Original Article

Condylar displacement between centric relation and maximum intercuspation in symptomatic and asymptomatic individuals

Soo Young Kim Weffort[a]; Solange Mongelli de Fantini[b]

ABSTRACT

Objective: To measure condylar displacement between centric relation (CR) and maximum intercuspation (MIC) in symptomatic and asymptomatic subjects.

Materials and Methods: The sample comprised 70 non-deprogrammed individuals, divided equally into two groups, one symptomatic and the other asymptomatic, grouped according to the research diagnostic criteria for temporomandibular disorders (RDC/TMD). Condylar displacement was measured in three dimensions with the condylar position indicator (CPI) device. Dahlberg's index, intraclass correlation coefficient, repeated measures analysis of variance, analysis of variance, and generalized estimating equations were used for statistical analysis.

Results: A greater magnitude of difference was observed on the vertical plane on the left side in both symptomatic and asymptomatic individuals ($P = .033$). The symptomatic group presented higher measurements on the transverse plane ($P = .015$). The percentage of displacement in the mesial direction was significantly higher in the asymptomatic group than in the symptomatic one ($P = .049$). Both groups presented a significantly higher percentage of mesial direction on the right side than on the left ($P = .036$). The presence of bilateral condylar displacement (left and right sides) in an inferior and distal direction was significantly greater in symptomatic individuals ($P = .012$). However, no statistical difference was noted between genders.

Conclusion: Statistically significant differences between CR and MIC were quantifiable at the condylar level in asymptomatic and symptomatic individuals. (*Angle Orthod.* 2010;80:835–842.)

KEY WORDS: Condylar displacement; Centric relation; Maximum intercuspation

INTRODUCTION

Regarding dental procedures, the mandible can assume two well-known positions as a reference for treatment: centric relation (CR) and maximum intercuspation (MIC).[1] These usually are not coincident in the general population.[1–20] The MIC position refers to the occlusal relationship in which the teeth of both arches are mostly interposed. In this case, the mandible generates a joint position dictated by the teeth. On the other side, CR is defined as the most anterior-superior position the condyles can achieve in the fossa, seated against the articular disc at the posterior slope of the eminence, centered transversely by coordinated masticatory muscles.[7,20] It has also been described as the most stable and comfortable position of the mandible in which the joints can be loaded without discomfort.[20]

Controversy continues about what is considered an ideal condyle-fossa relationship when the teeth establish MIC.[1–4] If any premature occlusal contact changes the jaw closing arc, the condyles might be displaced to achieve a maxillomandibular relationship in MIC, thus avoiding premature contact. It is not clear how occlusal changes (natural dentition development, occlusal treatments, or restoration procedures) affect the function of the temporomandibular joint.[21,22] Several studies have shown that in most cases the neuromusculature places the mandible in such a position that the highest number of occlusal contacts is established without taking into account the final condylar position.[1–4,13,23–26]

However, the role of condylar displacement in the context of morphologic and functional occlusion as a risk factor in temporomandibular disorder (TMD) development has not been clearly elucidated. For this

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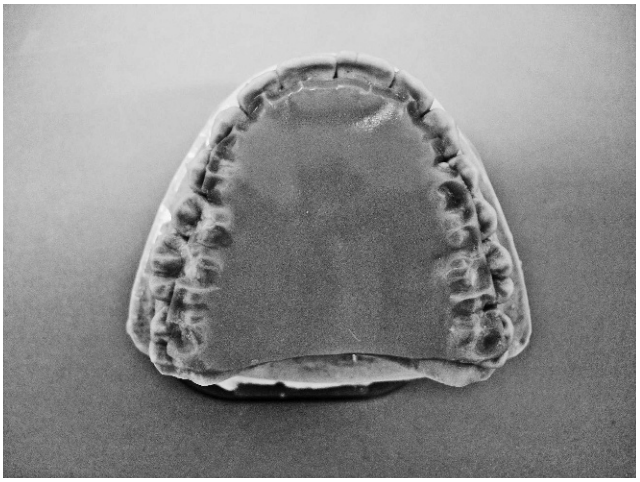

Figure 1. Maximal intercuspation (MIC) wax bite registration was taken with one sheet only of Beauty Pink Wax (Moyco Inc, Philadelphia, Pa).

Figure 2. For the centric relation (CR) bite record, Blue Bite Registration Delar Wax (Delar Corp, Lake Oswego, Ore) was used in two sections according to Roth's power centric technique.

reason, assessment of articulated models in CR should not be ignored because the malocclusion could be different, depending on the mandibular position adopted during the orthodontic diagnosis.[1–3,25–27]

Previous studies[1,2,4,24–26,28–30] have shown that CR-MIC discrepancies are frequently present in the general population, in symptomatic as often as in asymptomatic subjects, whether they are of a distinct facial pattern or not, and whether deprogrammed or not. Differences between CR and MIC are observed on three spatial planes, equally at the condylar level, by means of a condylar position indicator (CPI), and at the dental level, via an interdental relation examination. CR-MIC discrepancies observed at the level of the occlusion frequently have been shown not to correspond to those measured at the condylar level.[1,2,4,24–26,28–31]

The purpose of this cross-sectional study was to measure condylar displacement between CR and MIC in symptomatic and asymptomatic individuals with TMD. The objectives were as follows:

- Measure the CR-MIC discrepancy in the three dimensions of space
- Statistically compare the magnitude, direction, and frequency of CPI measurements in both study groups
- Compare condylar displacement among males and females

MATERIALS AND METHODS

The sample comprised 70 non-deprogrammed individuals, divided equally into two groups: a symptomatic group (mean age, 22.8 years) and an asymptomatic group (mean age, 23.6 years). Each group contained 20 females and 15 males, aged 18 to 30 years. Participants were selected from the students and patients of the Orthodontic Department at São Paulo Dental School, University of São Paulo, Brazil. All individuals signed an informed consent indicating their agreement with the research procedures. Approval for the procedures of this research was obtained from the Ethics Committee of the University of São Paulo (Project Number 82/05). All subjects completed a questionnaire to identify facial pain, joint and muscle complaints, problems of mastication, headache, parafunction, and clenching, grinding, and bite habits. Subsequent clinical muscle and joint examinations were performed on each patient.

On the basis of data collected during anamnesis and clinical examination, subjects were divided into two groups—a symptomatic group and an asymptomatic group—in accordance with the Research Diagnostic Criteria (RDC) for TMD (Axis I group I).[32] The temporomandibular joint (TMJ) physical examination included measurements of mouth opening, right and left excursion of the mandible, and protrusion. All these measurements were made on maximum unassisted extension. The joint noise level was verified by digital palpation during mandibular movements such as opening-closing, protrusion-retrusion, and lateral excursion. In the TMJ examination, possible restriction or deviation of jaw movement was observed. Following the previous examination, palpation for the reference point of muscle pain and tenderness was analyzed. As pressure was applied, the patient was asked if the palpation was painful, and if the reference point of the pain was located away from the palpation site. A numeric rating scale (0 to 10) was used to quantify pain levels experienced by patients.

The asymptomatic group had no history of any type of TMD (ie, absence of the following signs and symptoms: facial muscle pain/fatigue, tenderness

Figure 3. Centric relation (CR) position in condylar position indicator (CPI) instrumentation determined by CR bite record.

upon palpation, limited range of motion, pain upon movement, clicking or locking joint, or TMJ pain). The symptomatic group was identified as participants who presented with myofascial pain, in whom a click sound could be present or absent. Pain upon palpation at three or more muscular sites had to be present (pain level ≥5 on a numeric scale) on masticatory muscles. The muscle sites included the origin, body, and insertion of the masseter; the deep masseter; the anterior, medium, and posterior temporalis; the attachment of the temporalis on the coronoid process; and the medial and lateral pterygoid. Muscular spasm, muscular contracture, and myositis were considered to be exclusion criteria. None of the subjects had a history of head, jaw, or neck trauma, extensive restoration or rehabilitation, periodontal disease, or any condition causing pain of dental origin.

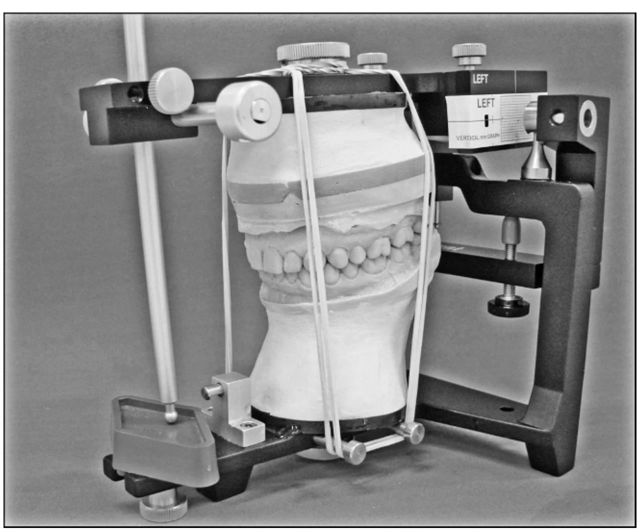

Figure 4. Maximal intercuspation (MIC) position in condylar position indicator (CPI) instrumentation determined by MIC bite record.

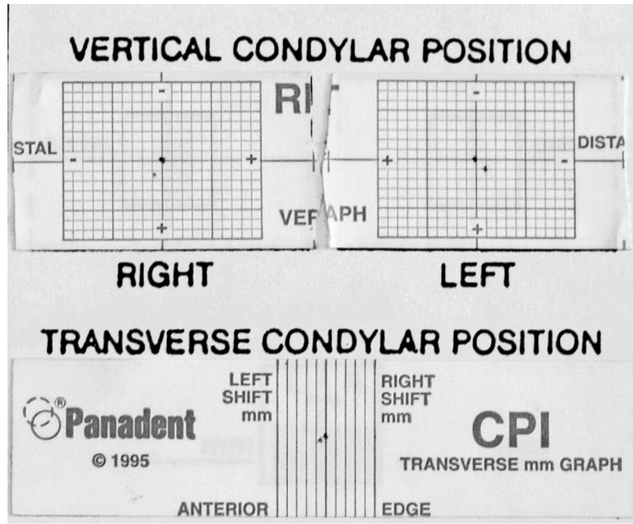

Figure 5. Centric relation (CR) position was marked in black, and maximal intercuspation (MIC) in red. On the vertical plane, a negative sign represents that MIC is dislocated in the superior direction, and on the horizontal plane, in the posterior direction. A positive sign on the vertical plane indicates inferior direction, and on the horizontal plane, anterior direction.

A wax bite registration in MIC was taken for each patient (Figure 1). The CR bite registration (Figure 2) was taken according to Roth's power centric technique[1,10] modified by Fantini,[33] with the patient in a supine position and bimanual mandibular manipulation applied to achieve the best CR available that day. No other deprogramming method was used. Maxillary and mandibular models of all participants were mounted on an articulator (Panadent, Panadent Corp, Grand Terrace, Calif). For the mounting of each subject, condylar displacement between CR (Figure 3) and MIC (Figure 4) was assessed with a CPI (Panadent) and was evaluated for frequency, direction, and magnitude on three planes of space (Figure 5). All

Table 1. Study Error for Repeatability and Reproductibility of CR-MIC Displacement Measurements[a]

Operator	CPI	Intraclass Correlation	IC (95%) Min	IC (95%) Max	Dahlberg's Index
Intra-	Ver R	0.98	0.96	0.99	0.011
	Ver L	0.99	0.98	0.99	0.009
	Hor R	0.95	0.90	0.98	0.044
	Hor L	0.90	0.80	0.95	0.055
	Trans	0.88	0.76	0.94	0.018
Inter-	Ver R	0.96	0.82	0.99	0.006
	Ver L	0.95	0.76	0.99	0.011
	Hor R	0.93	0.70	0.99	0.049
	Hor L	0.98	0.88	1.00	0.015
	Trans	0.99	0.93	1.00	0.003

[a] CPI indicates condylar position indicator; CR, centric relation; IC, intraclass correlation; max, maximum; MIC, maximal intercuspation; and min, minimum.

Table 2. Mean Values (SD), Minimum and Maximum (mm), of Condylar Displacement on Vertical, Horizontal, and Transversal Planes in Symptomatic and Asymptomatic Groups[a]

	Asymptomatic		Symptomatic	
CPI	Mean (SD)	Min-Max	Mean (SD)	Min-Max
Ver R	1.22 (0.74)	0.0–3.0	1.48 (0.69)	0.3–3.4
Ver L	1.30 (0.73)	0.0–3.0	1.72 (0.92)	0.6–4.0
Hor R	0.63 (0.50)	0.0–2.2	0.63 (0.49)	0.0–1.9
Hor L	0.63 (0.61)	0.0–2.4	0.64 (0.40)	0.0–2.0
Trans	0.23 (0.28)	0.0–1.0	0.41 (0.32)	0.0–1.5

[a] CPI, condylar position indicator; max, maximum; and min, minimum.

mounting models, records, and examinations were performed by one operator, except interoperator error analysis, in which a second operator participated. One articulator was used for all mountings.

Statistical Analysis

Intraoperator error for reproducibility of CR records was determined by collecting new CR records of 30 randomly selected subjects performed by the same operator. Interoperator error for repeatability was determined by having new CR records for 10% of the sample (randomly selected) performed by a second operator. Both were evaluated by intraclass correlation and Dahlberg's index. Repeated measures analysis of variance was used to compare the statistical significance of CPI means on vertical and horizontal planes in symptomatic and asymptomatic groups according to side and gender. The two-way analysis of variance (ANOVA) was used for comparison on the transverse plane. The possible association between the direction of condylar displacement and the symptoms was tested by means of generalized estimating equations (GEE). Pearson's chi-square test was undertaken to compare the frequency distribution of inferior and distal direction condylar displacement on both sides (left and right) and TMD symptoms. All tests were run at a 95% confidence level.

RESULTS

Results of study error analysis via intraclass correlation coefficient (ICC) and Dahlberg's index in all interoperator and intraoperator measurements showed high repeatability and reproducibility of the described technique (Table 1).

For the asymptomatic group, the absolute mean value of condylar displacement was 1.22 mm (right side) and 1.30 mm (left side) on the vertical plane; 0.63 mm (right and left sides) on the horizontal plane; and 0.23 mm on the transverse plane. In the symptomatic group, the values were 1.48 mm (right side) and 1.72 mm (left side) on the vertical plane; 0.63 mm on the horizontal plane on the right side and 0.64 mm on the left; and 0.41 mm on the transverse plane. The symptomatic group presented larger values in comparison with the asymptomatic group. Values of greater magnitude were observed on the vertical plane in both symptomatic and asymptomatic individuals (Table 2).

Because the parameters analyzed are not independent (ie, the condylar movement in the right joint is dependent on that on the left side), interactions between factors, side, symptom, and gender had to be calculated. For vertical and horizontal measures, no statistically significant effects of interactions were

Table 3. Repeated Measures Analysis of Variance with the Repeated Factor Side and the Fixed Factors Symptom and Gender for Means (SD) of Condylar Displacement on Vertical and Horizontal Planes in Symptomatic and Asymptomatic Groups According to Side and Gender[a]

			Interaction Effects (*P*)				Factor Effects (*P*)		
CPI	Female	Male	Side × Symptom × Gender	Side × Symptom	Side × Gender	Symptom × Gender	Side	Symptom	Gender
Vertical			.650	.234	.326	.468	**.033***	.065	.094
Asymptomatic									
Right	1.25 (0.65)	1.18 (0.86)							
Left	1.42 (0.69)	1.15 (0.78)							
Symptomatic									
Right	1.64 (0.76)	1.26 (0.53)							
Left	1.92 (1.01)	1.46 (0.75)							
Horizontal			.353	.909	.194	.887	.776	.927	.725
Asymptomatic									
Right	0.69 (0.58)	0.55 (0.38)							
Left	0.56 (0.45)	0.74 (0.78)							
Symptomatic									
Right	0.63 (0.55)	0.65 (0.40)							
Left	0.61 (0.36)	0.69 (0.47)							

[a] CPI, condylar position indicator.
* $P \leq 0.05$.

Table 4. Analysis of Variance of Condylar Displacement on Transversal Plane in Symptomatic Group Comparing Symptoms and Gender[a]

CPI	Factor	Sum of Squares	Square Mean	*P*
Trans	Symptom	0.567	0.567	**.015***
	Gender	0.007	0.007	.778
	Symptom × Gender	0.211	0.211	.133

[a] CPI, condylar position indicator.
* $P \leq .05$.

observed between side and gender ($P > .05$). A statistically significant effect was present on the factor side on the vertical plane ($P = .033$), and the means on the left side were significantly higher than on the right in both groups (Table 3). A statistically significant difference was found in the comparison of condylar displacement between symptomatic and asymptomatic groups on the transverse plane ($P = .015$) (Table 4), where greater values were observed in the symptomatic group.

No association was seen between displacement directions according to symptoms and side, and no statistically significant effect of interactions was observed between factors ($P > .05$). A statistically significant effect was noted on the factor side (Table 5) ($P = .036$), where the percentage of mesial direction on the right side was significantly higher than on the left side in both groups. Condylar displacement in the mesial direction was more prevalent in asymptomatic individuals (Table 5) ($P = .049$) than in the symptomatic group.

Analysis of the direction of condylar displacement showed that in the symptomatic group, 55.7% of the condyles were displaced in the posterior-inferior direction, 41.3% anterior-inferior, and 2.8% straight inferior. In the asymptomatic group, displacement was anterior-inferior in 55.7%, 35.7% followed a posterior-inferior direction, and 8.5% were straight inferior. The presence of bilateral condylar displacement (left and right sides) in an inferior and distal direction was significantly greater in symptomatic individuals (Table 6) ($P = .012$).

Table 5. Condylar Displacement Direction Distribution (Number of Cases and %) on Horizontal Plane According to Symptom Presence and Side[a]

	Asymptomatic		Symptomatic	
CPI	Right	Left	Right	Left
Horizontal direction				
Mesial	26 (74.3)	19 (54.3)	16 (45.7)	15 (42.9)
Distal	9 (25.7)	16 (45.7)	19 (54.3)	20 (57.1)
Interaction effects	*P*		Factor effects	*P*
Side × Symptom	.116		Side	**.036***
			Symptom	**.049***

[a] CPI, condylar position indicator.
* $P \leq .05$.

Table 6. Chi-Square Test for Comparison of Presence of Bilateral Condylar Displacement (Inferior and Distal Direction on Left and Right Sides)

Bilateral Condylar Displacement	Asymptomatic	Symptomatic
Presence	7 (20.0%)	17 (51.4%)
Absence	28 (80.0%)	18 (48.6%)
Total	35 (100%)	35 (100%)

* $P = .012$.

DISCUSSION

Condylar displacement between CR and MIC mandibular positions was analyzed in comparisons of symptomatic and asymptomatic groups. Results of study error analysis in this study confirmed those of previous studies.[1,10,29] The mean values of the asymptomatic group were consistent with those of Utt et al.,[26] Crawford,[2] Fantini,[24] and the hyperdivergent sample of Girardot,[25] also grouped asymptomatically. The mean values of displacements found in the symptomatic group are higher than those found, by other authors, in asymptomatic groups.[28,29] Because difficulty in mandibular manipulation is fairly frequent in symptomatic individuals, it was expected that symptoms could hamper condylar seating and consequently CR registration. However, this was not observed, indicating that mandibular bimanual manipulation was effective.

Values of greater magnitude on the vertical plane, observed in both groups, are in agreement with those of other studies,[1,24–26,28,30,31,34] being statistically different on the right and left sides (.033). Before major clinical conclusions are reached on the importance of results when the sides are compared, new studies are recommended, because these asymmetries have also been witnessed in the literature on subjects with distinct characteristics.[26,31] Wood and Korne[34] registered major displacements on the horizontal plane on the left side. On the other hand, Fantini[24] found asymmetry on the vertical plane, after neuromuscular deprogramming with "bite splints," and the displacements were greater on the right side. Upon studying symptomatic individuals, Rosner and Goldberg[28] found no difference between the two sides. Diverse authors[2,3,20,35] agree that symptomatic patients with TMD may present significant discrepancies between CR and MIC, especially on the transverse plane observed at the occlusal and articular levels.[4,26] The results of this study also demonstrate greater condylar displacement on the transverse plane in the symptomatic

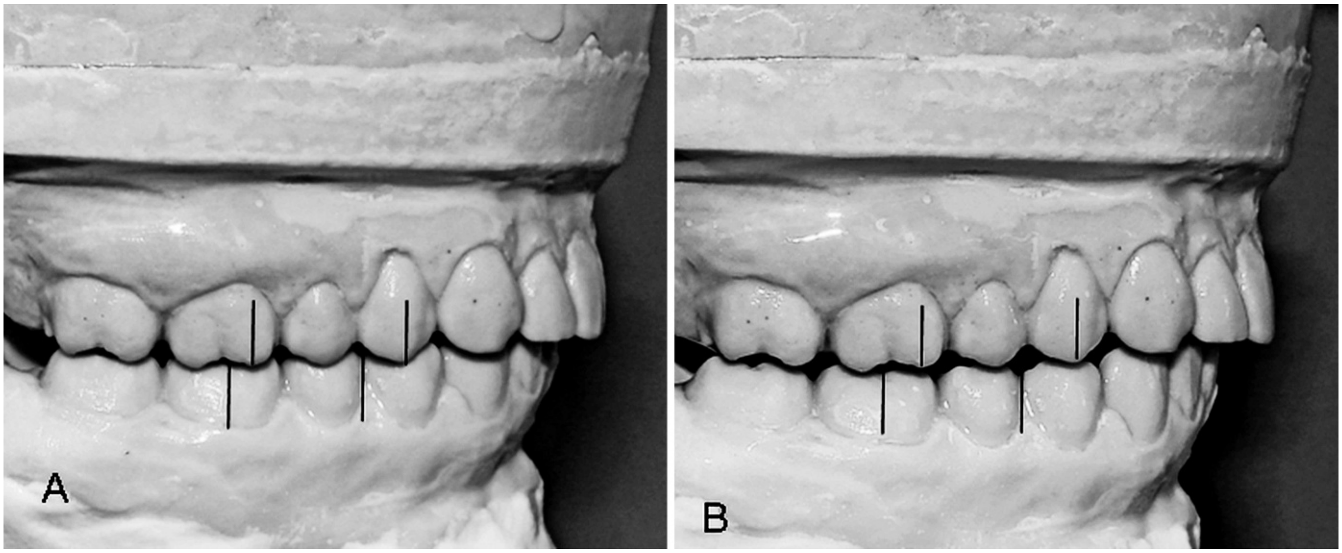

Figure 6. (A) Right lateral view of models mounted in maximal intercuspation (MIC). (B) Right lateral view of models mounted in centric relation (CR) from the same patient.

group. On evaluation of a possible correlation between condylar displacement direction and occurrence of signs and symptoms of TMD, asymptomatic individuals presented a major prevalence of displacement in the mesial direction when compared with symptomatic individuals. The prevalence of directions of displacement—posteroinferior, anterior-inferior, and straight inferior—is in close agreement with that of others who used analogous methods.[1,2,4] The posterior-inferior direction of displacement in symptomatic individuals has already been seen by Weinberg[36,37] and Mikhail and Rosen[38] on tomographs, and lately by Crawford,[2] utilizing similar methods to those used in this study. In comparisons between men and women in both studied groups, no statistical differences were identified. This finding confirms the same conclusions reached by Cordray,[1] Fantini et al.,[24] Utt et al.,[26] and Turasi.[4]

The magnitude of the CR-MIC discrepancy at the condylar level has an influence on occlusal relationships (Figures 6A,B and 7A,B), changing the type or severity of malocclusion, depending on the mandibular position adopted during the analysis. It cannot be quantified directly in the mouth because of some structural features, such as facial type, gonial angle, and occlusal plane inclination, all of which will also influence the resulting malocclusion. This means that patients with distinct facial characteristics will demon-

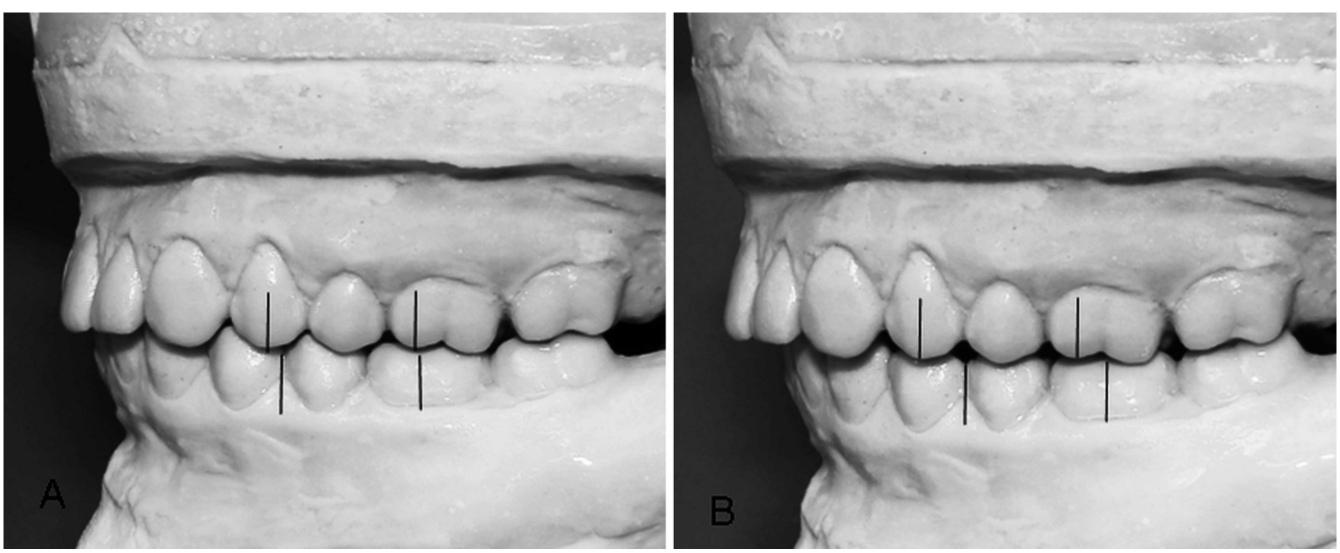

Figure 7. (A) Left lateral view of models mounted in maximal intercuspation (MIC). (B) Left lateral view of models mounted in centric relation (CR) from the same patient.

strate larger or smaller differences between arch relationships, even in the presence of the same amount of condylar displacement. The diagnosis for orthodontic treatment with mounted models in CR is recommended by various authors,[3,10,13,24–26,30,31] by allowing identification of discrepancies that may be masked when analyzed on traditional orthodontic models articulated by hand.

Because condylar displacement was observed in both study groups, orthodontic models mounted in CR are recommended for diagnosis as a routine procedure.[1,3,24] Clinical conditions of TMJ also should be checked at the beginning of, during, and at the end of orthodontic treatment.

CONCLUSIONS

- When the plane and the direction of the displacement were considered, statistically significant differences between CR and MIC were quantifiable at the condylar level in symptomatic and asymptomatic individuals.
- No statistical differences were noted between genders.

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