The importance of the seated condylar position in orthodontic correction

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It has been proposed that the discrepancy between the seated and unseated condylar position be identified and eliminated when the occlusion is reorganized. Identification of this discrepancy is most accurately accomplished through the use of diagnostic casts that have been taken from a deprogrammed patient and mounted in the seated condylar position on a semiadjustable articulator through an estimated facebow transfer. The amount and direction of any discrepancy is determined three dimensionally with condylar position instrumentation. *(Quintessence Int 2002;33:284–293)*

Key words: articulator, condylar displacement, condylar distraction, orthodontics, seated condylar position, unseated condylar position

A previous article outlined steps that orthodontists must take to advance the specialty into the new millennium[1]:

1. Specific, comprehensive, and universal treatment goals must be developed.
2. Occlusion, temporomandibular joint function, facial esthetics, and periodontics must receive greater emphasis in graduate orthodontic programs.
3. The quality of orthodontic records must be upgraded to include diagnostic study casts mounted in the seated condylar position.
4. A comprehensive orthodontic classification system must be developed.
5. Orthodontic diagnosis must become more accurate.
6. Orthodontic treatment time must be minimized.

These issues constitute the foundation for state-of-the-art orthodontic treatment in the 21st century, which will include the following:

1. The use of a repositioning splint to eliminate muscle symptoms and attain a comfortable, stable, and repeatable seated condylar position
2. Instrumental analysis of diagnostic study casts: mounting of diagnostic study casts in the seated condylar position on a semiadjustable articulator through the use of at least an estimated facebow transfer
3. Measurements of jaw deflections caused by tooth-dictated positions (currently measurable with the Condylar Path Indicator [CPI] [Panadent], the Mandibular Position Indicator [MPI] [SAM], and Cranio-Mandibular Position [CMP] [Denar] instrumentation)
4. Computer-assisted treatment planning, including corrected cephalometrics (conversion of lateral cephalograms from maximum intercuspation-centric occlusion (MIC-CO) to the seated condylar position); computerized cephalometric analyses corrected for jaw deflections; computerized growth determinations; and computer-aided treatment forecasts (Visualized Treatment Objectives [VTOs])
5. Video imaging as an aid to optimizing dental, skeletal, and soft tissue esthetics

Howat et al[2] have stated, "Orthodontic assessment of patients has evolved as treatment goals have changed," which leads to the discussion of a fundamental aspect of orthodontic treatment: What are the goals of orthodontic correction? Ultimately it comes down to clinical results. Two overriding concerns for those delivering orthodontic care are improved esthetics (facial and dental) and increased longevity of the dentition and associated structures (periodontium and temporomandibular joints).

How are these goals accomplished? Consistently excellent results are achieved by the application of sophisticated treatment goals and utilization of a sophisticated appliance system. Two areas of prime importance for both the practitioner (from a practice management standpoint) and the patient (from a satisfaction standpoint) are satisfying the patient's chief concern and treating the patient in the shortest time possible, to achieve the desired result.

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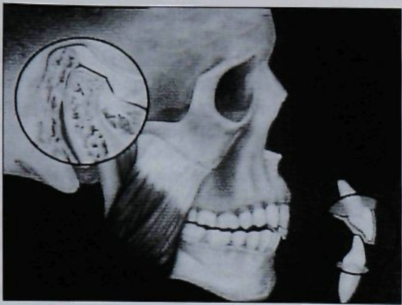


Fig 1 Seated condylar position: superior, anterior, and midsagittal.

Fig 2 Premature occlusal molar contact visible on casts mounted on an articulator in the seated condylar position.

ORTHODONTIC TREATMENT GOALS

The application of specific, comprehensive orthodontic treatment goals is paramount to the execution of the aforementioned principles.

Facial esthetics

Improved esthetics is what drives most patients to seek orthodontic care. The importance of esthetics for self-image cannot be overstated. The psychological and social development of patients is related in increasing amounts to attractiveness and a favorable self-image. A sensitivity to patient expectations and motivations, as well as treatment possibilities, must be developed if the orthodontist is to end up with consistently satisfied patients.

Dental esthetics

As a result of his pioneering research on the common characteristics of untreated ideal occlusions, Andrews[3] proposed "six keys to normal occlusion" as static occlusal goals for orthodontic correction. These keys are the ideal for static dental alignment, thus providing a guideline for the precise positioning of each tooth in all three planes of space.

Periodontal health

Periodontal health in the context of orthodontic treatment goals means both adequate hard and soft tissue support and management of soft tissue for stability and esthetics.

Functional occlusion and seated condylar position

A fundamental aspect of orthodontic correction is the need for coordination of tooth position with jaw function.[4-7] Roth[8,9] added further keys that relate Andrews' static occlusal goals[3] to occlusal function and developed the orthodontic treatment mechanics that make it possible to attain functional occlusion treatment goals orthodontically.

A number of practitioners have advocated mounting diagnostic study casts in the seated condylar position,[10-23] while others[3,8,9,24-34] have outlined practical techniques for accomplishing condylar position treatment goals orthodontically. If the treatment goal is coordinated tooth and jaw function (as is taught in all dental schools throughout the nation), then diagnosis from and treatment toward the seated condylar position is of paramount importance.

SEATED CONDYLAR POSITION

Definition

The *seated condylar position* is defined as superior, anterior, and midsagittal, centered transversely (Fig 1). This is the essence of optimal temporomandibular joint form and function.[28,35,36] It has been shown that the overwhelming majority of the human population exhibits an occlusal prematurity on the most posterior tooth.[21,37-39] Traditional orthodontic study casts (hand-held casts trimmed in MIC-CO) do not reflect this fact. When a premature occlusal contact (Fig 2) is present, the condyle is distracted or displaced down and away from the optimal seated position, in order to intercuspate the teeth into MIC-CO (the occlusion-dictated condylar position).

Condylar distraction or displacement is defined as the difference in condylar position between the seated and unseated (occlusion-dictated) positions (the position of the condyle caused by intercuspation of the teeth). Most condylar displacements are vertical displacements, not horizontal displacements, because the condyle drops inferiorly in the fossa as the mandible shifts superiorly in the region of the incisors.

Measurement techniques

Previous attempts to measure the seated condylar position have utilized methods such as intraoral visual estimation,[40] measurement of the hit-and-slide at the occlusal level,[41] radiographs (panoramic, transcranial, or lateral cephalometric radiography, corrected tomography, and arthrography),[42] and magnetic resonance imaging or computed tomography scans.[43] However, these do not allow measurement of the mandibular functional shift from the unseated (occlusion-dictated) condylar position to the seated condylar position in all three planes of space to 0.2 mm. In fact, it has been shown that condylar position cannot be accurately determined radiographically.[44-62] The new gold standard for the measurement of condylar position was proposed by the author in 1997.[63] Only three-dimensional condylar graph measurements made from articulated study casts that have been mounted in the seated condylar position from a deprogrammed patient will yield this information.

Identification of the discrepancy between the seated and unseated (occlusion-dictated) condylar position is most accurately accomplished with diagnostic study casts taken from a deprogrammed patient; these casts must be mounted in the seated condylar position on a semiadjustable articulator through the use of at least an estimated facebow transfer.[27,30-34,64-68] The amount (millimeters) and direction (anteroposterior, vertical, and transverse) of any discrepancy between the seated and unseated condylar position can be determined with ease through the use of condylar position instrumentation available today (CPI; MPI; CMP; Vericheck, Denar; modified Buhnergraph, Whip Mix).

Advantages and indications

The condylar graph measurement technique has a number of advantages:

1. It is simple and easy to perform.
2. It is available to every dental practitioner.
3. It is inexpensive (the most cost-effective method available to determine condylar position).
4. It is noninvasive.
5. It is highly accurate (the most accurate method for determining condylar position in all three planes of space to within 0.2 mm anteroposteriorly and vertically and 0.1 mm transversally).

The seated condylar position is a three-dimensional entity that must be assessed with a three-dimensional measuring device. This is a much more sophisticated and accurate method for measuring condylar position.[27,34,60,64-67]

Howat et al[2] have stated that the discrepancy between the seated and unseated condylar position must be identified and eliminated when the occlusion is to be reorganized, which is required:

1. When posterior occlusal stability is to be restored by occlusal adjustment or tooth restoration.
2. When mandibular dysfunction is to be treated.
3. Before placement of multiunit restorations.
4. Before fabrication of complete dentures.
5. When orthodontic treatment is planned.
6. When the condyle is to be positioned during orthognathic surgery.

Success or failure of treatment in each of these areas is completely dependent on the ability of the operator to attain a comfortable, stable, repeatable seated condylar position as a reference point.

Importance to orthodontic correction

The importance of the seated condylar position in orthodontic correction is as follows: orthodontics provides the ability to move every tooth in all three planes of space, making orthodontic treatment comparable to complete-mouth restoration or a complete denture setup.[69,70] Thus it is imperative to have a comfortable, stable, and repeatable seated condylar position to work from.

It has been asserted that in 25% to 30% of orthodontic cases the decision-making process would be affected by an articulator mounting in the seated condylar position, because of the presence of a significant condylar distraction.[9,71-75] However, the clinical experience of the author is that this information affects every orthodontic case that is treated. Seven important decision-making areas are affected:

1. Diagnosis:
   a. Magnitude (mm) of the horizontal discrepancy (Class II, Class III) to be corrected
   b. Magnitude (mm) of the vertical discrepancy (open bite, deep bite) to be corrected

c. Magnitude (mm) of the transverse discrepancy to be corrected
d. Direction of mandibular growth
e. Direction of mandibular rotation anticipated with treatment
2. Treatment planning:
a. Extraction versus nonextraction
b. Nonsurgical versus surgical treatment
3. Anchorage requirements (minimum, moderate, or maximum)
4. Treatment mechanics (dictated by all of the above, especially the diagnosis and anchorage requirements)
5. Occlusal finishing (arch coordination in all three planes of space)
6. Evaluation of orthodontic treatment effects
7. Evaluation of orthodontic relapse

Fig 3 Lateral cephalogram of a patient with severe vertical distraction of the condyles, resulting in a noticeable joint space *(arrows)* visible superior to the condyle.

It is faster, easier, less expensive, and more accurate to mount diagnostic study casts in the seated condylar position than to trim them in MIC-CO (habitual position).[2,29,34,76] Diagnostic accuracy is increased because muscle splinting is eliminated. Muscle splinting is part of the neuromuscular protective mechanism and postures the mandible into the best tooth fit. It does not allow the operator to detect the discrepancy between the seated and unseated condylar position clinically at the chairside when manipulating the jaw. Muscle splinting may disappear during orthodontic treatment, allowing the mandible to drop back, revealing a larger discrepancy than at the start of treatment (dual bite).

The problem lies in the fact that the effect of muscle splinting is not detectable clinically.[9,23,26,77]

Because the neuromusculature is programmed to close the mandible into the best tooth fit, it is difficult to identify the seated condylar position through clinical evaluation or mandibular manipulation alone. Patients avoid interferences and occlude into the best tooth fit, even at the expense of the joints. Occlusal disharmonies cannot be studied (or even consistently detected) in the functioning mouth because the muscles and nerve reflexes protect the teeth by overriding the joint's guidance.

Neuromuscular deprogramming is the key to reproducibility.[9,23,26,27,32,60,78–92] Without deprogramming, it is highly unlikely that the seated condylar position will be captured clinically. Therefore what is seen in the mouth may not be what is really being treated.[7,9,12,20,23,26,27,30,32,60,78,93–99] When indicated, a repositioning splint is an extremely valuable, reversible, and conservative appliance that aids in the therapeutic, diagnostic, and treatment planning phases of orthodontic correction.[9,26,30,60,93–99]

This information directly affects cephalometric evaluations as well. First, a significant condylar displacement can often be detected on a routine lateral cephalogram; when the condyle is severely distracted vertically, a noticeable joint space is visible superior to the outline of the condyle (Fig 3). This is not normal; typically these structures are superimposed when the condyle is seated near its undistracted position. If a condylar displacement is suspected on a lateral cephalogram or corrected tomogram, then it would be pertinent to determine the full extent of the condylar displacement by mounting the dental casts and accurately measuring the discrepancy. In addition, it has been shown that cephalometric measurements performed in the seated condylar position (rather than in the unseated or MIC-CO condylar position) yield more accurate diagnostic information regarding the magnitude of the skeletal and dental discrepancies in the horizontal and vertical planes.[100–105]

The information gained from an articulator mounting in the seated condylar position and three-dimensional condylar graph measurements can be applied across the broad spectrum of cases routinely encountered in clinical practice. In a high percentage of patients, the interarch relationships in the seated and unseated positions are substantially different. This can be evaluated by comparing the intraoral interarch relationship to the interarch relationship observed on mounted casts in the seated position. Thus, these cases could each be treatment-planned a number of different ways, depending on the overriding treatment objectives of the clinician.

For example, a basic treatment planning decision that is made for all orthodontic patients is whether or not to extract teeth and, if so, which teeth? In most cases, an argument could be made for either a nonextraction or an extraction treatment plan, depending on a number of factors, one of which is the magnitude of the horizontal, vertical, and/or transverse interarch discrepancy present. This information is precisely revealed by an articulator mounting in the seated condylar position. In addition, an articulator mounting may reveal an interarch discrepancy that may have a surgical treatment option as well as conventional orthodontic treatment options.

Furthermore, the anchorage requirements and choice of treatment mechanics is directly affected, depending on the magnitude of the horizontal or vertical interarch discrepancy present pretreatment, which is precisely revealed by an articulator mounting in the seated condylar position. However, the treatment planning and mechanical choices are limited if the overriding treatment objective is to reduce the pretreatment condylar displacement. Seating the condyle with orthodontic correction requires precise vertical control. Reduction of the pretreatment condylar displacement can be achieved orthodontically through the use of various treatment methods (extraction, nonextraction, high-pull facebow, transpalatal bars, bite blocks, elastics, mounted tooth positioner, splint wear, orthognathic surgery, and equilibration).

Occlusal finishing can be more accurately accomplished if the pre-deband casts are first mounted in the seated condylar position. The mounting is then used in two ways. First, it is used to assess the interarch relationships near the end of treatment, allowing the clinician to adjust tooth positioning as needed (anteroposteriorly, vertically, or transversally). Often this mounting will reveal either posterior torque deficiencies or transverse arch discrepancies (inclined plane contacts or arch coordination problems) that have to be addressed to gain posterior intercuspation without condylar displacement. Second, the mounting is used to fabricate a tooth positioner from an ideal setup with the condyle seated. The positioner is used to maintain condylar seating while settling of the dentition is controlled vertically.

Moreover, the seated condylar position is the benchmark from which true comparisons of treatment effectiveness (both skeletal and dental) can be made. It is the only valid reference point for comparison of treatment effects in orthodontics. The unseated (occlusion-dictated) condylar position (condylar position in MIC-CO) has inherent error as a reference point because of the lack of understanding of the magnitude of the mandibular functional shift (hit and slide) present before and after treatment. Failure to understand this principle has been the source of great confusion, misunderstanding, and miscommunication in both dentistry in general and orthodontics in particular.[68,106] To obtain precise measurements of the skeletal and dental changes with treatment, it is essential to begin with a stable, repeatable condylar position and end with a stable, repeatable condylar position and then assess the result. This is how treatment efficacy is accurately determined.

In the evaluation of orthodontic relapse, certain phenomena such as dual bites (both vertically and horizontally), relapse of horizontal (anteroposterior: Class II, Class III) correction, relapse of vertical (superoinferior: open bite, deep bite) correction, and the development of symptoms of temporomandibular dysfunction after orthodontic correction have previously been explained as dental compensations to orthodontic corrections. However, it is now understood that they are often skeletal compensations (skeletal relapse) resulting from treatment to an unseated condylar position.[9,30–32,34,60,64–67,107] Thus it is apparent that diagnostic accuracy is enhanced by an articulator mounting in the seated condylar position.

This concept is further reinforced by Ackerman and Proffit,[107] who have stated:

> It is clear that the condyles should not be displaced during treatment by more than a small distance from their relaxed (retruded) position. In addition to the possibility of TMD symptoms, treatment methods that reposition the mandible more than a small amount are likely to fail in the long run due to the musculature returning the mandible to a seated condylar position. When this occurs after treatment it is perceived as relapse. ("The boundaries of dental compensation for an underlying jaw discrepancy are established by...the neuromuscular influence on mandibular position.") Neuromuscular harmony is at risk when the condyles are not within 1 mm or so of a seated position when the teeth are in MIC. This is an important soft tissue limitation on orthodontic treatment.

CASE REPORT

A 26-year-old woman presented with complaints of muscle contraction headaches, a nightly clenching habit, and crowding. Intraorally she presented with a Class I moderately crowded occlusion (Figs 4a to 4c). Her mounted casts (made after deprogramming with a complete-coverage maxillary stabilization splint with anterior guidance to relieve her symptoms) indicated that the magnitude of the horizontal and vertical discrepancies was greater when her dentition was in the seated condylar position: The horizontal relationship changed from Class I to Class II, and the vertical relationship revealed a dental and skeletal open bite with moderate crowding (Figs 4d to 4f). The distobuccal cusp of the mandibular second molar had been fractured off (Fig 4g), and the premature occlusal contact

Figs 4a to 4c Pretreatment intraoral views of the patient in maximum intercuspation–centric occlusion.

Fig 4a

Fig 4b

Fig 4c

Figs 4d to 4f Pretreatment casts mounted in the seated condylar position (after the patient had been deprogrammed with a complete-coverage maxillary stabilization splint with anterior guidance to relieve her symptoms). Note the premature contacts on the mandibular left molars, the fractured distobuccal cusp of the mandibular left second molar, and the increased magnitude of the horizontal (Class II) and vertical (open bite) interarch discrepancies.

Fig 4d

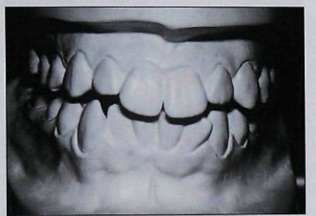


Fig 4e

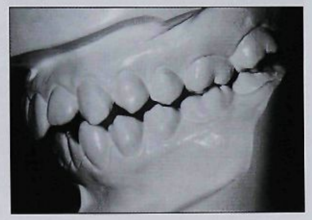


Fig 4f

Fig 4g Fractured distobuccal cusp of the mandibular left second molar *(arrow)*.

Figs 4h to 4j Posttreatment intraoral views of the patient in maximum intercuspation–centric occlusion.

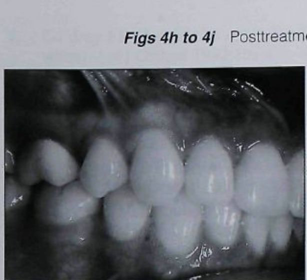


Fig 4h

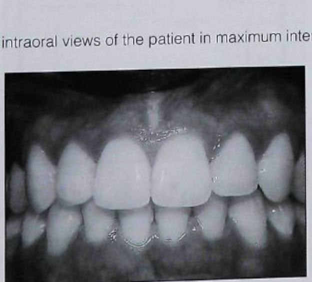


Fig 4i

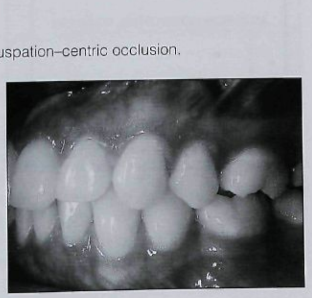
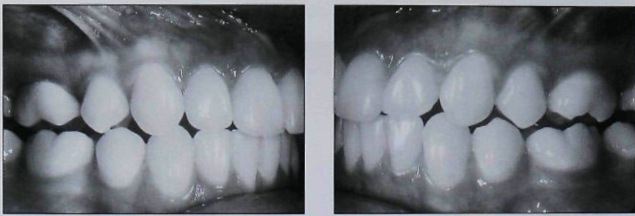


Fig 4j



Figs 4k and 4l Posttreatment intraoral views of lateral excursions, demonstrating the achievement of a mutually protected occlusion with canine guidance.

Figs 4m to 4o Posttreatment casts mounted in the seated condylar position. Note the reduction of the horizontal and vertical interarch discrepancies.

Fig 4m

Fig 4n

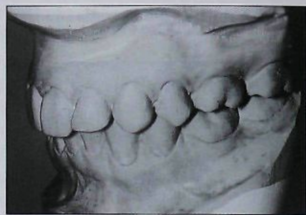
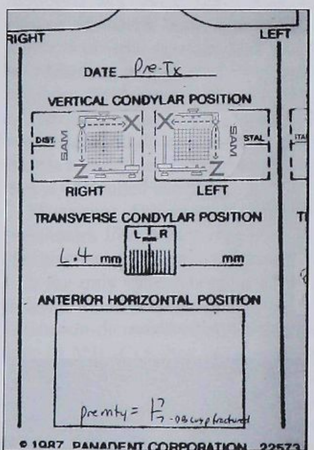


Fig 4o



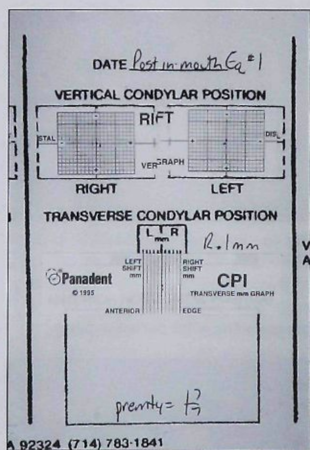


Fig 4p *(left)* Pretreatment CPI condylar graph measurements.

Fig 4q *(right)* Posttreatment CPI condylar graph measurements. Note the reduction of condylar distraction with orthodontic correction and equilibration in the seated condylar position.

was on these same mandibular second molars. The goal of orthodontic correction in this case was to gain ideal alignment and occlusal interdigitation while at the same time decreasing the condylar distraction to within normal limits (within 1 mm of the seated condylar position).

Treatment included extraction of four second premolars (to decrease the vertical dimension of occlusion) instead of four first premolars; thus, the treatment mechanics and anchorage requirements for this patient were substantially different (moderate to maximum for first premolar extractions and minimum for second premolar extractions). Finishing was accomplished with full-sized (21 × 25) braided rectangular arch wires, short vertical (Class II) elastics, a mounted tooth positioner, and complete-mouth equilibration. The symptoms were eliminated while function and esthetics were improved; total treatment time was 26 months (Figs 4h to 4o). The pretreatment and posttreatment CPI recordings are shown in Figs 4p and 4q; the pretreatment condylar distraction or displacement has been reduced by orthodontic correction and complete-mouth equilibration.

CONCLUSION

It has been shown in all areas of dentistry that the seated position is the most stable, comfortable, and repeatable condylar position from which extensive restoration of the dentition should be diagnosed and treatment planned. The techniques and instrumentation that make assessment of this position possible are simple and predictable and have proven to be faster, easier, less expensive, and more accurate than traditional orthodontic diagnostic techniques. Diagnostic accuracy and treatment execution are enhanced by the availability of an articulator mounting in the seated condylar position.

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