Condylar position assessed by magnetic resonance imaging after various bite position registrations

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Introduction: In this study, we evaluated the reliability and validity of 3 bite registrations in relation to condylar position in the glenoid fossae using magnetic resonance imaging in a symptom-free population. Methods: Nineteen subjects, 14 men and 5 women (ages, 20-39 years) without temporomandibular disorders were examined. Three bite registrations were taken and evaluated on each subject: centric occlusion, centric relation, and Roth power centric relation. The differences in condyle position among the 3 bite registrations were determined for the left and right condyles: centric occlusion-centric relation, centric occlusion-Roth power centric relation, and centric relation-Roth power centric relation for each plane of space. Results: The results indicated that (1) all measurements collected had large standard deviations and ranges with no statistical significance, and (2) of the 19 subjects and 38 condyles assessed, 33 condyles (87%) were concentric in an anteroposterior plane. In the transverse anatomic plane, all condyles were concentric. Conclusions: The clinical concept of positioning the condyles in specific positions in the fossae with various bite registrations as a preventive measure for temporomandibular disorders and as a diagnosis and treatment planning tool is not supported by this study. (Am J Orthod Dentofacial Orthop 2013;144:512-7)

The relationship among condylar position, occlusion, and temporomandibular disorders (TMD) has been the subject of much debate in dentistry for more than a century. A significant part of the debate involves establishing coincidence between a specific definition of centric relation and centric occlusion. It is believed by many gnathologists and the like that failure to achieve this position will predispose patients to developing TMD in the future.1 Despite the lack of data available to support this assertion, many dentists continue to persist in marrying a particular definition of centric relation with centric occlusion as a main goal of treatment. With the current emphasis in dentistry on evidence-based decision-making, the routine establishment of centric occlusion with centric relation in all patients is subject to question.

Centric relation is defined as a position of the condyles in the glenoid fossae, irrespective of the occlusion or tooth contact. Centric occlusion is an interocclusal dental position of the maxillary teeth relative to the mandibular teeth. Over the past half century, the definition of centric relation has evolved from a posterior position of the condyle in relation to the glenoid fossa to a posterosuperior position to eventually an anterior and superior position.2-6 Before 1968, centric relation was considered to be a retracted (posterior) condylar position. The latest edition of the Glossary of Prostodontic Terms defines centric relation as “a maxillomandibular relationship in which the condyles articulate with the thinnest avascular portion of their respective disks with the complex in the anterosuperior position against the slopes of the articular eminences.”6 Contemporary orthodontic gnathologists believe in attaining an anterosuperior condyle position at the
same time the teeth are in centric occlusion (centric relation equals centric occlusion); however, there is little or no scientific evidence to support this view. Dentists who believe in establishing a coincidence of a specific definition of centric relation with centric occlusion unnecessarily subject their patients to procedures that might include orthodontics and irreversible bite-altering procedures, leading to significant financial and biological costs to their patients. In fact, the evidence supports the contrary notion. According to Alexander et al, magnetic resonance imaging (MRI) data of the temporomandibular joint showed that condyles are not located in the assumed positions as advocated by certain centric bite registrations such as retruded centric relation and leaf-gauge generated centric relation registrations. Centric bite registrations attempting to locate retruded (posterosuperior) centric relation and contemporary anterosuperior centric relation do not correspond to the condyle positions of people without TMD. The location of the condyles in the glenoid fossa, irrespective of position, has not been demonstrated to be consequential to the presence or absence of TMD symptoms.

The Roth power centric relation is perhaps the most commonly used contemporary gnathologic record aimed at attaining an anterosuperior centric relation position. To date, MRI has not verified the actual anatomic position of the condyles when this bite registration is taken. The condylar positions in centric occlusion and Roth power centric relation have only been studied on articulators with mandibular or condylar position indicators. The validity of this approach has been questioned and is not supported by MRI data, presumably the most accurate ionizing radiation-free means of assessing 3-dimensional condyle-disc-fossa relationships. In this study, condylar position was assessed using MRI after the use of 3 common bite registrations: centric occlusion, retruded centric relation, and the so-called Roth power centric relation.

**MATERIAL AND METHODS**

Ethics approval for this study was obtained from the Human Research Ethics Committee at the University of Western Australia. Guided by a power analysis, a sample of 19 subjects was studied.

The subjects were 14 men and 5 women (ages, 20-39 years) who met the following criteria: (1) permanent dentition, (2) no congenital craniofacial anomaly or syndrome, (3) no skeletal asymmetry or premature tooth contacts leading to any functional mandibular displacements, (4) no history of trauma to the face or jaws, (5) positive overjet and overbite, (6) no TMD signs or symptoms (all subjects underwent a TMD examination based on the Research Diagnostic Criteria for TMD; although clicking without other symptoms does not indicate pathology or dysfunction, subjects with clicking were excluded from the study), and (8) completed an MRI safety screening check.

Each participant was also informed of the risk of finding any incidental pathology after the MRI scan, but no significant incidental pathology was found.

To standardize the bite registration technique, all records were taken by the same investigator (S.K.). Three bite positions were assessed. The first was centric occlusion, with the subject biting together in maximum intercuspation.

The remaining 2 bite registrations were taken in wax (blue wax; Delar, Lake Oswego, Ore).

Retruded centric relation was taken by applying distal pressure to the chin and taking a wax record at the first point of light occlusal contact. All subjects exhibited a discrepancy between centric relation and centric occlusion. By taking a record at the first point of light occlusal contact, we were able to establish a reference point to base our repeated measurements. This proved to be a highly reproducible registration technique in this study.

Roth power centric relation was taken with a 2-piece wax registration consisting of anterior and posterior sections. The anterior section was first constructed at a vertical where the posterior teeth are at least 2 mm apart. This piece of wax was chilled and allowed to harden. This wax was then placed back into the mouth, a softened posterior section was placed, and the patient was instructed to bite. The mandibular anterior teeth were guided into the hardened anterior section of wax without a slide into the indentations. As the patient closed into the hardened anterior section, he or she was instructed to “close firmly and hold.” The posterior section was chilled with air. When the posterior section had hardened sufficiently to prevent distortion, both wax sections were removed and chilled.

Once the hard wax bite registrations were obtained, they were used to position the subjects’ mandibles in the various occlusal positions as the MRI data were obtained. Originally, acrylic records of the bite positions were fabricated after the articulation of plaster, with the assumption that they would be more accurate. We found, however, that these acrylic records distorted significantly during the fabrication process and provided an inaccurate reflection of the bite records. Since the changes in the bite positions were small, this would have significantly affected the results. We then decided to use the hard wax records, which were stable and more accurate.
MRI scans of each subject were acquired as the subjects occluded at each of the 3 bite relationships. All scans were performed on the same MRI scanner (1.5 T, Signa Excite; General Electric, Fairfield, Conn). Scans were performed with dedicated phased array surface temporomandibular joint coils. An initial low-resolution T1-weighted (repetition time [TR]: 340 ms; echo time [TE], 8 ms) axial localizing scan was followed by a high-resolution T2-weighted (TR 2800 ms, TE 72 ms) sagittal oblique scan acquired perpendicular to the long axis of each condyle (Fig 1). The MRI scans were interpreted by a head and neck radiologist (R.B.) with 8 years of experience reading MRIs of the temporomandibular joint. He was blinded as to which bite registration he was assessing in each subject, and the order of scanning was randomized by the MRI technician. On each side and in each position, measurements of the anteroposterior and superoinferior positions of the condyle with respect to the temporal bone were measured using the following standard cortical bony landmarks: for the anteroposterior position, the anterior margin of the condyle and the summit of the articular eminence; for the superoinferior position, the highest point of the condyle and the deepest concavity of the glenoid fossa (Fig 2).

From the sagittal and transverse anatomic plane MRI views, the radiologist evaluated the concentricity of the left and right condyles in the glenoid fossa in the centric occlusion position. This was done by dividing the condyle into thirds and determining which third was within the central point of the glenoid fossa.

Guided by a power analysis, the 19 subjects were studied to produce 80% power to detect mean differences of at least 1 mm at the 0.05% level of significance.

To assess the variability and reproducibility associated with taking the centric occlusion, centric relation, and Roth power centric relation bite registrations, 3 sets of each were recorded on 3 separate occasions on 2 subjects. These readings were analyzed by a 1-way repeated-measures analysis of variance (ANOVA), which showed no significant (P <0.05) difference between the repeated positions, an indication that this method of determining centric occlusion, centric relation, and Roth power centric relation is reliable.

One observer (the radiologist, R.B.) made all measurements, 3 times on 2 randomly chosen subjects with a 1-week interval between measurements. Intra-class correlation coefficients (ICC) were used to determine the intraobserver reliability, and 95% prediction limits for the errors in measurement are provided. A mean ICC of 0.992 was determined, with an upper limit of 0.995 and a lower limit of 0.985.

Fig 1. Axial low-resolution T1-weighted planning scan (A), showing the plane for planning the oblique sagittal scans (white lines) perpendicular to the long axis of each condyle (C). Note that there is frequently some asymmetry of the axes of the condyles, as in this case. The resultant high-resolution T2-weighted sagittal oblique image (B), showing the articular disc (between arrows), the mandibular condyle (C), and the articular eminence (AE) of the temporal bone.

Statistical analysis

For both the left and right condyles, the differences in condyle position among the 3 bite registrations were determined: centric occlusion-centric relation, centric occlusion-Roth power centric relation, and centric relation-Roth power centric relation for each plane of space. The data were analyzed by 1-way ANOVA and by randomized block 1-way ANOVA with Tukey follow-ups.

RESULTS

For both the left and right condyles, the differences in condyle position between the different bite registrations were determined as follows: centric occlusion-centric relation, centric occlusion-Roth power centric relation, and Roth power relation-centric relation.
No pair of condyles had been positioned posteriorly. In the transverse anatomic plane, all condyles were concentric.

**DISCUSSION**

Based on our findings, the differences between the 3 bite positions were small and, more importantly, highly variable. Since 87% and 100% of the condyles were concentric in the glenoid fossa in centric occlusion in the anteroposterior and transverse planes, respectively, we can safely infer that any significant positioning that would occur from the centric relation and the Roth power bite registrations would be detectable. If the condyles were not concentric in centric occlusion, this would lead to much ambiguity in terms of condylar positioning that would occur with the bite registrations.

Our findings show that the posterior condylar positioning and the anterosuperior condylar positioning associated with centric relation and Roth power centric relation bite registrations, respectively, do not occur. Variability in the findings between the bite registrations appear to reflect the lack of accuracy and predictability in these bite registration processes, especially in terms of determining and positioning the condyles in certain locations of the glenoid fossae. Based on the findings that we are not positioning the condyles in specific positions in the fossae with various bite registrations, the clinical significance followed by the routine practice of condylar positioning must be questioned. Hence, previous studies reporting any changes as a result of these centric relation bite registrations and studies using these centric relation bite registrations to assess and report any differences between nongnathologically treated and gnathologically treated orthodontic patients would appear to be invalid.

The variability in the findings might be related to the asymmetry in the long axes of each pair of condyles in each subject. This is a normal finding, and this asymmetry prevents each pair of condyles from functioning like a hinge axis as originally proposed by the flawed terminal hinge axis theory of Posselt. The presence of 2 asymmetrically angulated condylar long axes would naturally lead to condyles translating and rotating simultaneously as soon as mandibular opening and closing is initiated.

The Roth power bite registration is taken when there is at least 2 mm of separation at the posterior teeth. This bite registration is then transferred onto an articulator, with its known inaccuracies, to facilitate mounting of the upper and lower study casts. After removal of the bite registration after the mounting, the upper and lower casts close down to occlude, reducing the vertical dimension. Since the condyles rotate and
translate on mandibular opening and closing, this further reduces the validity of determining or establishing any position of the condyles in the glenoid fossae from centric relation to centric occlusion. Furthermore, if the Roth power bite registration is taken when there is at least 2 mm of separation at the posterior teeth, then this is the position of the condyles at that particular vertical dimension. This would lead to the assumption that every patient’s vertical dimension is planned to be opened to at least 2 mm during orthodontic treatment to establish this particular Roth power centric relation. We must ask then ourselves, “What happens if further bite opening or closing occurs during treatment?”

It would appear from the data that if we cannot accurately predict and position condyles in certain locations in the fossae, then the original position of the condyles in centric occlusion is a reasonable physiologic guide on which to base treatment. These findings appear to support the logical and more compelling notion that any procedure that deviates or positions the condyles away from a position they naturally occupy is not only unphysiologic but perhaps also potentially harmful to the patient in the long term.

When centric relation bite registration procedures are carried out in children, it appears that little consideration is given to any growth-related changes during treatment in terms of trying to establish and then maintaining this particular centric relation. Not only are there cranial base, maxillary, and mandibular growth changes, but also condylar growth changes and glenoid fossae remodeling. This would mean that centric relation bite registrations need to be taken regularly during treatment to accommodate any growth-related changes; this is not done. This further reduces the validity of establishing any particular centric relation before, during, and after orthodontic treatment.

Because the practice of positioning condyles in specific positions in the fossae routinely to mitigate or prevent TMD has been followed for the last several decades, it would appear that condyles might have been placed unpredictably in the glenoid fossae, while clinicians have assumed otherwise. According to our findings, any observed reduction in TMD after treatment involving condylar positioning with different bite registrations would most likely be related to observer bias, the biopsychosocial medical model, the cyclical nature of TMD, and the placebo effect, rather than to some specific positioning of the condyles in the fossae that was actually random. Because of the small and unpredictable nature of condylar positioning associated with centric relation and Roth power bite registrations, advocating this modality routinely in clinical practice as a prophylactic measure for TMD is invalid and unjustified.

According to our findings and the available evidence-based literature, treatment philosophies based on clinical assumptions purporting an improved long-term functional superiority of one centric relation to another is unsupported and clinically insignificant.

**CONCLUSIONS**

Our data fail to support the claim that certain bite registrations can accurately and predictably position condyles into specific locations in the glenoid fossae. These findings question the physiologic and clinical relevance of certain treatment philosophies that aim to orthodontically establish occlusions around a particular centric relation position.

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**Table.** Means, ranges, and standard deviations (mm) for the left and right condyles of the differences in condyle position between the bite registrations for each plane

<table>
<thead>
<tr>
<th>Plane</th>
<th>Reference</th>
<th>Side</th>
<th>Mean (SD)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteroposterior</td>
<td>CO-CR</td>
<td>Right</td>
<td>0.16 (0.90)</td>
<td>−1.20</td>
<td>2.90</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>−0.16 (0.58)</td>
<td>−1.00</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CO-Roth CR</td>
<td>Right</td>
<td>−0.03 (0.78)</td>
<td>−1.20</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>−0.14 (0.80)</td>
<td>−1.50</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR-Roth CR</td>
<td>Right</td>
<td>0.19 (0.89)</td>
<td>−2.40</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>0.01 (0.57)</td>
<td>−0.90</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Superoinferior</td>
<td>CO-CR</td>
<td>Right</td>
<td>0.36 (0.43)</td>
<td>−0.70</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>−0.04 (0.43)</td>
<td>−0.80</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CO-Roth CR</td>
<td>Right</td>
<td>0.21 (0.53)</td>
<td>−0.70</td>
<td>1.40</td>
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<tr>
<td></td>
<td>CR-Roth CR</td>
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<td>−0.06 (0.43)</td>
<td>−0.90</td>
<td>0.80</td>
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<td>Left</td>
<td>0.07 (0.28)</td>
<td>−0.60</td>
<td>0.50</td>
<td></td>
</tr>
</tbody>
</table>

CO, Centric occlusion; CR, centric relation.
ACKNOWLEDGMENTS

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REFERENCES