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## An evidence-based evaluation of the concept of centric relation in the 21st century

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The concept and application of a temporomandibular joint (TMJ) relationship identified as centric relation (CR) has changed significantly over the past century. Originally proposed as a biologically reasonable position where maxillary and mandibular dentures should occlude, it later was applied to the dentate population as well. The term “ideal” was used by the gnathologic dental community as they sought to define the exact details of CR in terms of condyle-fossa relationships. Assessments of patients’ occlusion were then made in relation to CR, and discrepancies between the two positions were described as being problematic. Since not all dentists have accepted this concept, the clinical application of CR has become a topic of major dental confusion and controversy. To further complicate things, the formal definitions of CR have continuously changed over the

past 40 years. In this paper, the biologic development of occlusal and TMJ relationships is reviewed, followed by a discussion about the validity of applying CR concepts and procedures in contemporary clinical and research settings. Special attention is devoted to the alleged relationships between occlusion, jaw positions, and temporomandibular disorders (TMDs). Current evidence suggests that it is time to stop applying CR concepts to the evaluation and dental treatment of healthy dentate individuals. For patients with TMDs, it is time to apply current concepts of biopsychosocial assessment and management rather than following the 20th century mechanistic models of fixing dental and skeletal malalignments. (*Quintessence Int* 2018;49:755–760; doi: 10.3290/j.qi.a41011)

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For the dental profession, the concept of centric relation (CR) has been a major component of occlusion theories for over 100 years. Simply stated, the term CR refers to the clinically repeatable mandibular position involving the relationship of the mandibular condyles to the glenoid fossae within the temporal bone of the cranium. This position is independent of the tooth contacts. The first formal definition of CR appeared in the Glossary of Prosthodontic Terms (GPT) that was pub-



lished in 1987,<sup>1</sup> and it has been redefined in several subsequent editions by the Academy of Prosthodontics, with the latest version appearing in 2017 (GPT-9).<sup>2</sup> This concept assumes that while in CR, the mandible rotates around a relatively stable horizontal axis within the articular fossae. Among other things, registration of CR has been described as a necessary clinical step for the purpose of transferring the patient's maxillary and mandibular dental casts to an articulator.

The controversies related to CR exist primarily due to disagreements about its definition, position, and repeatability, as well as its clinical application and relevance. Clinically, this reference position of the mandible relative to the skull has generally been defined in terms of an anatomically described positional relationship of the condyle in the articular fossa. While the details of defining CR as well as the methods for finding it have changed several times over the years, the intention has consistently been to describe CR not only as a clinically important mandibular position, but also as a biologically sound and desirable jaw position. If CR either does not exist as defined, or is not always located in the same position relative to the cranium, one must question its reliability and validity as a reference for mounting maxillary and mandibular casts on an articulator.

The purpose and focus of this paper is, first, to review the biologic development of craniomandibular relationships in growing humans as it relates to the temporomandibular joints (TMJs) and occlusion, and then to discuss the validity of applying CR concepts and procedures in contemporary clinical practice as well as the alleged relationships between occlusion, jaw positions, and temporomandibular disorders (TMDs). TMDs comprise a group of neuromuscular skeletal conditions that involve the TMJs, the masticatory muscles, and associated tissues.

Three major areas of dental practice are considered in this discussion:

- Management of the edentulous patient
- Management of various occlusal conditions in dentate patients
- Management and/or prevention of TMDs.

## CRANIOMANDIBULAR GROWTH AND DEVELOPMENT IN HUMANS

For the first 6 months of life, the edentulous infant has a small ball-shaped condyle articulating with a shallow articular fossa.<sup>3</sup> As the craniofacial bones develop and the primary teeth erupt into occlusion, the occlusal contacts during closure determine where the condyles will be seated.<sup>4</sup> When the primary teeth exfoliate while the underlying permanent teeth erupt into a functional occlusion, the relationship of the mandibular condyles to the cranium continuously changes until dentofacial growth and development is complete.<sup>5-7</sup> Thus, the whole process of the establishment of the condyle-fossa relationship in a normally growing individual involves a complex synergistic process, which is driven by the occlusal relationship of the maxillary and mandibular teeth.<sup>8</sup> In adults, even in the absence of dental interventions, these relationships are changing continuously every day as result of tooth wear and remodeling of TMJ tissues, as well as adaptive TMJ remodeling due to cellular changes in the facial and masticatory muscles.<sup>9</sup> Adaptive remodeling in the TMJs refers to changes that occur over time within the joint including structures such as the disk and the fibrocartilage lining of the articular surface of the condyles and fossae. This homeostatic process is the biologic basis for each person's "normal" craniomandibular relationship, and it is worth noting that these relationships are almost always anterior to any definition of a CR position.<sup>10</sup>

In most healthy dentate subjects, the gross relationship of the bony components of the TMJs remains relatively stable over long periods of time; but with extreme dental wear, extensive tooth loss, or degenerative changes in the joint, there can be significant changes in the condyle-fossa relationship.<sup>11</sup> Degenerative changes within the joint commonly refers to deterioration of the articular tissues with osseous changes at the condyles and articular eminence. Based on all of these physiologic processes involved in growth as well as aging of the craniofacial hard and soft tissues, it is not logical to expect the mandibular condyles to stay in a specific position within the glenoid fossae over sev-



**Table 1** Definitions of commonly used terms regarding jaw relationships and occlusal relationships

Abbreviation	Term	Definition
CR	Centric relation	This refers to the relationship of the mandibular condyles to the cranium, independent of tooth contact. This has been described as the ideal jaw relationship.
CO	Centric occlusion	Formerly known as CRO, this is the relationship of the maxillary and mandibular teeth when the mandible is in CR. This may or may not coincide with maximum intercuspation, MI.
MI	Maximum intercuspation	This refers to maximum intercuspation of the maxillary and mandibular teeth independent of condylar position. Also known as maximal intercuspal position or as maximum interdigitation. When this occlusal relationship does not coincide with CR, it is referred to as the presence of an MI-CR discrepancy.
When CO = MI this has been described as the ideal occlusal relationship.		

Adapted from The Academy of Prosthodontics, Glossary of prosthodontic terms.<sup>2</sup> These terms are further described and discussed throughout this paper.

eral decades. Clinically, this means that each individual person who maintains an intact dentition may have many different versions of a “normal” TMJ relationship throughout their life.

## RELIABILITY AND VALIDITY OF THE CR POSITION

The main arguments for utilizing a CR concept in clinical dentistry have been that it represents some kind of ideal relationship between the mandible and the cranium, and that it is highly reproducible. Many clinicians believe that they are capable of clinically identifying a particular defined version of CR. This is usually carried out with various kinds of CR bite registration procedures, with or without a preceding process of occlusal deprogramming using oral appliances. The two main questions, however, have always been whether these centric bite registration procedures could actually identify a CR position clinically, and whether this position - once located - has any real clinical benefits.

Recent research indicates that the condylar positions obtained by various bite registration methods do not correspond to what the clinicians are describing. Furthermore, the location of the condyles in the glenoid fossa, irrespective of position, has not been demonstrated to be etiologically related to the presence or absence of TMD symptoms.<sup>12-15</sup>

A study by Alexander et al<sup>16</sup> performed over 25 years ago used magnetic resonance imaging (MRI) to

reveal that condyles were not predictably located in the assumed positions as proposed by certain clinicians; this included manual methods such as manipulation to a retruded CR position as well as leaf-gauge generated CR registrations. Alexander et al<sup>16</sup> also showed that bite registrations attempting to locate a traditional postero-superior CR<sup>1</sup> or a contemporary antero-superior CR<sup>2</sup>, did not produce results that corresponded to the expected condyle positions in subjects free of any TMD signs and symptoms.

According to the contemporary gnathology-based members of the orthodontic profession, the Roth Power centric relation registration method is the preferred gnathologic approach for attaining an antero-superior CR position.<sup>17-24</sup> More recently, however, the validity of this approach has been questioned in a clinical study utilizing MRI, which is the most accurate ionizing-radiation-free means of assessing three-dimensional condyle-disk-fossa relationships. In 2013, Kandasamy et al<sup>25</sup> assessed those relationships using MRI following the use of three common bite registrations: maximum interdigitation of the teeth (MI), retruded CR, and Roth Power CR (see Table 1). They found that neither the posterior condylar position (retruded CR) that is supposed to be attained by mandibular guidance, nor the more antero-superior Roth CR position, were consistently achieved by the clinicians performing those procedures. The variability in the findings between the bite registrations appears to reflect the lack of accuracy and predictability of these



registrations, rather than being due to any fault with the clinicians themselves. Therefore, the clinical utility of these types of CR registrations must be questioned.

## CLINICAL VALIDITY OF UTILIZING CR IN DENTAL PRACTICE

### Use of CR position in edentulous patients

The first dental experts who introduced a CR concept were focused mainly on the fabrication of maxillary and mandibular complete dentures. Since there were no teeth present to provide an antero-posterior guidance or vertical stop, clinicians had to devise a baseline method for establishing a reasonable horizontal and vertical jaw relationship in order to fabricate dentures that were both esthetic and functional.<sup>26</sup> The horizontal component of that method involved combinations of manual manipulation of the mandible and various jaw-closing training exercises. These procedures are still being used today in order to establish CR in patients who need that type of dental rehabilitation, including those who receive implant-supported full prostheses.

### Use of CR in management of occlusal conditions in dentate individuals

The transition from treating the edentulous population to the assessment of dentate patients was a major turning point in the history of clinical CR concepts.<sup>27</sup> Almost 100 years ago, the early gnathologists proposed that CR was not just a reference position, but in fact should be viewed as a biologically ideal jaw position. Therefore, the full interdigitation of maxillary and mandibular teeth in a dentate patient (MI, maximal intercuspation) should ideally occur when the mandible is in its reproducible CR. This ideal occlusal relationship was also known as centric relation occlusion (CRO), but in recent years it is referred to as centric occlusion (CO) (Table 1). Thus, when MI coincides with CO, the patient is described as having ideal occlusion. However, if the patient's MI is not reproducible, or if there appears to be a discrepancy or slide between CO and MI, then dental treatment must be carried out to correct this

discrepancy. This concept led to a variety of occlusal treatments including bite opening, equilibration, dental reconstruction, orthodontics, and orthognathic surgery being carried out in otherwise nonsymptomatic individuals.<sup>28</sup>

Interestingly, studies as early as in the 1960s<sup>29-32</sup> found that even when entire dentitions were reconstructed with the patients' mandibles in a CR position, many subjects continued to close and function in their more anterior positions. These findings highlight the importance of performing dental treatment within the physiologic limits of each individual patient, rather than basing it on a nonbiologic mechanical concept of the ideal jaw relationship.

### Use of CR in the management or prevention of TMDs

The history of occlusion-based etiologic theories for the development of TMD signs and symptoms has been discussed elsewhere by several authors.<sup>33,34</sup> A vast amount of research conducted over the past 30 years has shown that occlusal and skeletal disharmonies are not significant etiologic factors for the development of TMDs. Nevertheless, during the last half of the 20th century occlusal theories continued to be predominant in the TMD field. Because CR was an important component of such theories, the protocols for examining and treating TMD patients generally included manipulation of the patient's mandible to determine if it was in CR. This was followed by an assessment for a CO-MI discrepancy, after which occlusion-modifying procedures would be performed to establish their coincidence.<sup>17-24</sup> These procedures may have included equilibration, orthodontics, and other irreversible bite-altering protocols, leading to significant financial and biologic costs for patients.

The conceptual basis for this approach is, however, deeply flawed for several reasons. First, as discussed above, it has been shown that positioning condyles to specific locations within the glenoid fossae is not a valid procedure in terms of consistent and accurate outcomes. In addition to this major shortcoming, there are numerous limitations and significant errors associ-



ated with the use of instruments such as articulators, axiograph and pantograph tracings, and condylar position indicators. Furthermore, many problems exist regarding the whole CR transfer and mounting process. These include the registration and transfer of the face-bow record, errors in orientation of the casts, flexion of the bite fork when mounting the maxillary cast, mounting stone expansion and contraction, and usage of average articulator settings.<sup>35-39</sup> All of these factors make it impossible to accurately locate and transfer a CR position.

Meanwhile, a considerable amount of research evidence has demonstrated that condylar position and occlusal factors such as CO-MI discrepancies do not play a significant role in the etiology of TMDs. Instead, we have seen the evolution of the medical and biopsychosocial model for TMD diagnosis and management.<sup>40</sup> As a result, it has been concluded that there is no justification for using condylar repositioning or occlusal modification procedures as part of current diagnostic, preventative, or management approaches in patients diagnosed with TMD.

## CONTEMPORARY CLINICAL APPLICATIONS FOR THE CONCEPT OF CR

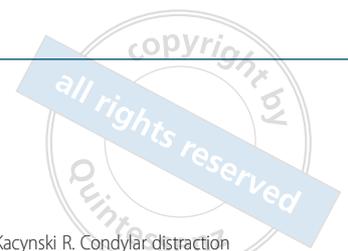
Despite the shortcomings of the concept of CR in clinical practice that have been reviewed in this article, there still are some clinical situations in dentistry where establishing a reasonable jaw relationship is required. These include fabrication of complete dentures as well as various types of full-mouth reconstructions involving fixed and/or removable prosthodontics, with or without implants. In addition, orthodontists need to have a reasonable target zone for finishing their cases in a biologically stable jaw relationship; this is especially true if functional appliances have been used at some stage to posture the mandible in a forward position during treatment. Finally, it is essential to finish cases in stable jaw relationships when performing any orthognathic jaw surgery procedures as well as with certain types of TMJ surgery.

The contemporary approach for establishing a biologically reasonable version of CR is based on simply ensuring that the patient does not have a significant dual bite (ie, a large discrepancy between CO and MI) or any other habitual functional bite position. A simple method of evaluating this is by gently guiding the chin posteriorly while the patient rolls his/her tongue back. This step should form part of a basic dental examination to detect the existence of any significant dual bite position, and also to identify the extent of the overjet and overbite as well as underlying skeletal and dental relationships. The presence of a significant dual bite relationship will indicate that the patient has a significant skeletal discrepancy and any diagnoses made regarding the patient's skeletal and dental malocclusion needs to be based on the patient's CO position. This is critical prior to embarking on any complex occlusion-changing procedures.

Finally, based on the current best evidence, the authors recommend using the original maxillomandibular relationship with the patient's teeth in maximum intercuspation as a reasonable physiologic guide when restoring and replacing teeth in dentate patients. In other words, the evidence seems to support the logical and compelling notion that a patient's existing and repeatable jaw relationships should be maintained during routine dental procedures, instead of deliberately altering condyle-fossa relationships. Finally, it is important to emphasize that any procedure that deviates or positions the condyles away from a position they naturally and physiologically occupy may not only be unnecessary, but it also can potentially be harmful to the patient in the long term.

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