto Alegre, Brazil. T1-weighted sequences (return of longitudinal magnetization) were used with a repetition time (RT) of 567 ms and an echo time (ET) of 11.4 ms. The T2-weighted sequences (transverse magnetization decay) employed an RT of 5.200 ms and an ET of 168.5 ms, with a spherical surface coil of 9 cm in diameter. The matrix used for the T1 sequences was 288 × 192 and 3 NEX (number of excitations); whereas, that for T2 sequences was 288 × 160 and 4 NEX, with a field of view of 11 × 11 cm.

Six images of each TMJ were obtained in the oblique sagittal plane, which was perpendicular to the axis of the mandibular condyle, at the maximum intercuspation and maximum interincisal distance in both T1 and T2, with cuts 3 mm thick and 10% spacing between cuts. Previously, an axial cut was performed to obtain an image of the axis and to locate the mandibular condyle (scanogram). Parallel to the axis of the mandibular condyle, six additional images of each TMJ were obtained in the oblique coronal plane (T1 and T2) in a single position, i.e. in the usual maximum intercuspation. To keep the patient relaxed, minimize movement, and maintain maximum interincisal opening, an inter-occlusal device was placed in the interincisal space. The entire procedure was conducted with a mean time of 30 min. A film measuring 43 × 35 cm with 1 3 × 4 images with 1.5× magnification was used.

### Image assessment

A radiologist and a TMD specialist with significant experience analyzing TMJ MRI data used the study by Ahmad et al. [23] as a reference to analyze the scans. To assess the AD positions with the mouth closed and open, the AD space was divided according to Murakami [24]. With the mouth closed, a line (H0) was drawn joining the lowest point of the articular tubercle (c) to the lowest point of the post glenoid process (e). Then, a second line (H1) was drawn parallel to the first, passing through the most anterior point of the functional surface of the mandibular condyle (a). Two lines (L1 and L2), parallel to each other and perpendicular to H0 and H1, were also drawn as follows: L1 passed through the posterior edge of the functional surface of the mandibular condyle (P), and L2 was perpendicular to point (a). Thus, the joint space was divided into the following four compartments: A (after the mandibular condyle); B (at 11:30 h); C (before the mandibular condyle); and D (below the articular tubercle). To analyze AD position with the mouth open, a line (P) was drawn crossing the point at which point the jaw head was closest to the articular tubercle, and the AD space was divided into two spaces, into the WO (anterior disc space) and SR (posterior disc space) regions (Figure 1). The AD morphology (Figure 2) was classified according to its shape, as follows: biconcave (Figure 2(A)), biplanar (Figure 2(B)), hemiconvex (Figure 2(C)), biconvex (Figure 2(D)), and folded (Figure 2(E)). The disc configuration is shown in Figure 2(F).

A standardized drawing of each MRI scan was created manually on 8 × 10 cm transparent acetate paper (G&H Wire Company, USA). The images were evaluated using a cold light negatoscope and black cardboard mask in a low light environment, a 0.3 HB pencil, a millimeter ruler, and a transfer set. Both examiners performed the analyses at different times. The calibration was conducted with 20 randomly chosen MRI samples and was repeated within an interval of 15 days. After calibration, the examiners assessed AD morphology and the sagittal position.

### Statistical analysis

The clinical data were submitted to descriptive analysis, with the frequency distribution shown in absolute numbers and percentages. Moreover, for the quantitative variables MID (continuous quantitative) and age (discrete quantitative), the position measures and mean dispersion and standard deviation were also calculated.

Bivariate analysis was carried out using Fisher's exact test with the objective of finding possible associations between the clinical variables (predictor) and the two response variables, AD morphology and sagittal position. The Cochran-Mantel-Haenszel (CMH) test was used to calculate the odds ratio (OR) within the categories. Thus, the model was adjusted to obtain OR estimates.

Since the variable AD sagittal position presented four possibilities with the mouth closed ((A)–(D); Figure 1(A)) and two with the mouth open (WO, SR; Figure 1(B)), a multivariate analysis was conducted with the multinomial logistic model. The categories considered as reference

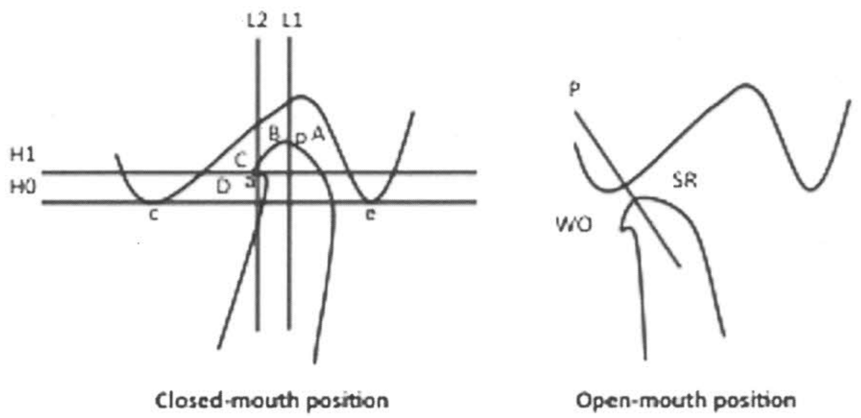


Figure 1. Subdivision of the articular space with the mouth closed and open. (A) posterior to the mandibular condyle; (B) at 11:30 h; (C) anterior to the mandibular condyle; (D) below the articular tubercle; SR- after the mandibular condyle; and WO- before the mandibular condyle (Murakami et al.). SR = the posterior disc space and WO = the anterior disc space.

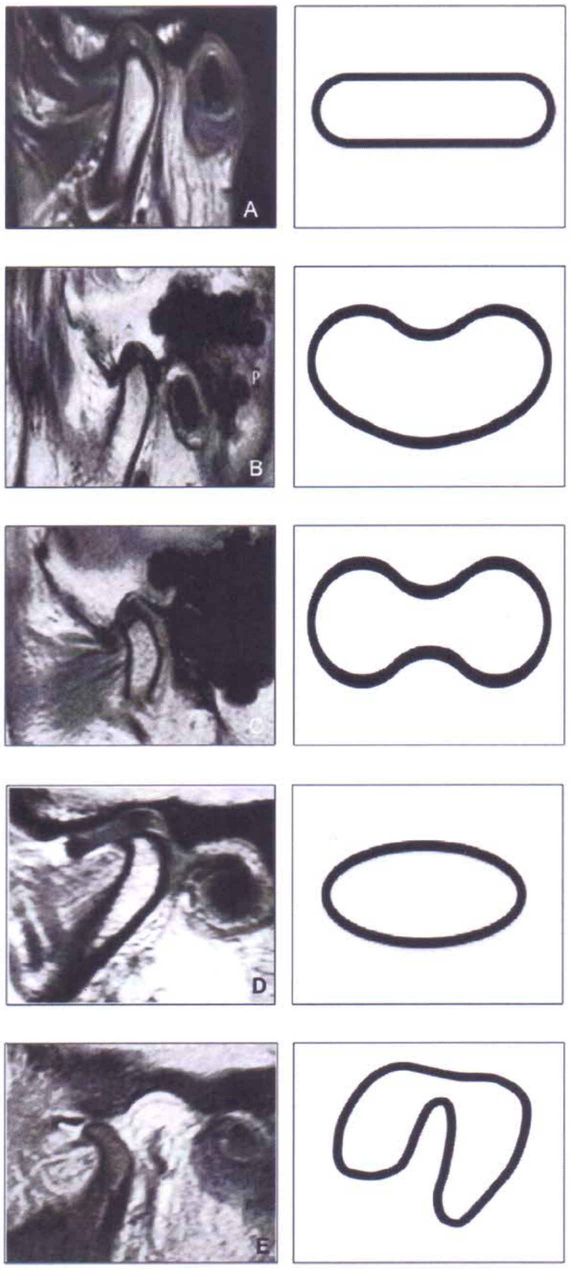


Figure 2. Magnetic resonance imaging (MRI) scans of the articular disc (AD) morphology of participating patients with disc displacement with reduction (DDWR): (A) Biplanar; (B) Hemiconvex; (C) Biconcave; (D) Biconvex; (E) Folded; (Murakami et al.) and (F) Drawings representing the disc configuration.

(baseline) for the multivariate analysis were the biconcave morphology and position B (at 11:30 h). A Kappa test was performed to establish intra- and inter-examiner agreement.

The data were analyzed using the program R version 3.2.1 for Windows (2013) and SAS version 9.03, which was available in the Statistics Department of the State University of Maringá, Brazil. The level of significance adopted for the tests and models was set at 5%.

## Results

Of the 109 participants (mean age 36.8 years), 69.7% were female (mean age 36.9 months) and 30.3% male (mean age 36.6 months). A total of 42 patients (38.2%) were less than 31 years of age, 36 (33.4%) were between 31 and 44 years, 20 (18.6%) were between 45 and 56 years, and 11 (9.8%) were older than 56 years. The mean age for all morphological categories was in the range of 35–40 years, both on the left and right sides. Kappa (0.95) showed almost perfect intra- and inter-examiner agreement.

### *AD morphology*

Frequency distribution of the AD morphologies observed with the mouth open and closed on the right and left sides is presented in Table 1. Folded morphology was not observed in any position.

Bivariate analysis demonstrated a significant association between biconcave, biplanar and hemiconvex AD morphologies with both sides of the TMJ ($p < 0.05$). As a result, the biconvex and folded morphologies were removed from further analyses. The multivariate analysis showed that with the mouth closed, the hemiconvex morphology presented a higher risk of occurrence both on the left (OR = 11.61; CI = 4.17–36.41) and right sides (OR = 33.80; CI = 8.91–193.92). With the mouth open, the biconcave AD morphology presented a higher risk of occurrence both on the left (OR = 26.25; CI = 10.62–73.14) and right sides (OR = 35.40; CI = 14.09–100.41).

The AD morphology was investigated in relation to the variables age, gender, MID, and pain level (VAS).

- ***Age and gender***: There were no significant associations between age or gender, with any of the AD morphologies, on either side of the mouth, or in the open or closed positions ($p > 0.05$).
- ***MID*** (maximum interincisal distance): A total of 32 individuals (31.3%) presented restricted mouth opening (MID < 40 mm). The AD morphology frequencies found on the right side were similar to those on the left side. The mean and median MID values for each AD morphology were similar and varied from 40–46 mm. The only exception was the biplanar AD morphology on the right side, for which the mean value was 30 mm. However, for the left side, the mean was 35 mm.

Bivariate analysis indicated an association between AD morphology on the right ($p = 0.012$) and left sides

Table 1. Frequency distribution of articular disc morphologies.

| Mouth position | | Articular disc morphology | | | | |
|---|---|---|---|---|---|---|
| | | Biconcave (%) | Biplanar (%) | Hemiconvex (%) | Biconvex (%) | Folded |
| Closed | Right | 17.3 | 20.18 | 59.63 | 2.75 | – |
| | Left | 22.01 | 20.18 | 56.88 | 0.91 | – |
| Open | Right | 86.23 | 3.66 | 10.09 | – | – |
| | Left | 82.56 | 6.42 | 8.25 | 2.75 | – |

($p = 0.016$). Multivariate analysis, performed with the biconcave AD morphology as the baseline value, demonstrated that MID < 40 mm was significantly associated with the biplanar AD morphology on the left side ($p = 0.014$; OR = 12.96; CI = 1.47–621.06) and the right side of the TMJ ($p = 0.007$). These results demonstrated that the chance of an individual having a restricted mouth opening with biplanar morphology was almost 13 times greater than having a restricted mouth opening with biconcave morphology.

- ***VAS:*** The frequency distribution of the three possible morphologies on the right and left sides of the TMJ in relation to the visual analog scale (VAS) pain scores (0–10) are presented in Table 2. None of the patients reported VAS = 1. Three individuals showed AD biconvex morphology with VAS scores of 4, 6 and 9. Bivariate analysis found no significant association between VAS scores and any of the AD morphologies in the open or closed mouth positions on either side.

### Associations with AD morphology on the right and left sides

#### Right side

Fisher's exact test demonstrated that only the variables gender ($p = 0.102$) and MID ($p = 0.023$) were candidates for the binomial and multinomial logistic regression model analyses. However, these variables were not shown to be risk factors for the development of the biplanar, hemiconvex or biconvex AD morphologies in any of the analyses. The confidence intervals were very broad, revealing that these clinical variables were sometimes risks and sometimes protective. Additionally, the value of the test was not significant for any position ($p > 0.05$). Logistic regression analysis also demonstrated that the variables MID and gender were not associated with the biplanar or hemiconvex morphologies.

#### Left side

The variables that were significant with the mouth closed and candidates for the logistic regression model and

Table 2. Frequency distribution of visual analog scale (VAS) pain scores for each articular disc (AD) morphology on the right and left sides with the mouth closed and open.

| | Right side | | | | | |
|---|---|---|---|---|---|---|
| | Mouth closed | | | Mouth open | | |
| VAS | Biconcave | Biplanar | Hemiconvex | Biconcave | Biplanar | Hemiconvex |
| 0 | 1 | 0 | 1 | 2 | 0 | 0 |
| 2 | 2 | 1 | 1 | 4 | 0 | 0 |
| 3 | 2 | 3 | 7 | 12 | 0 | 0 |
| 4 | 3 | 2 | 11 | 15 | 0 | 2 |
| 5 | 3 | 10 | 14 | 21 | 2 | 4 |
| 6 | 1 | 1 | 11 | 14 | 1 | 0 |
| 7 | 3 | 4 | 11 | 17 | 0 | 1 |
| 8 | 2 | 3 | 7 | 9 | 1 | 2 |
| 9 | 3 | 1 | 2 | 7 | 0 | 0 |
| 10 | 1 | 0 | 1 | 1 | 0 | 1 |
| VAS | Left side | | | | | |
| | Mouth closed | | | Mouth open | | |
| | Biconcave | Biplanar | Hemiconvex | Biconcave | Biplanar | Hemiconvex |
| 0 | 1 | 0 | 1 | 2 | 0 | 0 |
| 2 | 2 | 0 | 2 | 4 | 0 | 0 |
| 3 | 3 | 4 | 5 | 11 | 1 | 0 |
| 4 | 2 | 4 | 11 | 15 | 1 | 0 |
| 5 | 5 | 7 | 15 | 19 | 4 | 4 |
| 6 | 2 | 3 | 9 | 13 | 1 | 0 |
| 7 | 4 | 3 | 11 | 17 | 0 | 2 |
| 8 | 3 | 1 | 8 | 10 | 1 | 1 |
| 9 | 2 | 1 | 4 | 6 | 0 | 0 |
| 10 | 1 | 0 | 1 | 2 | 0 | 0 |

Table 3. Values resulting from the logistic regression model and multiple multinomial logistic model for the clinical variables for the left side of the closed mouth.

| | | Gender | MID | Joint noise | Eccentric bruxism |
|---|---|---|---|---|---|
| Mouth closed | Logistic regression model | $p < 0.037$ | $p < 0.076$ | $p < 0.146$ | $p < 0.004$ |
| Left side | Multiple multinomial logistic | Not significant | Not significant | Not significant | $p < 0.007$ |

Notes: MID: maximum interincisal distance.

multiple multinomial logistic analysis are demonstrated in Table 3. Eccentric bruxism was the only clinical variable that was also a risk factor for the development of hemiconvex morphology ($p = 0.007$).

With the mouth open, bivariate multinomial regression analysis demonstrated that MID < 40 mm was a risk factor for the development of biplanar morphology. However, multiple analyses showed that eccentric bruxism was also a risk factor for the biplanar and hemiconvex morphologies ($p < 0.001$).

## AD sagittal position

The frequency distribution of the AD sagittal position is presented in Table 4. Fisher's exact correlation test was used to analyze the association between the clinical variables gender, MID, articular noise, VAS, trauma, eccentric and centric bruxism, and unknown etiology with open and closed mouth AD sagittal positions. The variables that presented a value of $p \leq 0.20$ were considered as candidates for the multivariate regression model. The clinical variables selected included MID ($p = 0.221$), centric bruxism ($p = 0.153$), unknown etiology ($p = 0.079$), and VAS ($p = 0.194$). Therefore, these characteristics were represented by the number 1 for the odds ratio value, i.e. exposure to these values did not predispose an individual to any position other than the physiological position B.

Significant clinical variables according to bivariate analysis were tested using the logistic regression mode to verify which variable alone behaved as a risk factor for the development of each of the three non-physiological positions tested (A, C, and D). In a second analysis, the statistically significant clinical variables according to Fisher's exact test were placed together in the logistic regression model to identify the variable that could behave as a risk factor for the development of any of the AD positions studied.

Table 4. Frequency distribution of articular disc sagittal position.

| | | Articular disc sagittal position | | | |
|---|---|---|---|---|---|
| Mouth position | | A (%) | B (%) | C (%) | D (%) |
| Closed | Right | 0.91 | 27.52 | 25.68 | 45.87 |
| | Left | – | 24.77 | 33.94 | 41.28 |
| | | WO (%) | | Normal (%) | |
| Open | Right | 2.57 | | 97.43 | |
| | Left | 2.75 | | 97.24 | |

Notes: WO: anterior position.

### Right side

As there was only one individual in position A, this position was not considered in the statistical analysis. The variable unknown etiology was significantly associated with positions C and D (OR > 1, $p < 0.05$). However, for position D, the confidence interval included the number 1, i.e. sometimes indicating protection and sometimes not, demonstrating that unknown etiology was associated with position C, but not with position D. VAS scores between 2 and 7 presented OR > 1 and confidence intervals and $p$ values that confirmed that they were risk factors associated with positions C and D. No evidence was found that MID < 40 mm or centric bruxism were risk factors or a protective factor for any of the studied positions.

With the mouth open, although the variables eccentric bruxism ($p = 0.121$), unknown etiology ($p = 0.103$), and VAS scores ($p = 0.026$) were candidates for the multiple logistic regression model, the very small number of individuals in the non-physiological position (WO) did not permit the application of the logistic regression model for these factors.

### Left side

As no AD was located in position A, this was not included in the statistical analysis. With the mouth closed, Fisher's exact test demonstrated that the variables centric bruxism ($p = 0.006$) and VAS pain level ($p = 0.116$) were candidates for the logistic regression model. In the bivariate analysis, no clinical variable was significant for any of the positions, and very wide confidence intervals with no significance ($p = 0.823$) were observed. Therefore, pain alone was not associated with positions C and D on the left side. In the multivariate analysis, adjusted for AD sagittal position with the mouth closed, no variable was shown to be a risk factor for the development of AD in position C ($p > 0.05$). In position D, VAS scores between 2 and 7 were considered risk factors ($p < 0.001$; OR = 3.22 and OR = 2.44, respectively) with confidence intervals greater than 1 (1.096–9.517; and 1.069–5.578, respectively).

With the mouth open, no AD was found to be completely posterior to the mandibular condyle. However, the vast majority (97.24%) were in the normal physiological position, whereas only 2.75% were observed before the mandibular condyle (WO), which prevented any further statistical analysis.

## Discussion

The objective of this study was to correlate different clinical aspects of symptomatic patients with chronic articular DDWR with changes in AD morphology and sagittal position using MRI scans acquired with the mouth open and closed. The results demonstrated that mouth position (open or closed) influenced AD morphological changes, which supported the rejection of the hypothesis (I).

Eccentric bruxism was shown to be a risk factor for the development of biplanar and hemiconvex morphologies, whereas MID was a risk factor for the development of biplanar morphology. AD sagittal positions C (before the mandibular condyle) and D (below the articular tubercle) were associated with pain level (VAS between 2 and 7), which also supported the rejection of hypothesis (II).

Parafunctional habits, such as bruxism, are considered greater risk factors for the development of TMDs [25–27]; this study found an association between eccentric bruxism with the development of biplanar and hemiconvex morphologies. Similarly, the correlation between restriction mouth open (MID) and AD biplanar morphology was 13 times greater than the correlation with AD biconcave morphology. It is possible that these changes to the articular disc are the initial manifestation of an anterior displacement of the disc with reduction to without reduction or an adaptive response of the internal components of the temporomandibular joint.

At least eight types of anomalous AD positions have been identified, with anterior ADD being the most common and posterior ADD the most rare [28,29]. In DDWRs, a normal relationship between the AD and mandibular condyle is reestablished when the mouth is open.

MRI scans are useful in determining AD morphology and posterior band behavior, which is thicker and longer in the anteroposterior direction and are a determining factor for alterations of TMJ biomechanics and AD morphology. When this structure is enlarged, the AD changes from the biconcave to the biplanar or biconvex morphologies [30,31]. With the mouth closed, the majority of anterior discs presented hemiconvex or biplanar morphologies both on the right and left sides of the TMJ. However, with the mouth open, the ADs returned to their original biconcave morphology with just a small proportion that remained hemiconvex or biplanar (Table 1). These results demonstrated that changes in AD morphology were significantly associated with mouth position but not with mouth side. This observation was supported by the similar frequency of findings for the same morphological changes with the mouth closed and open. These results are in agreement with those reported by Almasan et al. [32], who analyzed AD length and morphology in patients with ADD. As in the present study, no significant differences in AD dimensions were observed when the mouth was closed. With the mouth open, the AD length of the anterior band, intermediate zone and posterior band of patients with DDWR tended to increase. The authors concluded that the dynamics of AD dimension variation were strongly related to mandibular biomechanics.

It is interesting to note that, in the present sample of patients with DDWR, very few ADs presented the biconvex morphology and none presented the folded morphology. A previous study showed that 32% of patients with DDWR presented the same elongated format, whereas in patients with DDWOR, the folded and rounded morphologies were more common [30]. According to the classification proposed by Murakami et al. [24], this corresponds to the biconvex AD. Thus, the absence of biconvex or folded AD morphologies in the present study can be explained by the fact that these are more likely to be observed in patients with DDWOR than in DDWR.

It is assumed that ADDs are approximately three times more common in women than in men [2,4,10]. Generally, TMDs begin during puberty in both genders, and the highest incidence in women is reached during the third and fourth decades of life [10]. Although the literature describes a relationship between the ADD type and age [27], the results of the present study demonstrated no association between AD morphology and age. As in this study, Larheim et al. [33] did not find significance in the regression analysis for age, gender and open mouth ADD. Based on autopsy studies, ADD was observed in 25–67% of the TMJs of elderly individuals [34,35] and in 7–12% of young individuals [36,37].

The events that occur in the intra-articular tissues of the TMJ may be adaptive or degenerative in nature, and ADD can be considered either a variation of the normal AD anatomy or a pathological event [38]. In this sense, it is necessary to distinguish between pathological changes and those that occur due to age.

The literature describes the prevalence of asymptomatic ADDs in 30–39% of patients [3], suggesting that osteoarthrosis, synovitis, joint effusion and morphological changes on the surface of the two lateral pterygoid muscles may be the cause of painful symptomatology [7]. The results of the present study seem to confirm these findings, as no correlation between VAS and AD morphological changes was found. In the present study, centric bruxism and the presence of pain (VAS scores between 2 and 7) were found to be risk factors for the AD posterior band to be positioned before the mandibular condyle (position C) or before the articular tubercle (position D) with the mouth closed. VAS scores of 8, 9 and 10, however, did not show such a risk with any clinical sagittal position in the present study. Some authors have argued that the ADD scan is not responsible for the limitation of mandibular mobility [39] and that the altered movement of the mandibular condyle is probably responsible for such limited movement. This may explain why patients with painful symptomatology may present such limitations.

## Conclusions

Considering the results found in the present study, it can be concluded that mouth position, but not the side of the mouth, influences AD morphological changes. Eccentric bruxism was shown to be a risk factor for the development of biplanar and hemiconvex morphologies. Pain level (VAS = 1 and 2) and unknown etiology were correlated with sagittal positions C and D.

## Geolocation information

The present study was carried out in southern Brazil.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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