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

Soo Young Kim Weffort\textsuperscript{a}; Solange Mongelli de Fantini\textsuperscript{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).\textsuperscript{1–20} These usually are not coincident in the general population.\textsuperscript{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

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Accepted: December 2009. Submitted: September 2009. © 2010 by The EH Angle Education and Research Foundation, Inc.

DOI: 10.2319/090909-510.1 835 Angle Orthodontist, Vol 80, No 5, 2010
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 studies1,2,4,24–26,28–30 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 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...
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.

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 technique1,10 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 Reproducibility of CR-MIC Displacement Measurements

<table>
<thead>
<tr>
<th>Operator</th>
<th>CPI</th>
<th>Intraclass Correlation</th>
<th>IC (95%)</th>
<th>Dahlberg’s Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ver R</td>
<td>0.98</td>
<td>0.96 0.99</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>Ver L</td>
<td>0.99</td>
<td>0.98 0.99</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Hor R</td>
<td>0.95</td>
<td>0.90 0.98</td>
<td>0.044</td>
<td></td>
</tr>
<tr>
<td>Hor L</td>
<td>0.90</td>
<td>0.80 0.95</td>
<td>0.055</td>
<td></td>
</tr>
<tr>
<td>Trans</td>
<td>0.88</td>
<td>0.76 0.94</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Inter-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ver R</td>
<td>0.96</td>
<td>0.82 0.99</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>Ver L</td>
<td>0.95</td>
<td>0.76 0.99</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>Hor R</td>
<td>0.93</td>
<td>0.70 0.99</td>
<td>0.049</td>
<td></td>
</tr>
<tr>
<td>Hor L</td>
<td>0.98</td>
<td>0.88 1.00</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>Trans</td>
<td>0.99</td>
<td>0.93 1.00</td>
<td>0.003</td>
<td></td>
</tr>
</tbody>
</table>

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

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

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.

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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 observed (Table 3).
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 asymptomatic 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) ($P = .012$).

### 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. The mean values of the asymptomatic group were consistent with those of Utt et al., Crawford, Fantini, and the hyperdivergent sample of Girardot, also grouped asymptomatically. The mean values of displacements found in the symptomatic group are higher than those found, by other authors, in asymptomatic groups. 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, 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. Wood and Korne registered major displacements on the horizontal plane on the left side. On the other hand, Fantini 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 found no difference between the two sides. Diverse authors 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. The results of this study also demonstrate greater condylar displacement on the transverse plane in the symptomatic

<table>
<thead>
<tr>
<th>CPI</th>
<th>Factor</th>
<th>Sum of Squares</th>
<th>Square Mean</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trans</td>
<td>Symptom</td>
<td>0.567</td>
<td>0.567</td>
<td>.015*</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>0.007</td>
<td>0.007</td>
<td>.778</td>
</tr>
<tr>
<td></td>
<td>Symptom × Gender</td>
<td>0.211</td>
<td>0.211</td>
<td>.133</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>CPI</th>
<th>Right</th>
<th>Left</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal direction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesoiais</td>
<td>26 (74.3)</td>
<td>19 (54.3)</td>
<td>16 (45.7)</td>
<td>15 (42.9)</td>
</tr>
<tr>
<td>Distal</td>
<td>9 (25.7)</td>
<td>16 (45.7)</td>
<td>19 (54.3)</td>
<td>20 (57.1)</td>
</tr>
<tr>
<td>Interaction effects</td>
<td>$P$</td>
<td>Factor effects</td>
<td>$P$</td>
<td></td>
</tr>
<tr>
<td>Side × Symptom</td>
<td>.116</td>
<td>Side</td>
<td>.036*</td>
<td>Symptom</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Bilateral Condylar Displacement</th>
<th>Asymptomatic</th>
<th>Symptomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence</td>
<td>7 (20.0%)</td>
<td>17 (51.4%)</td>
</tr>
<tr>
<td>Absence</td>
<td>28 (80.0%)</td>
<td>18 (48.6%)</td>
</tr>
<tr>
<td>Total</td>
<td>35 (100%)</td>
<td>35 (100%)</td>
</tr>
</tbody>
</table>

* $P = .012$. 

### Table 4. Analysis of Variance of Condylar Displacement on Transversal Plane in Symptomatic Group Comparing Symptoms and Gender*  

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

### Table 6. Chi-Square Test for Comparison of Presence of Bilateral Condylar Displacement (Inferior and Distal Direction on Left and Right Sides)
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.\textsuperscript{1,2,4} The posterior-inferior direction of displacement in symptomatic individuals has already been seen by Weinberg\textsuperscript{36,37} and Mikhail and Rosen\textsuperscript{38} on tomographs, and lately by Crawford,\textsuperscript{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,\textsuperscript{1} Fantini et al.,\textsuperscript{24} Utt et al.,\textsuperscript{26} and Turasi.\textsuperscript{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 6](image-url) (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.

![Figure 7](image-url) (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.

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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, \cite{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. \cite{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.

ACKNOWLEDGMENTS

The authors would like to gratefully acknowledge Dr Frank Cordray, Assistant Clinical Professor in the Department of Orthodontics, Ohio State University, for his precious help in reviewing this manuscript, and also Laura K. Franklin for her assistance in editing and grammar correction. We would like to thank the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for the financial support provided for the development of this study (Grant 05/60076-4). Based on a dissertation submitted to the Faculty of Dentistry, University of São Paulo, Brazil, in partial fulfillment of requirements for the master’s degree.

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