



Original Article

# Assessment of mandibular kinematics values and its relevance for the diagnosis of temporomandibular joint disorders



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## KEYWORDS

Articular;  
Disc displacement;  
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TMD;  
TMJ

**Abstract** *Background/purpose:* Temporomandibular disorders (TMD) are common conditions that involve the temporomandibular joints (TMJs), jaw muscles, or both, and can cause alteration in the mandibular kinematics. The aim of this study was to assess the relationship between mandibular kinematics and temporomandibular joint disorders (TMJD) as a clinical tool for evaluation and diagnosis of these patients.

*Materials and methods:* A retrospective study based on the analysis of the clinical findings from patients' charts was carried out, with a sample size of 476 patients. Statistical analysis was made with chi-square test for qualitative variables and student t-test for quantitative variables. Then, odds ratio with its confidence interval were calculated. A p value < 0.05 was considered statistically significant.

*Results:* Most patients were female (80.7%) and between 16 and 25 years old. Disc displacement with reduction (DDwR) and subluxation were associated with increased kinematic parameters, while disc displacement without reduction (DDwoR) and retrodiscitis were associated with decreased kinematic values. A soft end feel was related to osteoarthritis (OA). Structural incompatibility was most prevalent in older patients.

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**Conclusion:** Mandibular kinematic values are associated with specific temporomandibular joint disorders and could be considered as a useful clinical tool to perform the right diagnosis of TMJD.

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## Introduction

Temporomandibular disorders (TMD) are conditions that involve the temporomandibular joints (TMJs), jaw muscles, and associated structures, and affect approximately 5%–12% of the population.<sup>1,2</sup> The TMJ is formed by an osseous component (temporal bone and the mandibular condyle) and the articular disc, which promotes mandibular stability and allows mandibular movements in the six degrees of freedom.<sup>3,4</sup> Temporomandibular joint disorders (TMJD), are inflammatory and non-inflammatory pathologies, which can affect mandibular movements. Within these groups is the disc displacement with reduction, disc displacement without reduction, structural incompatibility, adherence/adhesion, ankylosis, capsulitis, synovitis, retrodiscitis, dislocations and osteoarthritis.<sup>1,3,5–10</sup>

The correlation between some TMDs and mandibular kinematics has been described.<sup>11</sup> Maulén-Yáñez et al.,<sup>12</sup> related values of mandibular kinematics with TMD muscle diagnoses, however, there is still not enough scientific evidence to establish a strong relationship between the ranges of mandibular kinematics with TMJ diagnoses.

Currently, there is no clinical reference that includes the values of mandibular kinematics and correlates them with the different TMJ diagnoses. Therefore, the aim of this study is to assess the relationship between mandibular kinematics and TMJD as a useful clinical tool for the evaluation and diagnosis of these patients.

## Materials and methods

### Design and data collection

A retrospective descriptive study was carried out based on the analysis of clinical findings. The study included patients with TMJD from the Temporomandibular Disorders (TMD) and Orofacial Pain (OFP) Clinic between 2004 and 2017. All clinical data were anonymized. The exclusion criteria were: patients without a diagnosis of TMJD, incomplete clinical records and patients with an absence of anterior teeth. From a total of 615 patients, 521 patients presented at least one diagnosis of TMD, from which a sample size of 476 patients was obtained considering the exclusion criteria.

The examiners were postgraduate students in the specialty of TMD and OFP, who were trained for several months through lectures and practical clinical activities. The diagnoses were discussed in meetings between students and professors of the specialty. For the measurement of mandibular movements, a millimetric rule was used, considering the displacement of the lower incisor in

relation to the upper incisor. The mandibular kinematics variables were categorized according to Maulén-Yáñez et al.<sup>12</sup> The “end feel” was obtained by bringing the jaw to a maximum assisted mouth opening, and it was considered “hard” when it could not be carried beyond 2 mm from the maximum mouth opening of the patient, beyond that, it was considered “soft”.

### Joint diagnoses

The TMJ diagnoses were considered according to Okeson:<sup>13</sup>

- **Disc displacement with reduction (DDwR).** Disorder that occurs when the disc is anterior to the condyle in a closed mouth position and is reduced during mouth opening. This reduction causes a click, pop or snap noise during opening (single click) or during opening and closing (reciprocal click). It can be painful.
- **Disc displacement without reduction (DDwoR).** Disorder that occurs when the disc is anterior to the condyle in the closed mouth position, and is not reduced during mouth opening. It can be acute or chronic and bimanual manipulation can generate pain.
- **Structural incompatibility.** Morphological alteration that causes incompatibility of the condyle, fossa and/or disc surfaces. Most of these alterations cause a dysfunction or noise in a specific point of the movement. Alterations in the form of the bony articular structures include fluttering of the condyle or fossa, whereas alterations in the disc include perforation and thinning of the borders. It can be painful.
- **Adherence/adhesion.** Adherence is a temporary sticking between the disc and osseous surface until a single click, pop or snap noise is perceived during mandibular function. The diagnosis is based on the dental history. Adhesion is a more permanent condition that is not released due to movement. Bimanual manipulation does not generate pain.
- **Ankylosis.** It is represented as a fibrous or osseous structural connection between the condylar and fossa surfaces. In this condition the condyle cannot translate from the fossa.
- **Subluxation.** Hypermobility characterized by anterior displacement of the disc–condyle complex to the articular eminence, which can be felt as a sudden jump during the final phase of the mouth opening and leaves a depression behind the palpable condyle. The patient can return to a closed position.
- **Luxation (spontaneous dislocation or open block).** Anterior displacement of the condyle in front of the joint

eminence. The patient cannot close again by their own means.

- *Capsulitis/synovitis*. They are described together because they can only be distinguished by arthroscopy. Preauricular pain that increases during mandibular function and palpation on the lateral pole of the condyle.
- *Retrodiscitis*. Preauricular pain that exacerbates with mandibular movements, tooth clenching and/or palpation in the posterior area to the condyle. It can present itself as an ipsilateral posterior open bite.
- *Osteoarthritis (OA)*. Degenerative joint disorder characterized by a destructive process of the bony articular surfaces. Crepitus can be detected in any mandibular movement and it is often painful. The diagnosis was made based on clinical criteria. Primary and secondary OA and polyarthritis were considered in this same group.

## Statistical analysis

The data obtained were organized and the statistical analysis was performed with a 95% of confidence interval, using the SPSS program (IBM Statistics 21.0). P values < 0.05 were considered statistically significant. After the description, a chi-square test was used for the analysis of qualitative variables and a student t-test for quantitative variables to evaluate the association. For variables that showed a significant association, the odds ratio with its confidence interval was calculated.

## Results

From a total of 615 patients present in the database, 476 patients were included in this study, considering the exclusion criteria. The average age was 31.03 years old ( $\pm 15.8$  years). Most of patients were women and 44.5% of the joint diagnoses occurred in patients aged 16–25 years (Table 1). Twelve joint diagnoses were considered in this study. The most frequent diagnoses were retrodiscitis, OA and DDwR (Table 2). Adherence/adhesion (6 cases), ankylosis (4 cases) and luxation (15 cases) were not considered

in the statistical analysis because they presented with a prevalence of less than 5%. A total of 1096 joint diagnoses were presented in the 476 patients, which gives an average of 2.3 joint diagnoses for each patient.

After the statistical association between variables, the odds ratio was calculated for each statistically significant value ( $p < 0.05$ ). DDwR was associated with increased kinematic parameters (Fig. 1), while the DDwoR was associated with decreased kinematic values (Fig. 2). The significant kinematic values for the other TMJ diagnoses are shown in Table 3. Structural incompatibility was associated with older patients and subluxation with increased kinematic values, while retrodiscitis was associated with decreased kinematic values. The association of the variables with the joint diagnoses are showed schematically in Fig. 3.

## Discussion

The TMJs are composed of different structures, which can generate articular disorders. The measurement of kinematic values is one of the main tools to guide the diagnosis of TMD, which is influenced by the joints, the musculature and occlusal factors.<sup>12,14</sup> The aim of this study was to assess the relationship between mandibular kinematics and TMJD, providing a useful clinical tool for diagnosis. Most of patients were aged between 16 and 25 years old (44.5%), coinciding with the English literature, that reported a peak of signs and symptoms of TMD between 16 and 19 years of age.<sup>15</sup> Most of the individuals included were women, obtaining a female to male ratio of 4:1, similar to the 5:1 ratio reported previously.<sup>16</sup>

It is interesting to mention that each patient has an average of 2.3 joint diagnoses, which is explained because the two TMJs are independent, but interrelated in their functioning. For this reason, the same patient can present an articular diagnosis on one side and a different diagnosis on the other, which creates difficulties at the time of the analysis of the data. Furthermore, one joint can present more than one diagnosis, because some structural diagnoses can be accompanied by an inflammatory pathology.

The most frequent joint diagnoses in this study were retrodiscitis, OA and DDwR, which is similar to that reported in the literature.<sup>17,18</sup> On the other hand, the less frequent diagnoses were adherence/adhesion, ankylosis and luxation.

Adherence is practically impossible to detect clinically, because it is a momentary joint condition that usually occurs in the morning upon awakening or after an episode of overload in the TMJ, and then it disappears.<sup>7,19</sup> The evolution can lead to adhesion, and the diagnostic gold standard is the dynamic sequence of magnetic resonance imaging (MRI) or the arthroscopy. These methods were not obtained in all patients. Adhesion can generate ankylosis, which is characterized by the restriction of the mandibular movement ranges.<sup>1,8</sup> Only four people presented this diagnosis. Structural incompatibility is the alteration of the shape of the articular bone surfaces that generate a noise at opening and closing.<sup>13</sup> In this study, it was more frequent in people older than 25 years. This disorder is often painless,<sup>13</sup> which could explain the diagnosis at older ages.

**Table 1** Description of the number of patients with TMJD according to age and sex.

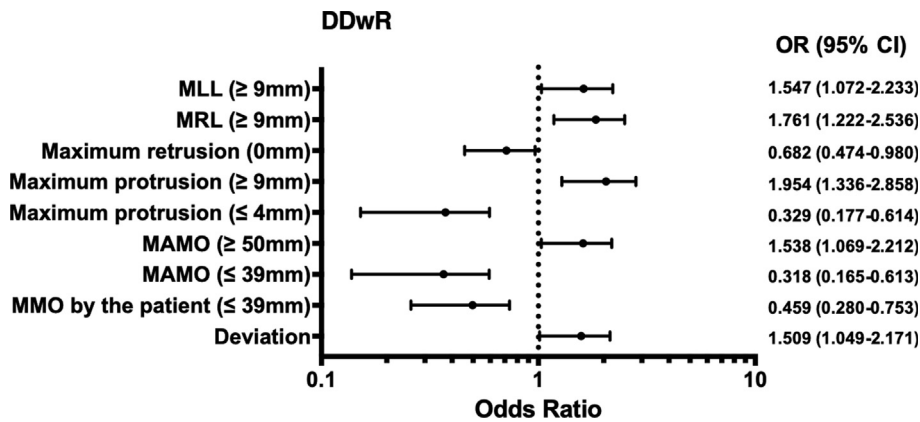
	With TMJD n (%)
<b>Age (years)</b>	
< 16	49 (10.3)
16 - 25	212 (44.5)
26 - 40	86 (18.1)
41 - 55	80 (16.8)
> 55	49 (10.3)
<b>Sex</b>	
Female	384 (80.7)
Male	92 (19.3)
<b>Total</b>	<b>476</b>

TMJD = temporomandibular joint disorders.  
n (%) = number of patients and percentage.

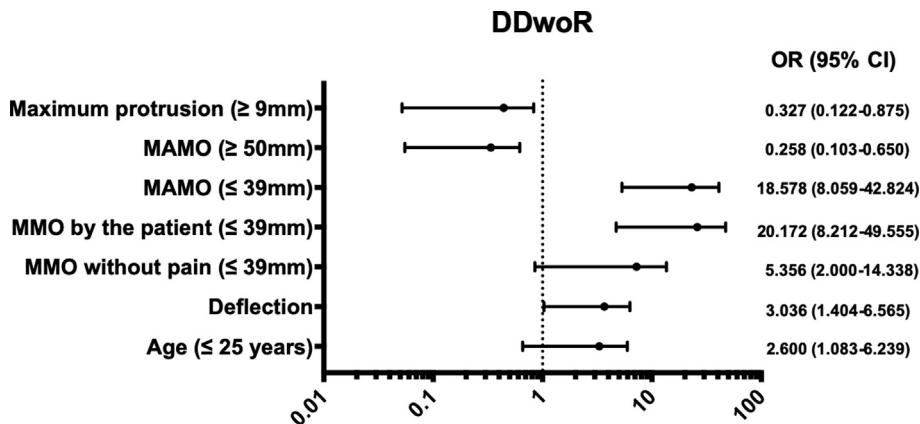
**Table 2** Description of the joint diagnosis in relation to age and sex.

	TMJ Diagnoses								
	DDwR	DDwoR	SI	Sublux	Cap/Syno	Retro	OA	Others	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
<b>Age (years)</b>									
< 16	29 (11.0)	3 (10.7)	2 (6.7)	11 (9.2)	3 (7.3)	33 (10.2)	29 (11.0)	5 (20.0)	115 (10.5)
16 - 25	123 (46.8)	18 (64.3)	9 (30.0)	63 (52.5)	15 (36.6)	157 (48.3)	123 (46.6)	8 (32.0)	516 (47.1)
26 - 40	52 (19.8)	3 (10.7)	6 (20.0)	20 (16.7)	9 (22.0)	58 (17.8)	49 (18.6)	5 (20.0)	202 (18.4)
41 - 55	39 (14.8)	3 (10.7)	8 (26.7)	21 (17.5)	6 (14.6)	44 (13.5)	36 (13.6)	6 (24.0)	163 (14.9)
> 55	20 (7.6)	1 (3.6)	5 (16.7)	5 (4.2)	8 (19.5)	33 (10.2)	27 (10.2)	1 (4.0)	100 (9.1)
<b>Sex</b>									
Female	219 (83.3)	23 (82.1)	22 (73.3)	97 (80.8)	36 (87.8)	268 (82.5)	224 (84.8)	21 (84.0)	910 (83.0)
Male	44 (16.7)	5 (17.9)	8 (26.7)	23 (19.2)	5 (12.2)	57 (17.5)	40 (15.2)	4 (16.0)	186 (17.0)
<b>TOTAL n (%)</b>	<b>263 (24.0)</b>	<b>28 (2.6)</b>	<b>30 (2.7)</b>	<b>120 (10.9)</b>	<b>41 (3.7)</b>	<b>325 (29.7)</b>	<b>264 (24.1)</b>	<b>25 (2.3)</b>	<b>1096</b>

DDwR = disc displacement with reduction; DDwoR = disc displacement without reduction; SI = structural incompatibility; Sublux = subluxation; Cap/Syno = capsulitis/synovitis; Retro = retrodiscitis; OA = osteoarthritis. A/A = adherence/adhesion; Ank = ankylosis; Lux = luxation. TOTAL n(%) = Percentage is in relation to the total of joint diagnoses.



**Figure 1** Odds ratio of the statistically significant associated kinematic values with displacement with reduction (DDwR). MMO = maximum mouth opening; MAMO = maximum assisted mouth opening; MRL = maximum right lateralization; MLL = maximum left lateralization.

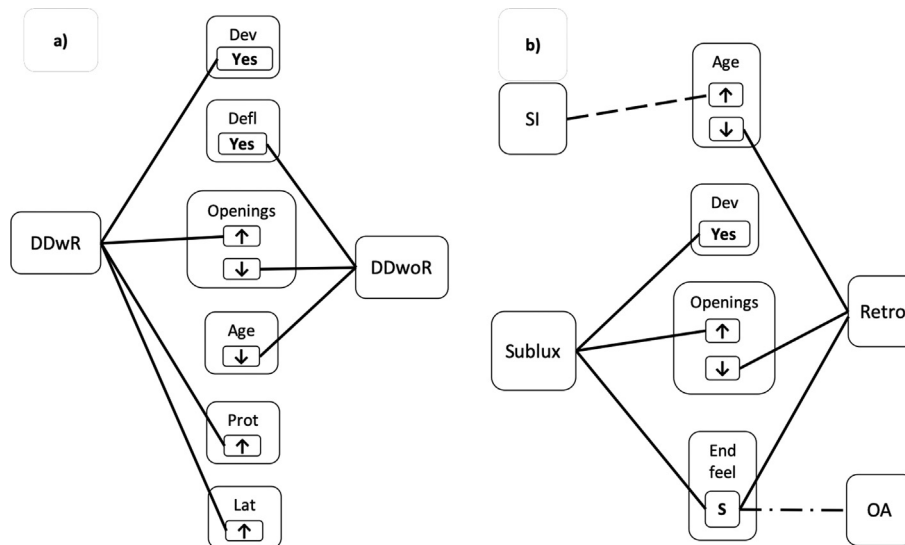


**Figure 2** Odds ratio of the statistically significant associated kinematic values with displacement without reduction (DDwoR). MMO = maximum mouth opening; MAMO = maximum assisted mouth opening.

**Table 3** Significant kinematic values in other TMJ diagnoses.

TMJ Diagnosis /Variable	n/N (%)	OR (95% CI)	
<b>Structural incompatibility</b>			
Age	> 25 years	19/215 (8.8%)	2.203 (1.024–4.738)
	≤ 25 years	11/261 (4.2%)	
<b>Subluxation</b>			
Deviation	With	77/257 (30.0%)	1.751 (1.142–2.684)
	Without	43/219 (19.6%)	
Maximum mouth opening by the patient			
	Level 1 (≤39 mm)	9/79 (11.4%)	0.331 (0.160–0.686)
	Levels 2–3 (>39 mm)	111/397 (28.0%)	
	Level 3 (≥50 mm)	59/174 (33.9%)	2.027 (1.330–3.089)
	Levels 1–2 (<50 mm)	61/302 (20.2%)	
Maximum assisted mouth opening			
	Level 1 (≤39 mm)	3/46 (6.5%)	0.187 (0.057–0.613)
	Levels 2–3 (>39 mm)	117/430 (27.2%)	
	Level 3 (≥50 mm)	75/236 (31.8%)	2.019 (1.320–3.086)
	Levels 1–2 (<50 mm)	45/240 (18.8%)	
End feel	Soft	111/368 (30.2%)	4.751 (2.318–9.739)
	Hard	9/108 (8.3%)	
Maximum protrusion			
	Level 1 (≤4 mm)	5/51 (9.8%)	0.293 (0.114–0.756)
	Levels 2–3 (>4 mm)	115/425 (27.1%)	
Maximum retrusion			
	Level 1 (0 mm)	46/223 (20.6%)	0.629 (0.412–0.959)
	Levels 2–3 (>0 mm)	74/253 (29.2%)	
<b>Capsulitis/Synovitis</b>			
Deflection	With	5/125 (4.0%)	0.365 (0.140–0.951)
	Without	36/351 (10.3%)	
Maximum mouth opening by the patient			
	Level 3 (≥50 mm)	9/174 (5.2%)	0.460 (0.214–0.988)
	Levels 1–2 (<50 mm)	32/302 (10.6%)	
Maximum right lateralization			
	Level 3 (≥9 mm)	14/247 (5.7%)	0.450 (0.229–0.881)
	Levels 1–2 (<9 mm)	27/229 (11.8%)	
Maximum left lateralization			
	Level 3 (≥9 mm)	15/276 (5.4%)	0.385 (0.198–0.747)
	Levels 1–2 (<9 mm)	26/200 (13.0%)	
<b>Retrodiscitis</b>			
Age	≤ 25 years	190/261 (72.8%)	1.586 (1.075–2.338)
	> 25 years	135/215 (62.8%)	
Maximum mouth opening without pain			
	Level 1 (≤39 mm)	169/230 (73.5%)	1.598 (1.081–2.364)
	Levels 2–3 (>39 mm)	156/246 (63.4%)	
	Level 3 (≥50 mm)	35/63 (55.6%)	0.530 (0.309–0.910)
	Levels 1–2 (<50 mm)	290/413 (70.2%)	
Maximum mouth opening by the patient			
	Level 3 (≥50 mm)	109/174 (62.6%)	0.668 (0.449–0.992)
	Levels 1–2 (<50 mm)	216/302 (71.5%)	
End feel	Soft	265/368 (72.0%)	2.058 (1.322–3.204)
	Hard	60/108 (55.6%)	
<b>Osteoarthritis</b>			
End feel	Soft	216/368 (58.7%)	1.776 (1.153–2.738)
	Hard	48/108 (44.4%)	

n/N (%) = number of patients with the variable and joint diagnosis/total number of patients with the variable (percentage).

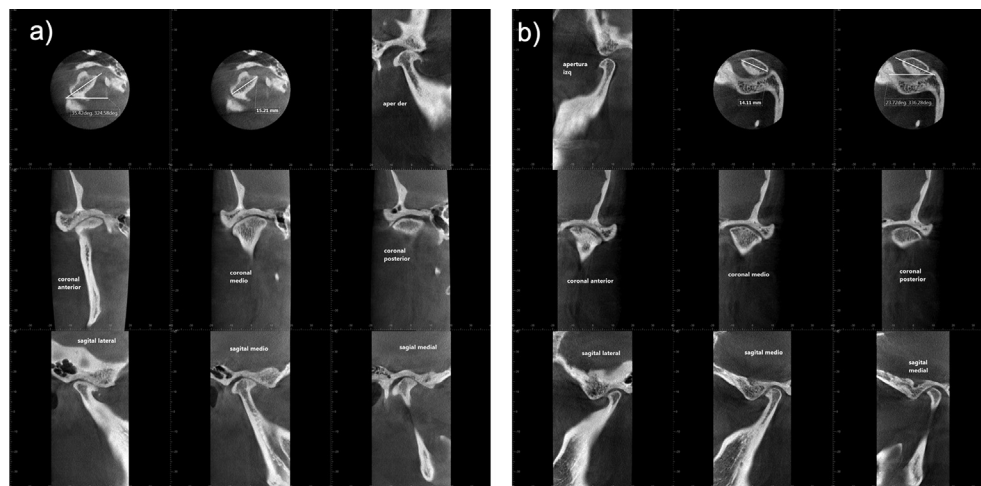


**Figure 3** Relationship of different joint diagnoses and variables obtained from the results presented in Figs. 1 and 2 and Table 3 A) association between disc displacements and variables. B) association between the other joint diagnoses and variables. **DDwR** = disc displacement with reduction; **DDwoR** = disc displacement without reduction; **SI** = structural incompatibility; **Sublux** = subluxation; **Retro** = retrodiscitis; **OA** = osteoarthritis; **Dev** = mandibular deviation; **Defl** = mandibular deflection; **Prot** = protrusion; **Lat** = lateralization; **S** = soft; ↑ = increased; ↓ = decreased.

Dislocation is a term used to describe the displacement of the mandibular condyle outside the joint. It can be partial (subluxation) or total (luxation) and occur due to an imbalance of neuromuscular function or a structural deficit.<sup>20</sup> Fifteen patients reported luxation. This condition is painful and requires immediate treatment, and most of the patients are treated in emergency medical services.<sup>10</sup> This may explain the low number of cases found in the sample. Subluxation has been associated with a greater laxity of the articular disc and the capsular ligament,<sup>20</sup> and the condyle can return by their own means to the glenoid cavity, presenting an increase in the mandibular kinematic ranges. Maximum mouth opening by the patient at level 3

(≥50 mm), maximum assisted mouth opening at level 3 (≥50 mm) and soft end feel were associated with this diagnosis. Deviation was also associated, when the condyle exceeds the articular eminence at the end of the movement.

DDwR has been described as the most frequent internal derangement of the TMJ,<sup>21</sup> however, in this study it was the third most frequent diagnosis, after retrodiscitis and OA, probably associated with the diagnostic criteria, because patients with joint noises and radiographic signs of bone degeneration were cataloged as OA. Ligaments are formed mainly by collagen and do not have elastic behavior, so if they are subjected to high forces they will deform. Once



**Figure 4** A representative radiographic image of osteoarthritis of one of the patients of this study. A) Right TMJ; b) Left TMJ. In both TMJs, a decreased joint space is observed. An altered condylar morphology with osteophyte formation. Sclerosis of cortical bone and with erosions. Right TMJ also has a flattened articular eminence. Decreased condylar mobility in both TMJs.

the ligaments have elongated, their biomechanical function is no longer the same, being able to generate a disc displacement, which in turn can trigger a degenerative joint process.<sup>22</sup> Range of movement depends on the length of the ligaments.<sup>23</sup> In this study, maximum assisted mouth opening at level 3 ( $\geq 50$  mm), protrusion at level 3 ( $\geq 9$  mm), right and left lateralization at level 3 ( $\geq 9$  mm) and deviation were associated with the diagnosis of DDwR. Deviation is related to this disorder because the condyle cannot be moved due to the disc, but once it is recaptured the midline is corrected.<sup>24</sup>

The prevalence of DDwoR reported in the literature has a range between 11.6% and 26.1%.<sup>25–27</sup> The frequency found in the sample was 28 patients (5.9%), which can be considered low and can be explained by two factors: first, people with long-standing DDwoR can present normal kinematic ranges;<sup>28</sup> second, patients with long-standing DDwoR can generate a degenerative process such as secondary OA to DDwoR,<sup>29</sup> and in the present study, these patients were classified as OA. The definitive diagnosis of DDwoR needs an MRI, however, not all patients were diagnosed with an MRI. Decreased mandibular movement ranges have been reported within the clinical features of the DDwoR.<sup>28</sup> The authors found a strong association with decreased kinematic values such as maximum mouth opening without pain at level 1 ( $\leq 39$  mm), maximum mouth opening by the patient at level 1 ( $\leq 39$  mm), maximum assisted mouth opening at level 1 ( $\leq 39$  mm). In this study, young patients ( $\leq 25$  years old) were more likely to present a DDwoR, coinciding with some studies,<sup>29</sup> although other authors have reported that it is more frequent in people between 20 and 40 years old.<sup>30</sup> Deflection is also related to DDwoR, by the impediment of translation of the condyle of the affected joint.

The degenerative diseases of the TMJ are osteoarthritis and osteoarthrosis. Osteoarthritis is characterized by degenerative changes in the joint and when these changes are accompanied by arthralgia is called osteoarthrosis (OA).<sup>29</sup> Some authors have considered the terms osteoarthrosis and OA as synonyms,<sup>31</sup> referring to both conditions as OA with periods of remission and/or exacerbation of pain. This condition has been related to advanced age, nevertheless, studies have reported an increase in children and adolescents.<sup>29,32</sup> Disc displacements have been described as etiological factors of OA, even a study suggested that joints with anterior DDwR and DDwoR have 2.73 times and 8.25 times more probability of generating a degenerative process, respectively.<sup>33</sup> Considering that disc displacements are the most frequent pathology in the TMJ,<sup>21</sup> it is not unusual that the degenerative processes are increasingly frequent in children and adolescents, especially if they are not opportunely treated. The progression of the OA generates progressive destruction of the joint structures, generating a dysfunction of the joint. Radiographically, it can be observed as an erosion, subcondral cyst, sclerosis or osteophyte of the condyle (Fig. 4).<sup>34</sup> It is controversial how mandibular kinematics affects the OA, but it has been reported that it produces a decreased range of mandibular movements,<sup>35</sup> due to the pain caused by the activity of the affected joint.<sup>36</sup> However, OA in some patients could be an asymptomatic degenerative process.<sup>37</sup> In this study, only the soft end feel was an important variable

for the diagnosis of this condition. As previously mentioned, the kinematics of OA may vary depending on the level of pain and the degree of bone degeneration. All this leads to a diverse clinical presentation of OA.<sup>38</sup>

Inflammatory disorders of the joint are capsulitis, synovitis and retrodiscitis, caused mainly by trauma. Only 41 patients presented capsulitis/synovitis. In the present study no variable was associated with these disorders, but maximum mouth opening by the patient level 3 ( $\geq 50$  mm), maximum right and left lateralization ( $\geq 9$  mm) and deflection were less associated with these diagnoses. The fact of having a painful joint will cause decreased border movements. In most cases, joint pain was associated with other diagnoses, being considered in those groups. As mentioned earlier, retrodiscitis was the most frequent diagnosis and was associated with decreased kinematic values. Maximum mouth opening without pain at level 1 ( $\leq 39$  mm) was associated with retrodiscitis. The retro-discal tissue is characterized for being a highly innervated tissue, with a greater sensibility on palpation of this area. In 2014, the DC/TMD protocol defined a standard for the palpation of the retro-discal area.<sup>39</sup> The patients were evaluated from 2004 to 2017, and possibly, this is the reason why retrodiscitis is the most frequent diagnosis.

In conclusion, mandibular kinematic values are associated with specific articular diagnoses. DDwR and subluxation are associated with increased kinematic values, whereas DDwoR and retrodiscitis are associated with decreased kinematic values. Structural incompatibility is related to older patients. Soft end feel is related to OA, while the kinematics would be affected by the presence of pain. Finally, the authors can conclude that the study of kinematic values is a useful clinical tool to perform the diagnosis of TMJD.

## Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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