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UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"
Instituto de Ciência e Tecnologia
Campus de São José dos Campos

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Analysis of condylar positioning in the temporomandibular joint cavity using interocclusal devices in patients with temporomandibular dysfunction – a case-control clinical study

Análise do posicionamento condilar na cavidade da articulação temporomandibular com o uso de dispositivos interoclusais em pacientes com disfunção temporomandibular – estudo clínico tipo caso-controle

Antonio Adamastor CORRÊA JÚNIOR[1], **Ariel de Vasconcelos BARBOSA**[2], **João Felipe Barboza de OLIVEIRA**[2], **Lídia Maria Pinto de OLIVEIRA**[2], **Paulo Goberlânio de Barros SILVA**[1], **Regina Glaucia Lucena Aguiar FERREIRA**[2], **Lívia Maria Sales Pinto FIAMENGUI**[1], **Karina Matthes de Freitas PONTES**[1]

1 - Universidade Federal do Ceará, Programa de Pós-graduação em Odontologia. Fortaleza, CE, Brazil.
2 - Universidade Federal do Ceará, Faculdade de Farmácia, Odontologia e Enfermagem, Fortaleza, CE, Brazil.

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ABSTRACT

Objective: This cross-sectional, case-control clinical study evaluated the condylar position in sagittal tomographic images of temporomandibular joints (TMJs) among symptomatic and asymptomatic patients with temporomandibular disorders (TMD) during maximum habitual intercuspation (MHI) and while using inclined interocclusal devices with anterior guidance (IID) or horizontal interocclusal devices (HID). **Material and Methods:** The sample included 60 symptomatic patients and 10 asymptomatic controls diagnosed with muscular-type TMD using the RDC/TMD criteria. All participants were dentate, with occlusal stability, and adequate vertical dimension. Impressions and casts were mounted on semi-adjustable articulators, and IID and HID were fabricated using self-polymerizing acrylic resin and aluminum. Cone beam tomography was used to assess TMJ images during MHI with each device, measuring anterior (A), superior (C), and posterior (P) spaces (mm) between the condyle and temporal bone. The data were analyzed using Student's t-test for intergroup comparisons, ANOVA with Bonferroni correction, and Pearson's correlation for intragroup analysis. **Results:** Fifty-two symptomatic patients completed the study. No statistically significant differences were found between TMD patients and controls regarding the condylar position in different occlusal situations. Within the TMD group, the condyles were positioned more posteriorly in both MHI and IID, while they were more centralized with HID. The anterior space showed similar changes across MHI, IID, and HID, and the superior space varied proportionally with the posterior space in the three occlusal conditions. Control patients exhibited smaller and more consistent A and P measures than C, indicating centralized condyles. Positive correlations were observed between the different space measurements and occlusal positions. **Conclusion:** Condylar position did not predict the presence of TMD. Symptomatic TMD patients tended to have posteriorly positioned condyles in MHI and IID, while HID centralized them. Asymptomatic patients exhibited centralized condyles.

KEYWORDS

Mandibular condyle; Masticatory muscles; Occlusal splints; Temporomandibular joint disorders; Tomography.

RESUMO

Objetivo: O objetivo do estudo foi avaliar a posição condilar em imagens tomográficas de corte sagital das articulações temporomandibulares (ATMs) entre pacientes sintomáticos e assintomáticos com disfunção temporomandibular (DTM), em máxima intercuspidação habitual (MHI) e utilizando dispositivos interoclusais inclinados com abertura anterior (IID) ou dispositivos horizontais (HID). **Material e Métodos:** Amostra incluindo 60 pacientes sintomáticos e 10 assintomáticos (controle) para DTM muscular, diagnosticados pelo RDC/TMD (todos dentados, com estabilidade oclusal e dimensão vertical adequada). As moldagens, montagem dos modelos foram realizadas em articuladores semi-ajustáveis, os IID e HID foram fabricados em resina acrílica autopolimerizável e alumínio. A tomografia de feixe cônico avaliou as imagens durante MHI com cada dispositivo, avaliando os espaços anterior (A), superior (C) e posterior (P) (mm) entre o côndilo e o osso temporal. Os dados foram submetidos ao teste T-Student (intergrupo), testes ANOVA/Bonferroni e correlação de Pearson (intragrupo). **Resultados:** Cinquenta e dois pacientes permaneceram no estudo. Não houve diferenças significativas entre pacientes com DTM e controle quanto à posição condilar em diferentes oclusões. No grupo DTM, os côndilos eram mais posteriores no MHI e no IID, enquanto no HID eram centralizados; a medida anterior mudou proporcionalmente em MHI, IID e HID; e o espaço superior mudou proporcionalmente ao posterior nas três situações oclusais. Os pacientes do grupo controle exibiram medidas A e P semelhantes e menores que C, indicando côndilos centralizados. Observou-se correlações positivas entre cada medida e diferentes oclusões separadamente. **Conclusão:** A posição condilar não determinou a presença de DTM. Pacientes com DTM sintomática apresentavam côndilos posteriores em MHI e IID, enquanto o HID os centralizava; pacientes assintomáticos tinham côndilos centralizados.

PALAVRAS-CHAVE

Côndilo mandibular; Músculos mastigatórios; Placas oclusais; Distúrbios da articulação temporomandibular; Tomografia.

INTRODUCTION

Despite advances in the science of biomechanics and the neuromuscular physiology of the temporomandibular joint (TMJ), as well as in the understanding of musculoskeletal disorders related to this joint and the mechanisms of pain involved, clinicians continue to face difficulties in identifying the etiology of temporomandibular dysfunction (TMD) and directing treatment toward its underlying cause [1]. These difficulties arise from the multifactorial nature of TMD, with biological, environmental, social, emotional, and cognitive factors—acting alone or in combination—contributing to the onset or persistence of characteristic signs and symptoms [2,3].

A study conducted in Brazil reported a TMD prevalence of approximately 36% of the population, with 5% experiencing severe limitations due to pain, based on the Research Diagnostic Criteria for Temporomandibular Disorders – RDC/TMD [4]. However, other studies report varying prevalence rates [5-10]. These differences may result from methodological variations, especially in sample selection and the lack of standardized diagnostic criteria for TMD [11,12]. It is noteworthy that only 5% of symptomatic patients require non-conservative intervention for treatment [13-15].

Discrepancies have long existed in the literature regarding the ideal position of the condyle and its possible relationship with TMD and TMJ structural alterations, without reaching a consensus on the ideal position [16-22]. Some authors have historically associated non-concentric condyle-fossa relationships with abnormal TMJ function [23], while others have linked bilateral condylar symmetry to the absence of clinical symptoms in adults [24]. Additionally, some researchers have identified mandibular asymmetry as a risk factor for disc displacement [25]. Recent studies show that the non-centralization of the condyle in the joint cavity alone is not sufficient for diagnosing TMD [26-28], noting that a concentric condyle is present in only about 2% of individuals [21]. Furthermore, other studies suggest that slightly anteriorly positioned condyles may be less prone to disc displacement [29,30].

Centric relation (CR), often used as a reference for condylar position, is not always considered a physiological position [27,31]. Discrepancies between centric relation (CR) and maximum habitual intercuspation (MHI), and their therapeutic implications, have been widely debated throughout the history of dentistry [16,18,32,33], generating disagreements regarding their clinical use. Historically, centric relation was defined as the most retruded (superior and posterior) position of the condyle. However, it is now considered the most anterior and superior position of the condyle relative to the posterior surface of the temporal bone [34-36]. A posteriorly positioned condyle in the mandibular fossa may compress the posterior end of the disc, leading to morphological changes, inflammation, pain (local or referred), and disc displacement [21,37].

The literature also highlights the influence of malocclusion patterns on the position of the condyle in the joint cavity, further complicating discussions on this topic [38]. Studies have shown that patients with Angle Class I and II malocclusion patterns tend to exhibit anterior condylar positioning [21,39]. In contrast, patients with a skeletal pattern of vertical growth and deep overbite are more likely to have posteriorly positioned condyles [40].

Accurate assessment of a patient's condylar position requires the appropriate selection of imaging modalities. The correlation of TMJ imaging findings with clinical data has improved the understanding of the pathophysiology of TMJ disorders [41]. Panoramic and transcranial radiographs, as well as computed tomography—including conventional CT and cone beam computed tomography (CBCT)—and magnetic resonance imaging (MRI), allow visualization of specific TMJ structures, with the latter two being the most accurate for this purpose [28,31,42,43]. CBCT, using a relatively small and cost-effective scanner, provides three-dimensional images of mineralized maxillofacial tissues with minimal distortion and significantly reduced radiation doses compared to conventional tomography [28,44,45].

As mentioned earlier, regardless of the diagnosis, the most effective therapeutic approaches for TMD are conservative and reversible. Physical therapy, medication, stabilizing occlusal splints, psychological treatment, and, in more complex cases, corrective surgeries are among the most common therapeutic interventions for TMD patients [35,46,47]. One of the key advantages of splint therapy is its reversible and non-invasive application. However, the mechanism underlying its therapeutic effect remains unclear, with clinical success attributed to various factors, ranging from a possible placebo effect to a new positioning of the disc-condyle complex, which reduces pressure between its structures [30,48-51].

According to Okeson [43], splints temporarily provide an occlusal condition that allows the TMJ to remain in an orthopedically stable position, potentially alleviating TMJ signs and symptoms. Supporting this, studies [52-54] highlight that occlusal splints promote a more stable and functional condylar position, normalize muscular activity, reduce pain in the masticatory muscles, and help the mandible assume a more adequate position, thereby reducing TMD signs and symptoms. Another study demonstrated that the effectiveness of these devices is independent of their design [55]. There are relatively few studies examining the effects of occlusal splints or devices on the condylar position within the joint cavity, which could help explain their therapeutic effect. Linsen et al. [54] found that pivot splints associated with chin cups shifted the condyle to a more anterior and inferior position in asymptomatic patients. Similarly, Liu et al. [49] found the same effect with stabilizing occlusal splints in patients with anterior disc displacement with reduction.

Thus, the aim of this study was to analyze, through sagittal plane tomographic images, the positions assumed by the condyle in the joint cavity in symptomatic and asymptomatic TMD patients, comparing MHI with the use of inclined interocclusal devices (IID) with anterior guidance and horizontal interocclusal devices (HID). The working hypothesis is that condylar position may differ between symptomatic and asymptomatic TMD patients and that interocclusal devices could alter these positions.

MATERIAL & METHODS

Study type and general design

This prospective, cross-sectional, case-control clinical study involved 10 asymptomatic patients (Group 1) and 60 symptomatic patients (Group 2) with muscular TMD. Tomographic images of the right and left TMJ were analyzed for each patient in three different occlusal positions: maximum habitual intercuspation (MHI), using a horizontal interocclusal device (HID), and using an inclined interocclusal device (IID) with anterior guidance.

This study was approved by the Research Ethics Committee of the Universidade Federal do Ceará, Brazil, under protocol number 492.384 (CAAE 04706412.3.0000.5054).

Study participants

Participants were diagnosed and assigned to groups through a clinical examination based on the RDC-TMD criteria for muscular TMD diagnosis [4]. This examination was performed by a researcher identified as "Researcher 1," who has extensive experience and expertise in TMD and is proficient and calibrated in the use of RDC-TMD for musculoskeletal diagnoses, thus ensuring reliable group allocation.

As inclusion criteria, participants in both groups were required to have teeth in both arches, with occlusal stability and an adequate vertical dimension of occlusion. Symptomatic patients had to be aware of their dysfunction. Individuals of both sexes, aged between 25 and 70 years, were included in both groups.

Patients were excluded if they met at least one of the following conditions: neurological or disabling diseases; arthritis, arthrosis, or other joint diseases; absence of anterior teeth in one or both arches; unilateral or bilateral free ends (from the first molar); use of interocclusal devices or occlusal plates within the past three months; ongoing orthodontic treatment; or pregnancy.

Patients from both groups whose tomographic images did not allow for the necessary measurements or who did not attend the tomographic examination were excluded from the study.

Research location

The research was conducted at the prosthetics clinic of the Dentistry Department at the Faculty of Pharmacy, Dentistry, and Nursing (FFOE) of the Federal University of Ceará (UFC) and at a private radiology clinic in Fortaleza, Ceará, Brazil.

Intervention

Patients from both groups underwent the same procedures (Figure 1), performed by "Researcher 2," who was unaware of each patient's group assignment. "Researcher 2" is an assistant professor at the School of Dentistry at the Federal University of Ceará, holding both a Master's degree and a PhD. His expertise lies in occlusion within prosthodontics, and he has extensive experience in implantology, particularly with tomographic imaging techniques.

Fabrication of Interocclusal Devices (Horizontal and Inclined)

Impressions of both dental arches were obtained with alginate (Hydrogum 5, Zhermack, Badia Polesine, Italy). The casts, made of Type III plaster (Asfer, Indústria Química Ltda., São Caetano do Sul, Brazil), were mounted on a semi-adjustable articulator using a facebow (JP 30, Gnatus, Ribeirão Preto, Brazil). Interocclusal records were taken, ensuring a 2 mm space between the upper and lower first molars, using an intermaxillary registration palette (ProBite, São Paulo, Brazil) and three sheets of wax. A 2 mm leaf gauge was placed in the molar region, and the patient was instructed to occlude. Subsequently, a second leaf gauge was placed in the central incisor region to measure and stabilize the interincisal space. The first leaf gauge was removed and replaced with base plate wax while maintaining the anterior gauge to ensure 2 mm disocclusion in the molar region.

Interocclusal devices were fabricated on the upper casts using a vacuum thermoforming system (Plastvac P7, Bio-art, São Carlos, Brazil) with a 1.0 mm thick clear acrylic plate (PET-G, Bio-Art), covering the anterior teeth from canine to canine (elements 13 to 23). A rectangular aluminum plate (1.2 mm thick, 10 mm wide, and 20 mm long) was attached to the palatal surface of the interocclusal device using self-polymerizing acrylic resin (Clássico, São Paulo, Brazil). The inclination of the aluminum plate varied depending on the type of device: either perpendicular to the incisal surface of the lower central incisors (horizontal device) or at a 45-degree angle to the incisal surface of the lower central incisors (inclined device with anterior guidance). The lower central incisors were the only teeth in contact with the aluminum plate of the interocclusal device.

The same spacer used during the initial interocclusal record was reused to adjust the devices directly in the oral cavity, ensuring consistent posterior interocclusal spacing for all patients.

Tomography

After fabricating the interocclusal devices, each patient was referred to the radiology clinic to undergo tomographic examination of the following regions: right and left TMJs in MHI; right and left TMJs with the HID; and right and left TMJs with the IID.

A radiology technician, identified as "Researcher 3", performed the tomographic examinations. Researcher 3 was properly trained and blinded to the patients' group assignments to maintain objectivity. During the imaging process, standardized mandibular immobilization

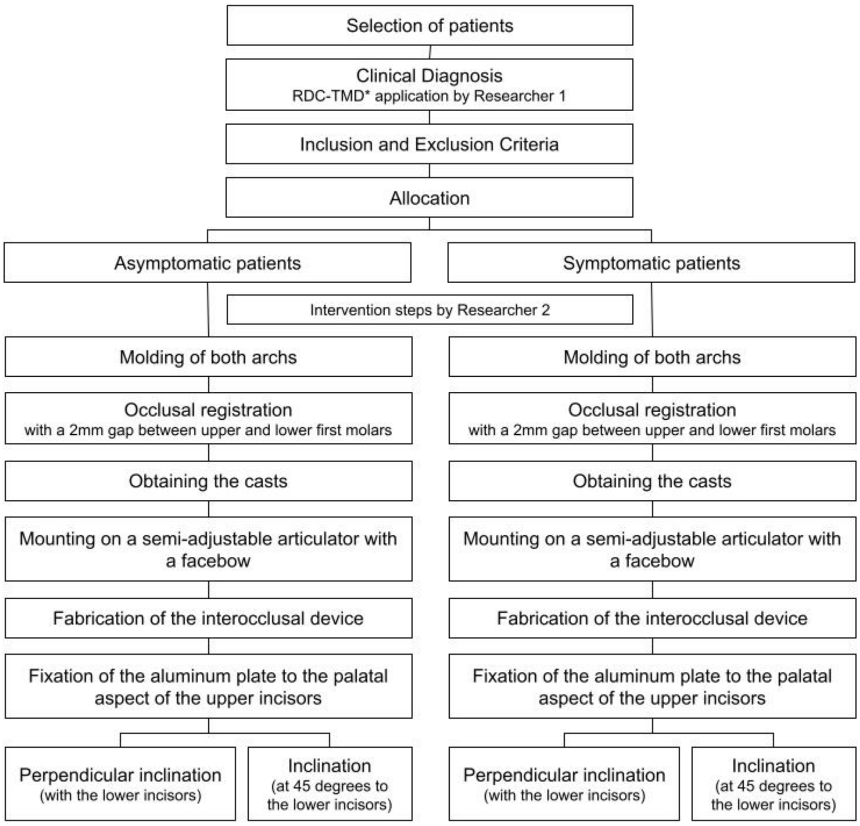

Figure 1 - Intervention - Steps for Patient Observation.

procedures were used to ensure image accuracy. These included head and chin immobilizers integrated with the tomograph, along with instructions for patients to refrain from moving, speaking, or swallowing during the examination. The imaging system used was a Kavo 3D I-CAT tomograph (Cone Beam Volumetric Tomography and Panoramic Dental Imaging System, Imaging Sciences International, Hatfield, USA). The protocol used was 120 kV, 36.9 mA, with a field of view of 13 x 23 cm and a voxel size of 0.4 mm [21]. Images were analyzed using the Woopir Tomo program (Imaging Sciences International), and condylar positioning measurements were performed (Figures 2 and 3). The most central slices were selected for analysis, where the petrotympanic fissure of the temporal bone was visible, serving as a reference point for defining the inferior and posterior boundaries of the articular cavity.

The condylar position was determined by measuring, in millimeters, the anterior (A), superior (C), and posterior (P) spaces between the condyle and the temporal bone from sagittal plane images that met pre-established criteria for the right and left TMJs of each individual, as illustrated in Figure 3 [33]. A line was drawn connecting the most posterior and inferior parts of the articular cavity, tangent to the petrotympanic fissure, to the most anterior and inferior part of the articular eminence (Line 1). The segment of this line passing through the condyle was measured and divided in half to determine the central point of the condyle (Point X). A second line (Line 2), parallel to Line 1, was drawn tangent to the most superior part of the articular cavity. A third line (Line 3), perpendicular to both Lines 1 and 2, was drawn from Point X. The space between the superior end of the condyle and the most superior part of the articular cavity along this line determined the C measurement (superior space). Next, bisectors were drawn for the angles formed between Lines 1 and 3. The spaces corresponding to these bisectors, connecting the end of the condyle to the temporal bone, determined the A (anterior) and P (posterior) measurements. This methodology ensured that the measurements were consistently reproduced across different images at the same anatomical locations.

Outcome

This study determined the condylar position in the sagittal plane by measuring the anterior

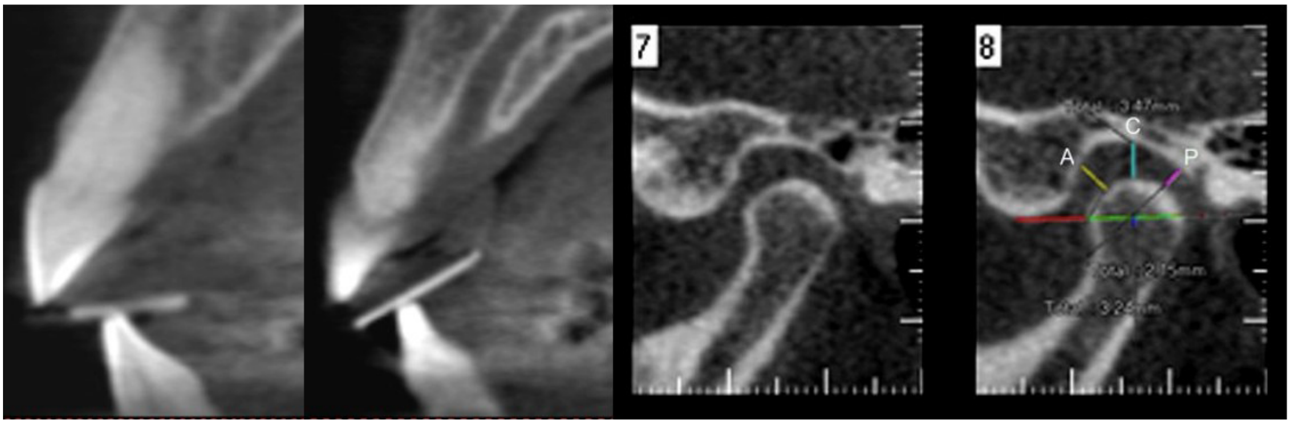

Figure 2 - Representative image of a patient using the two different interocclusal devices, horizontal and inclined; Ilustrative TMJ image with the tracings for measurements A, C, and P.

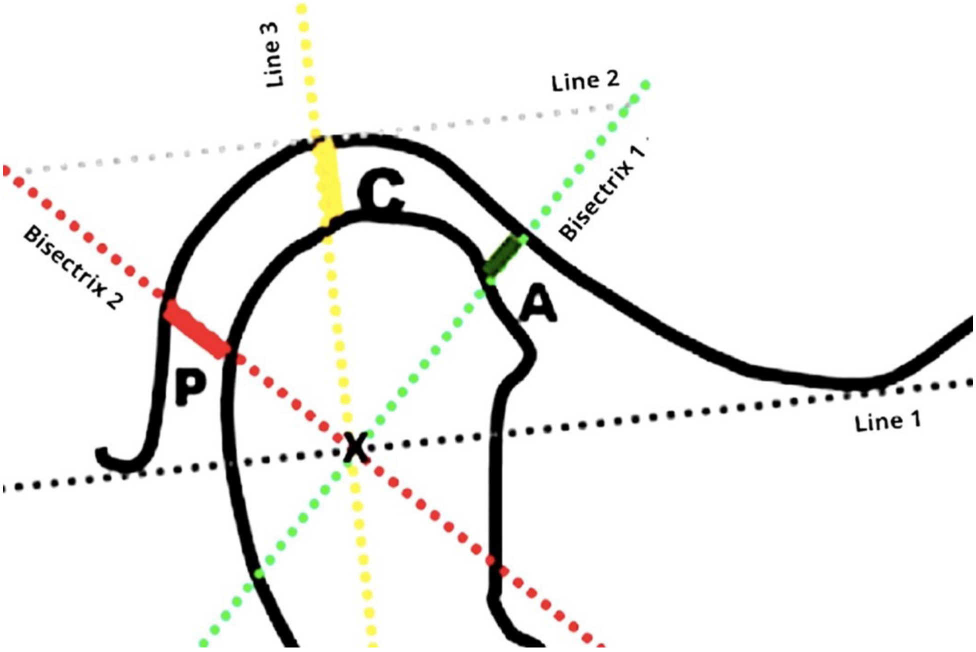

Figure 3 - Schematic drawing of the tracings made on the TMJ images to provide the measurements.

(A), superior (C), and posterior (P) spaces between the condyle and temporal bone in tomographic images of the right and left TMJs, comparing individuals symptomatic for muscular temporomandibular disorders with asymptomatic individuals.

Sample size calculation

The sample size estimation was initially based on previous studies. Henriques et al. [32] analyzed condylar position in the sagittal and frontal planes using tomographic images of TMJs from 20 patients, divided into four different occlusal patterns (five patients per group), comparing MHI and centric relation using the Student's t-test (α = 0.05). Similarly, Merigue et al. [21] included 49 patients divided into two groups with different occlusal patterns, using the same outcome measure and statistical test. The power of the test was 80%, with alpha = 0.05.

Based on these findings, our study included 70 patients, comprising 10 asymptomatic controls and 60 symptomatic patients with TMD, to analyze the same outcome, providing a safety margin to ensure good statistical power in the obtained data.

Statistical analysis

The A, C, and P measurements were subjected to the Kolmogorov-Smirnov normality test and expressed as mean and standard deviation (parametric data). Comparisons between the control and TMD groups were performed using the Student's t-test, while intragroup comparisons—evaluating variations in condylar position from MHI to the devices—were conducted using repeated measures ANOVA, followed by Bonferroni post-hoc tests and Pearson's linear correlation. All analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 17.0 for Windows, with a 95% confidence level ($\alpha = 0.05$).

RESULTS

Of the 70 patients selected, 10 were asymptomatic (Control group) and 60 were symptomatic (TMD group) (Figure 4).

Of the 60 patients in the symptomatic group, 52 remained in the study, as 8 were excluded due to unsuitable images for standardized measurements according to the methodology proposed in this study. In the asymptomatic control group, all 10 patients completed the study. The TMD group consisted of 35 females and 17 males, while the control group had 7 females and 3 males.

The intergroup analysis, shown in Table I, revealed no significant differences in condylar position between symptomatic and asymptomatic patients in any occlusal condition—MHI, HID, or IID—either on the right (R) or left (L) side ($p > 0.05$).

In Table II, which presents the intragroup analysis, the different A, C, and P spaces of each group were compared separately. It was observed that in the asymptomatic patients (control group), the condyles were centralized within the articular cavity, with equal anterior (segment A) and posterior (segment P) measurements, regardless of the occlusal position. On the other hand, in symptomatic patients (TMD), the condyles assumed a more posterior position in the MHI situation and when using the inclined interocclusal device (IID), positioning centrally when using the horizontal interocclusal device (HID) ($p < 0.001$).

Based on the analysis of the existing correlations between the changes in condylar positions in the Control and TMD groups in the three different situations proposed in this study (Table III), the control group presented fewer correlations than the TMD group (noting that bold numbers with a positive r-value indicate a significant directly proportional correlation, while bold numbers with a negative r-value indicate a significant inversely proportional correlation).

In asymptomatic patients (control), in MHI, the anterior position of the condyle changed in direct proportion when using both types of interocclusal devices. The condyle height (average distance) also changed proportionally from the MHI position to either the HID or IID

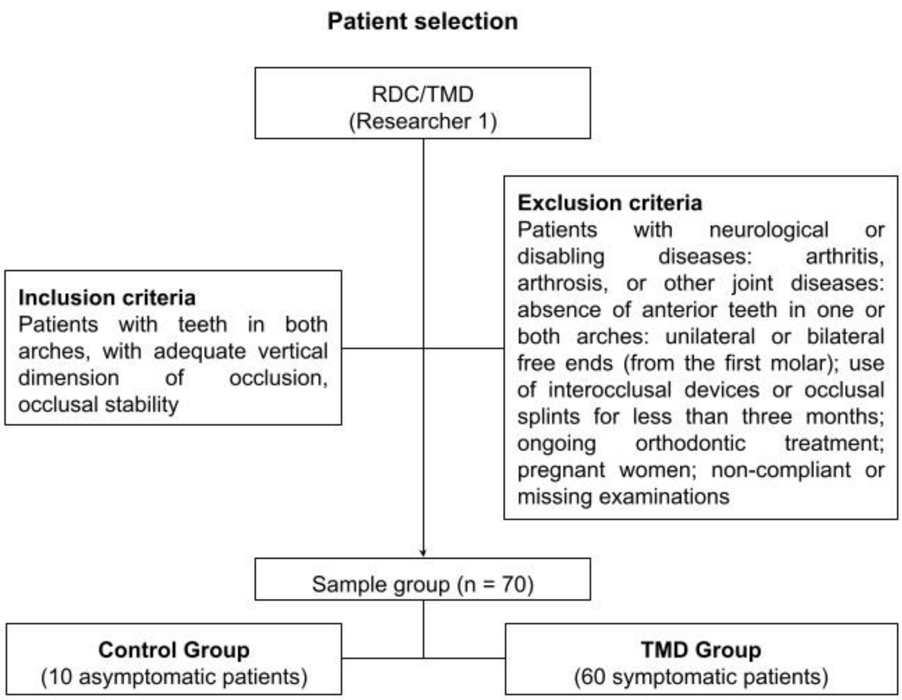

Figure 4 - Patient Selection Identifying Ideal Candidates.

Table I - Comparison of A, C, P (mm) spaces of the right (R), left (L), and both TMJs between Control and TMD groups in three different occlusal positions

	Control	TMD	p-value
		MHI	
MHI Anterior R	239 ± 72	258 ± 105	0.587
MHI Superior R	321 ± 84	305 ± 98	0.633
MHI Posterior R	193 ± 50	198 ± 86	0.853
MHI Anterior L	237 ± 43	241 ± 102	0.834
MHI Superior L	334 ± 96	300 ± 103	0.332
MHI Posterior L	263 ± 113	197 ± 94	0.054
MHI Anterior both	238 ± 53	250 ± 94	0.598
MHI Superior both	328 ± 81	303 ± 92	0.427
MHI Posterior both	228 ± 73	198 ± 81	0.278
		IID	
IID Anterior R	211 ± 68	242 ± 103	0.360
IID Superior R	292 ± 64	285 ± 96	0.834
IID Posterior R	177 ± 70	172 ± 70	0.826
IID Anterior L	232 ± 49	233 ± 96	0.963
IID Superior L	303 ± 98	273 ± 100	0.387
IID Posterior L	238 ± 123	163 ± 80	0.088
IID Anterior both	222 ± 53	238 ± 90	0.586
IID Superior both	297 ± 71	279 ± 88	0.538
IID Posterior both	208 ± 86	168 ± 67	0.100
		HID	
HID Anterior R	194 ± 48	238 ± 93	0.144
HID Superior R	308 ± 79	313 ± 112	0.901
HID Posterior R	205 ± 95	212 ± 118	0.859
HID Anterior L	216 ± 53	235 ± 94	0.550
HID Superior L	327 ± 126	304 ± 111	0.553
HID Posterior L	256 ± 96	204 ± 101	0.140
HID Anterior both	205 ± 47	237 ± 84	0.254
HID Superior both	318 ±94	309 ± 105	0.796
HID Posterior both	231 ± 91	208 ± 102	0.520
	Student's T test (average ± DP)		

position, with the same pattern observed for the posterior distance of the condyle. In symptomatic patients (TMD), the anterior distance of the condyle (segment A) changed in the same proportion, regardless of whether the patient was in MHI, using HID, or IID. The condyle height (superior distance or segment C) in MHI changed in the same proportion as the posterior distance in MHI, and this directly proportional relationship also occurred when patients used both types of interocclusal devices (HID or IID). The posterior distance of the condyle in MHI changed proportionally to the superior and posterior distances when patients used either the inclined or horizontal interocclusal devices. In summary, the condylar position of patients with TMD, in terms of superior and posterior distances within the articular cavity, is mutually influenced, both in MHI and when using either device (HID or IID).

DISCUSSION

A significant portion of studies investigating condylar position using TMJ imaging reported predominantly female samples [25,29,41,50,56,57],

Table II - Comparison of different occlusal positions regarding condylar position (mm) within each group (intragroup analysis)

Oclusal Position	Condilar Position			p-Valor
	Posterior	Anterior	Superior	
Control				
MHI	228 ± 73 =	238 ± 53 <	328 ± 81	0.013
IID	208 ± 86 =	222 ± 53 <	297 ± 71	0.036
HID	231 ± 91 =	205 ± 47 <	318 ± 94	0.014
TMD				
MHI	198 ± 81 <	250 ± 94 <	303 ± 92	< 0.001
IID	168 ± 67 <	238 ± 90 <	279 ± 88	< 0.001
HID	208 ± 102 =	237 ± 84 <	309 ± 105	< 0.001

Repeated measures ANOVA/Bonferroni test (Mean±SD).

with few maintaining a sex-balanced sample [27,58]. Additionally, some studies found differences in condylar position between males and females [27,56,57]. In this study, both sexes were represented, with participants aged between 25 and 70 years in both groups.

The intergroup analysis, shown in Table I, corroborates the findings of Lelis et al. [27], who compared cone-beam tomographic images between patients with and without articular TMD symptoms, in both centric relation and MHI, reporting no significant differences between the groups. Similarly, Paknahad et al. [26] found no significant differences in condylar position when comparing asymptomatic patients to those with both articular and muscular TMD symptoms in MHI using TMJ CBCT images.

The findings in Table II suggest that the use of flat horizontal interocclusal devices without anterior guidance may be more effective, as they position the condyle similarly to asymptomatic patients. This information may be useful for designing an occlusal splint, which could be clinically significant.

Although in a general analysis no differences were observed between TMD patients and the control group based on the Student's t-test, when analyzing the groups separately using repeated-measures ANOVA and Bonferroni correction, a tendency for a more posterior condylar position was found in symptomatic patients. This posterior positioning was corrected only with the horizontal device, which was able to reposition the mandible to the same pattern demonstrated by asymptomatic patients. In the Student's t-test analysis, the comparison was not paired, as these were different populations. In contrast, the repeated-measures ANOVA, used for the separate group analysis, allowed for the pairing of condylar positions within the same patient, which may explain the seemingly divergent test results.

This more posterior condylar positioning observed in symptomatic patients may be a predisposing factor for not only articular TMD but also muscular TMD due to pressure on retrodiscal tissues and ligament elongation.

The results of this research are consistent with those of Dalili et al. [57], who found that centralized condyles were more common in patients with normal occlusion and normal function of the TMJ. Kandasamy et al. [59] found a lot of variability in positions in the sample of asymptomatic patients, but on average, 87% of the analyzed condyles were more centralized. Dupuy-Bonafé et al. [58] found that 49% of asymptomatic patients with normal occlusion had centralized condyles, but they also observed a high incidence of asymmetries between right and left TMJs. Mazzeto et al. [56] concluded that patients with pain and functional problems in the TMJ generally had more posterior and inferior positioned condyles. Regarding the use of interocclusal devices, Linsen et al. [54] found that jigs made in centric relation increased the posterior space of the TMJs, while Liu et al. [49] observed that the use of stabilizing occlusal splints moved the condyles anteriorly and inferiorly, corroborating the results of this research.

A similar study by Imanimoghaddam et al. [44] in asymptomatic and TMD patients found a positive correlation between superior and posterior spaces in both groups, with the TMD group also showing a positive correlation between anterior and superior spaces. Paknahad et al. [26], on the contrary, did not find a correlation between TMD and mandibular positions.

Table III - Results of Pearson correlation test

			MHI Ant.	MHI Sup.	MHI Post.	IID Ant.	IID Sup.	IID Post.	HID Ant.	HID Sup.	HID Post.
Control											
MHI	MHI Anterior	r	-	0.56	0.131	0.862*	0.039	-0.085	0.808*	0.083	-0.216
		p-Value	-	0.092	0.719	0.001	0.914	0.815	0.005	0.819	0.549
	MHI Superior	r	-	-	-0.157	0.571	0.679*	-0.207	0.465	0.694*	-0.209
		p-Value	-	-	0.666	0.085	0.031	0.565	0.176	0.026	0.562
	MHI Posterior	r	-	-	-	-0.179	-0.149	0.930*	-0.107	-0.31	0.444
		p-Value	-	-	-	0.621	0.681	<0.001	0.768	0.383	0.198
IID	IID Anterior	r	-	-	-	-	0.169	-0.3	0.940*	0.352	-0.274
		p-Value	-	-	-	-	0.641	0.4	<0.001	0.319	0.444
	IID Superior	r	-	-	-	-	-	0.022	0.228	0.879*	0.201
		p-Value	-	-	-	-	-	0.953	0.527	0.001	0.579
	IID Posterior	r	-	-	-	-	-	-	-0.171	-0.126	0.559
		p-Value	-	-	-	-	-	-	0.636	0.729	0.093
HID	HID Anterior	r	-	-	-	-	-	-	-	0.405	0.001
		p-Value	-	-	-	-	-	-	-	0.245	0.998
	HID Superior	r	-	-	-	-	-	-	-	-	0.209
		p-Value	-	-	-	-	-	-	-	-	0.563
	HID Posterior	r	-	-	-	-	-	-	-	-	-
		p-Value	-	-	-	-	-	-	-	-	-
DTM											
MHI	MHI Anterior	r	-	0.166	-0.282*	0.888*	0.192	-0.086	0.866*	0.217	0.106
		p-Value	-	0.24	0.043	<0.001	0.172	0.546	<0.001	0.122	0.452
	MHI Superior	r	-	-	0.555*	0.248	0.871*	0.389*	0.206	0.737*	0.401*
		p-Value	-	-	<0.001	0.076	<0.001	0.004	0.144	<0.001	0.003
	MHI Posterior	r	-	-	-	-0.216	0.447*	0.676*	-0.205	0.347*	0.447*
		p-Value	-	-	-	0.124	0.001	<0.001	0.144	0.012	0.001
IID	IID Anterior	r	-	-	-	-	0.303*	-0.064	0.896*	0.288*	0.127
		p-Value	-	-	-	-	0.029	0.653	<0.001	0.038	0.369
	IID Superior	r	-	-	(s-	-	-	0.565*	0.192	0.859*	0.535*
		p-Value	-	-	-	-	-	<0.001	0.174	<0.001	<0.001
	IID Posterior	r	-	-	-	-	-	-	-0.151	0.480*	0.673*
		p-Value	-	-	-	-	-	-	0.286	<0.001	<0.001
HID	HID Anterior	r	-	-	-	-	-	-	-	0.214	0.033
		p-Value	-	-	-	-	-	-	-	0.128	0.814
	HID Superior	r	-	-	-	-	-	-	-	-	0.762*
		p-Value	-	-	-	-	-	-	-	-	<0.001
	HID Posterior	r	-	-	-	-	-	-	-	-	-
		p-Value	-	-	-	-	-	-	-	-	-

*p<0.05, given r, the Pearson correlation coefficient

Among the limitations of this study is the lack of analysis of the condylar position in other planes. However, the primary focus was on the anteroposterior position, not the mediolateral, which simplified the tomographic examination. Additionally, the study involved only one clinical examiner and one radiology technician, which may introduce variability in the assessment. The radiology technician was also aware of the jaw position (whether in MHI or using either device). Furthermore, the control group size was relatively small, which may limit the generalizability of the findings. Despite these limitations, it is important to note that the researcher closely collaborated with the radiologist to ensure standardization of procedures throughout the study.

The partial-coverage interocclusal devices used in this research were fabricated specifically for the tomographic examinations to reduce research costs. Patients did not use them outside of the radiology clinic. The techniques for impression, occlusal registration, and articulator mounting were conducted following the same methodology as for full-coverage occlusal splints so that even with full dental coverage, the interocclusal and condylar positioning would be the same in tomographic images. The authors unanimously believe that the devices used in this research replicated the positioning of the arches as if using a full occlusal splint with either a horizontal or inclined anterior design.

This study has clinical relevance by contributing to the understanding of interocclusal device mechanisms of action on the TMJ, suggesting that a different occlusal splint design could influence the condylar position in patients with TMD. Future studies comparing various designs of stabilizing occlusal splints and their roles in condylar positioning and symptomatology of muscular, articular, or mixed TMDs should be conducted to further investigate the hypotheses raised by this study's results. The findings also raise questions regarding the need to achieve an ideal occlusion in extensive prosthetic rehabilitation, as different occlusal positions did not result in different condylar positions in asymptomatic patients, whereas symptomatic patients showed variable positioning, indicating a need for greater attention.

CONCLUSION

The examination of the condylar position does not definitively indicate the presence or absence of TMD. In symptomatic patients with muscular TMD, condyles were more posteriorly positioned during maximum intercuspation and when using an anterior-guided interocclusal device. However, the horizontal interocclusal device led to centralization. In contrast, asymptomatic patients consistently showed centrally positioned condyles regardless of occlusal position.

Author's Contributions

AACJ: Conceptualization, Investigation, Resources, Data Curation, Writing – Original Draft Preparation. AVB: Writing – Review & Editing, Visualization. JFBO: Writing – Review & Editing. LMPO: Writing – Review & Editing. PGBS: Software, Validation, Formal Analysis. RGLAF: Formal analysis: LMSPF: Methodology, Project Administration. KMFP: Methodology, Supervision, Project Administration.

Conflict of Interest

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the Research Ethics Committee of the Universidade Federal do Ceará, Brazil. The approval code for this study is: 492.384 (CAAE 04706412.3.0000.5054).

REFERENCES

1. Barrera-Mora JM, Escalona EE, Labruzzi CA, Llamas Carrera JM, Ballesteros EJC, Reina ES, et al. The relationship between malocclusion, benign joint hypermobility syndrome, condylar position and TMD symptoms. Crânio. 2012;30(2):121-30. PMid:22606856.
2. Wojciechowska B, Szarmach A, Michcik A, Wach T, Drogoszewska B. Association between clinical manifestations in temporomandibular joint disorders and corresponding radiographic findings. J Clin Med. 2024;13(16):4886. http://doi.org/10.3390/jcm13164886. PMid:39201027.
3. Čimić S, Žaja M, Šimunković SK, Kopić M, Ćatić A. Influence of occlusal interference on the mandibular condylar position. Acta Stomatol Croat. 2016;50(1):116-21. http://doi.org/10.15644/asc50/2/3. PMid:27789908.
4. Progiante PS, Pattussi MP, Lawrence HP, Goya S, Grossi PK, Grossi ML. Prevalence of temporomandibular disorders in an adult Brazilian community population using the Research Diagnostic Criteria (Axes I and II) for Temporomandibular Disorders (The Maringa Study). Int J Prosthodont. 2015;28(6):600-9. http://doi.org/10.11607/ijp.4026. PMid:26523719.
5. Alrizqi AH, Aleissa BM. Prevalence of temporomandibular disorders between 2015-2021: a literature review. Cureus. 2023;15(4):e37028. http://doi.org/10.7759/cureus.37028. PMid:37143640.
6. Wolford LM, Dingwerth DJ, Talwar RM, Pitta MC. Comparison of 2 temporomandibular joint total joint prosthesis systems. J Oral

Maxillofac Surg. 2003;61(6):685-90, discussion 690. http://doi.org/10.1053/joms.2003.50112. PMid:12796878.

7. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet J-P, et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium network* and orofacial pain special interest group†. J Oral Facial Pain Headache. 2014;28(1):6-27. http://doi.org/10.11607/jop.1151. PMid:24482784.

8. Valesan LF, Da-Cas CD, Réus JC, Denardin ACS, Garanhani RR, Bonotto D, et al. Prevalence of temporomandibular joint disorders: a systematic review and meta-analysis. Clin Oral Investig. 2021;25(2):441-53. http://doi.org/10.1007/s00784-020-03710-w. PMid:33409693.

9. National Institute of Dental and Craniofacial Research [Internet]. Facial pain. 2013 [cited 2013 Jan 1]. Available from: https://www.nidcr.nih.gov/research/data-statistics/temporomandibular-disorders-jaw-pain

10. Ton LAB, Mota IG, De Paula JS, Martins APVB. Prevalence of temporomandibular disorder and its association with stress and anxiety among university students. Braz Dent Sci. 2020;23(1). http://doi.org/10.14295/bds.2020.v23i1.1810.

11. Kumar R, Pallagatti S, Sheikh S, Mittal A, Gupta D, Gupta S. Correlation between clinical findings of temporomandibular disorders and MRI characteristics of disc displacement. Open Dent J. 2015;9(1):273-81. http://doi.org/10.2174/1874210601509010273. PMid:26464595.

12. Silva TVA, Coriolano MGWS, Lins CCSA. Disfunção temporomandibular na Doença de Parkinson: uma revisão integrativa da literatura. Rev CEFAC. 2017;19:702-11. http://doi.org/10.1590/1982-0216201719516416.

13. Asquini G, Pitance L, Michelotti A, Falla D. Effectiveness of manual therapy applied to craniomandibular structures in temporomandibular disorders: A systematic review. J Oral Rehabil. 2022;49(4):442-55. http://doi.org/10.1111/joor.13299. PMid:34931336.

14. Sá M, Faria C, Pozza DH. Conservative versus Invasive Approaches in Temporomandibular Disc Displacement: A Systematic Review of Randomized Controlled Clinical Trials. Dent J. 2024;12(8):244. http://doi.org/10.3390/dj12080244. PMid:39195088.

15. Okeson JP, de Leeuw R. Differential Diagnosis of Temporomandibular Disorders and Other Orofacial Pain Disorders. Dent Clin North Am. 2011;55(1):105-20. http://doi.org/10.1016/j.cden.2010.08.007. PMid:21094721.

16. Utt TW, Meyers CE Jr, Wierzba TF, Hondrum SO. A three-dimensional comparison of condylar position changes between centric relation and centric occlusion using the mandibular position indicator. Am J Orthod Dentofacial Orthop. 1995;107(3):298-308. http://doi.org/10.1016/S0889-5406(95)70146-X. PMid:7879763.

17. Jasper JJ, McNamara JA Jr. The correction of interarch malocclusions using a fixed force module. Am J Orthod Dentofacial Orthop. 1995;108(6):641-50. http://doi.org/10.1016/S0889-5406(95)70010-2. PMid:7503042.

18. Hidaka O, Adachi S, Takada K. The difference in condylar position between centric relation and centric occlusion in pretreatment Japanese orthodontic patients. Angle Orthod. 2002;72(4):295-301. PMid:12169028.

19. Rinchuse DJ, Kandasamy S. Centric relation: a historical and contemporary orthodontic perspective. J Am Dent Assoc. 2006;137(4):494-501. http://doi.org/10.14219/jada.archive.2006.0222. PMid:16637479.

20. Ikeda K, Kawamura A, Ikeda R. Assessment of optimal condylar position in the coronal and axial planes with limited cone-beam computed tomography. J Prosthodont. 2011;20(6):432-8. http://doi.org/10.1111/j.1532-849X.2011.00730.x. PMid:21689204.

21. Merigue LF, Conti ACCF, Oltramari-Navarro PVP, Navarro RL, Almeida MR. Oltramari-Navarro PVp, Navarro R de L, Almeida MR de. Tomographic evaluation of the temporomandibular joint in malocclusion subjects: condylar morphology and position. Braz Oral Res. 2016;30(1). http://doi.org/10.1590/1807-3107BOR-2016.vol30.0017.

22. Badel T, Vojnović S, Buković D, Zadravec D, Anić Milošević S, Smoljan Basuga M, et al. The asymmetry of the mandible in patients with unilateral temporomandibular joint disc displacement confirmed by magnetic resonance imaging. Acta Stomatol Croat. 2023;57(2):167-76. http://doi.org/10.15644/asc57/2/7. PMid:37427358.

23. Ananthan S, Pertes RA, Bender SD. Biomechanics and derangements of the temporomandibular joint. Dent Clin North Am. 2023;67(2):243-57. http://doi.org/10.1016/j.cden.2022.11.004. PMid:36965929.

24. Pullinger AG, Seligman DA. Overbite and overjet characteristics of refined diagnostic groups of temporomandibular disorder patients. Am J Orthod Dentofacial Orthop. 1991;100(5):401-15. http://doi.org/10.1016/0889-5406(91)70079-C. PMid:1951193.

25. Myers DR, Barenie JT, Bell RA, Williamson EH. Condylar position in children with functional posterior crossbites: before and after crossbite correction. Pediatr Dent. 1980;2(3):190-4. PMid:6938933.

26. Paknahad M, Shahidi S, Iranpour S, Mirhadi S, Paknahad M. Cone-beam computed tomographic assessment of mandibular condylar position in patients with temporomandibular joint dysfunction and in healthy subjects. Int J Dent. 2015;2015:301796. PMid:26681944.

27. Lelis ÉR, Guimarães Henriques JC, Tavares M, de Mendonça MR, Fernandes AJ No, Almeida GA. Cone-beam tomography assessment of the condylar position in asymptomatic and symptomatic young individuals. J Prosthet Dent. 2015;114(3):420-5. http://doi.org/10.1016/j.prosdent.2015.04.006. PMid:26047805.

28. Al-Rawi NH, Uthman AT, Sodeify SM. Spatial analysis of mandibular condyles in patients with temporomandibular disorders and normal controls using cone beam computed tomography. Eur J Dent. 2017;11(1):99-105. http://doi.org/10.4103/ejd.ejd_202_16. PMid:28435374.

29. Kanavakis G, Mehta N. The role of occlusal curvatures and maxillary arch dimensions in patients with signs and symptoms of temporomandibular disorders. Angle Orthod. 2014;84(1):96-101. http://doi.org/10.2319/111312-870.1. PMid:23509999.

30. Venturelli FA, Zuim PRJ, Antenucci RMF, Garcia AR. Analysis of mandibular position using different methods of location. Acta Odontol Latinoam. 2009;22(3):155-62. PMid:20302213.

31. Wood GN. Centric relation and the treatment position in rehabilitating occlusions: A physiologic approach. Part II: The treatment position. J Prosthet Dent. 1988;60(1):15-8. http://doi.org/10.1016/0022-3913(88)90341-1. PMid:3165459.

32. Henriques JCG, Fernandes-Neto AJ, Almeida GA, Machado NAG, Lelis ÉR. Cone-beam tomography assessment of condylar position discrepancy between centric relation and maximal intercuspation. Braz Oral Res. 2012;26(1):29-35. http://doi.org/10.1590/S1806-83242011005000017. PMid:22344335.

33. Goldstein GR. Centric relation: A needed reference position. J Prosthodont. 2023;32(6):482-8. http://doi.org/10.1111/jopr.13603. PMid:36074517.

34. Galeković NH, Fugošić V, Braut V, Ćelić R. Reproducibility of centric relation techniques by means of condyle position analysis. Acta Stomatol Croat. 2017;51(1):13-21. http://doi.org/10.15644/asc51/1/2. PMid:28740266.

35. Weffort SYK, De Fantini SM. Condylar displacement between centric relation and maximum intercuspation in symptomatic and asymptomatic individuals. Angle Orthod. 2010;80(5):835-42. http://doi.org/10.2319/090909-510.1. PMid:20578853.

36. Ren Y-F, Isberg A, Westesson P-L. Condyle position in the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995;80(1):101-7. http://doi.org/10.1016/S1079-2104(95)80025-5. PMid:7552848.

37. Baccetti T, Antonini A, Franchi L, Tonti M, Tollaro I. Glenoid fossa position in different facial types: a cephalometric study. Br J Orthod. 1997;24(1):55-9. http://doi.org/10.1093/ortho/24.1.55. PMid:9088604.

38. Katsavrias EG, Halazonetis DJ. Condyle and fossa shape in Class II and Class III skeletal patterns: a morphometric tomographic study. Am J Orthod Dentofacial Orthop. 2005;128(3):337-46. http://doi.org/10.1016/j.ajodo.2004.05.024. PMid:16168330.

39. Ganugapanta VR, Ponnada SR, Gaddam KPR, Perumalla K, Khan I, Mohammed NA. Computed tomographic evaluation of condylar symmetry and condyle-fossa relationship of the temporomandibular joint in subjects with normal occlusion and malocclusion: A comparative study. J Clin Diagn Res. 2017;11(2):ZC29-33. http://doi.org/10.7860/JCDR/2017/21678.9328. PMid:28384976.

40. Lewis EL, Dolwick MF, Abramowicz S, Reeder SL. Contemporary imaging of the temporomandibular joint. Dent Clin North Am. 2008;52(4):875-90, viii. http://doi.org/10.1016/j.cden.2008.06.001. PMid:18805233.

41. Fardim KAC, Ribeiro TMAM, Correa ECDCB, Ogawa CM, Costa ALF, de Castro Lopes SLP. Magnetic resonance imaging texture analysis of the temporomandibular joint for changes in the articular disc in individuals with migraine headache. Braz Dent Sci. 2023;26(1):e3649. http://doi.org/10.4322/bds.2023.e3649.

42. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc. 2006;72(1):75-80. PMid:16480609.

43. Okeson JP. Management of Temporomandibular Disorders and Occlusion [Internet]. Vol. 6. USA: Elsevier; 2008 [cited 2024 May 24]. Available from: http://www.amazon.com/Management-Temporomandibular-Disorders-Occlusion-Jeffrey/dp/0323046142

44. Imanimoghaddam M, Madani AS, Mahdavi P, Bagherpour A, Darijani M, Ebrahimnejad H. Evaluation of condylar positions in patients with temporomandibular disorders: A cone-beam computed tomographic study. Imaging Sci Dent. 2016;46(2):127-31. http://doi.org/10.5624/isd.2016.46.2.127. PMid:27358820.

45. Ommerborn MA, Kollmann C, Handschel J, Depprich RA, Lang H, Raab WHM. A survey on German dentists regarding the management of craniomandibular disorders. Clin Oral Investig. 2010;14(2):137-44. http://doi.org/10.1007/s00784-009-0282-4. PMid:19440738.

46. Giraki M, Schneider C, Schäfer R, Singh P, Franz M, Raab WHM, et al. Correlation between stress, stress-coping and current sleep bruxism. Head Face Med. 2010;6(1):2. http://doi.org/10.1186/1746-160X-6-2. PMid:20205705.

47. Schindler HJ, Rues S, Türp JC, Schweizerhof K, Lenz J. Jaw clenching: muscle and joint forces, optimization strategies. J Dent Res. 2007;86(9):843-7. http://doi.org/10.1177/154405910708600907. PMid:17720852.

48. Ettlin DA, Mang H, Colombo V, Palla S, Gallo LM. Stereometric assessment of TMJ space variation by occlusal splints. J Dent Res. 2008;87(9):877-81. http://doi.org/10.1177/154405910808700903. PMid:18719217.

49. Liu MQ, Lei J, Han JH, Yap AUJ, Fu KY. Metrical analysis of disc-condyle relation with different splint treatment positions in patients with TMJ disc displacement. J Appl Oral Sci. 2017;25(5):483-9. http://doi.org/10.1590/1678-7757-2016-0471. PMid:29069145.

50. Forssell H, Kalso E. Application of principles of evidence-based medicine to occlusal treatment for temporomandibular disorders: are there lessons to be learned? J Orofac Pain. 2004;18(1):9-22, discussion 23-32. PMid:15022533.

51. Müller L, Kellenberger CJ, Cannizzaro E, Ettlin D, Schraner T, Bolt IB, et al. Early diagnosis of temporomandibular joint involvement in juvenile idiopathic arthritis: a pilot study comparing clinical examination and ultrasound to magnetic resonance imaging. Rheumatology (Oxford). 2009;48(6):680-5. http://doi.org/10.1093/rheumatology/kep068. PMid:19386819.

52. Paiva G, Mazzeto M. Atlas de Placas Interoclusais. São Paulo: Livraria Santos Editora; 2008.

53. De Nordenflycht D, Salinas J, Armstrong L. Thermoformed occlusal splints for the treatment of masticatory muscle pain: a clinical trial. Braz Dent Sci. 2022;25(3):e3401. http://doi.org/10.4322/bds.2022.e3401.

54. Linsen SS, Stark H, Matthias A. Changes in condylar position using different types of splints with and without a chinstrap: a case-control study. Cranio. 2012;30(1):25-31. http://doi.org/10.1179/crn.2012.004. PMid:22435174.

55. Giannakopoulos NN, Katsikogianni EN, Hellmann D, Eberhard L, Leckel M, Schindler HJ, et al. Comparison of three different options for immediate treatment of painful temporomandibular disorders: a randomized, controlled pilot trial. Acta Odontol Scand. 2016;74(6):480-6. http://doi.org/10.1080/00016357.2016.1204558. PMid:27410169.

56. Mazzetto MO, Veneziam GC, Magri LV, Nasr MK, Paiva AF, Paiva G. Evaluation of the condylar position in subjects with temporomandibular joint functional disorders by cone beam computed tomography. Braz Dent Sci. 2014;77-82. http://doi.org/10.14295/bds.2014.v17i2.968.

57. Dalili Z, Khaki N, Kia SJ, Salamat F. Assessing joint space and condylar position in the people with normal function of temporomandibular joint with cone-beam computed tomography. Dent Res J (Isfahan). 2012;9(5):607-12. http://doi.org/10.4103/1735-3327.104881. PMid:23559927.

58. Dupuy-Bonafé I, Otal P, Montal S, Bonafé A, Maldonado IL. Biometry of the temporomandibular joint using computerized tomography. Surg Radiol Anat. 2014;36(9):933-9. http://doi.org/10.1007/s00276-014-1277-7. PMid:24619474.

59. Kandasamy S, Boeddinghaus R, Kruger E. Condylar position assessed by magnetic resonance imaging after various bite position registrations. Am J Orthod Dentofacial Orthop. 2013;144(4):512-7. http://doi.org/10.1016/j.ajodo.2013.06.014. PMid:24075658.

Karina Matthes de Freitas Pontes
(Corresponding address)
Universidade Federal do Ceará, Programa de Pós-graduação em Odontologia, Fortaleza, CE, Brazil.
Email: kamatthes@yahoo.com.br/karinapontes@ufc.br

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