

## **Clinical Indications for Altering Vertical Dimension of Occlusion**

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*This article was published in Quintessence International, Vol 31, No 4 (April 2000).*

### **Functional and Biologic Considerations for Reconstruction of the Dental Occlusion**

Definition and epidemiologic studies.

There are 3 critical interfaces between muscle and bone in the masticatory system: the temporomandibular joint, the periodontium, and the dental occlusion. According to Moyers and Wainright,<sup>1</sup> the dental occlusion is the most critical interface and is determined by bone growth, dental development, and neuromuscular maturation. Structurally, the relationship of the buccal cusps of the mandibular posterior teeth and the lingual cusps of the maxillary posterior teeth against the opposing fossa and marginal ridges maintain the distance between the maxilla and mandible after growth is complete. By definition, vertical dimension of occlusion is the distance between the mandible and maxilla when the opposing teeth are in contact.<sup>2</sup>

Functional occlusion of the dentition occurs within the border movements of the mandible and, generally, begins with the mandible in a physiologic rest position. The clinical rest position is highly variable and can be influenced by a number of factors including cranial-cervical position, the presence or absence of dentures,<sup>3</sup> speech,<sup>4</sup> and stress.<sup>5</sup> The term rest position is also somewhat of a misnomer, since the jaw muscles in this position do not necessarily display their least amount of electromyographic (EMG) activity.<sup>6</sup> This rest, or postural, position is generally in the range of 2 to 4 mm relative to the intercuspal position.<sup>7</sup> In this position, the mandibular condyles are in an acquired centric position, anteriorly positioned along the condylar translation pathway. In this regard, most clinicians agree that the postural position should not be used as a starting point in the determination of the vertical dimension of occlusion.

In 1934, Costen described a symptom complex that included loss of dental occlusal support, ear symptoms (such as pain and tinnitus), and sinus pain. Since that description, others have demonstrated beneficial effects of occlusal therapy on auditory symptoms in some patients.<sup>8,9</sup> However, Schwartz<sup>10</sup> was unable to confirm the relationships described in Costens syndrome. On the other hand, Agerberg<sup>11</sup> has reported that the number of missing teeth was directly correlated with increasing symptoms of mandibular dysfunction. These findings are consistent with the report of Pullinger et al<sup>12</sup> that occlusal factors do contribute to specific subclassifications of temporomandibular disorders (TMD). In this regard they reported 5 occlusal conditions that reached significant levels of association with TMD: anterior open bite, overjet greater than 6 to 7 mm, occlusal slides from retruded contact position greater than 2 mm, unilateral maxillary crossbites, and missing posterior teeth. Mejersjö and Carlsson<sup>13</sup> suggested that the lack of posterior occlusal support is not an etiologic factor and does not affect treatment outcomes for most patients.

However, they were quick to point out that such an occlusal deficiency may lead to osteoarthritis and increased pain due to overload in these joints. Under these circumstances, DeBoever and Carlsson<sup>14</sup> considered the lack of molar support as a perpetuating factor for TMD.

Rivera-Morales and Mohl<sup>15</sup> presented a review of the literature regarding the adaptability of the occlusal vertical dimension. They concluded that postural rest position has a considerable range of adaptability to increases in the occlusal vertical dimension. However, the range of comfort varied considerably among individuals and even within a single individual under different conditions. The hypothesis that increased vertical dimension will cause an increase in masticatory muscle hyperactivity is not supported by the literature. However, the implication that increased EMG activity would be the natural response to encroachment on the postural position, and that this would relate to increased muscle pain, may be invalid. Stohler<sup>16</sup> has shown that the injection of saline into the elevator muscles of the jaw, which resulted in increased pain, caused a decrease in EMG activity and a decrease in the bite force. The increased tenderness to palpation Christensen<sup>17</sup> noted in all of the masticatory muscles could explain the decrease in EMG activity in the elevator muscles that were tested by Carlson et al.<sup>18</sup> These findings support the need to determine the psychobiologic status of each individual patient as accurately as possible through the history, clinical exam, and appropriate investigations. Such information will help to establish a working hypothesis with regard to the adaptive capacity of each patient and the potential impact of altering the vertical dimension of occlusion on the biologic system.

Determinants of vertical dimension of occlusion. Although a static relationship in principle, the vertical dimension of occlusion is initially determined by the interaction of the genetic growth potential of the craniofacial tissues, environmental factors, and the dynamics of neuromuscular function during growth. Maintenance of the vertical dimension of occlusion is principally related to the interaction of environmental factors and the dynamics of neuromuscular function throughout the aging process. According to Moyers and Wainright,<sup>19</sup> craniofacial morphology, growth, and dental morphology account for much of the variability in dental occlusion. The correlations among these 3 factors increase up to the age of 12 years. These concepts are consistent with those of Lavergne and Petrovic,<sup>20</sup> who emphasize the relationship among 3 tiers of influences on the development of the occlusion: (1) the magnitude of tissue and cell growth; (2) the spatial ordering of the facial skeleton; and (3) the dental occlusion as it affects the rate, amount, and direction of mandibular growth.

Environmental factors play a particular role in the development of the vertical dimension of the facial skeleton and ultimately the vertical dimension of occlusion. Function of the upper respiratory system has been shown in a number of studies to play a particular role in this regard. Upper respiratory obstruction has been shown to cause changes in masticatory muscle recruitment patterns that correlate with changes in facial soft tissue that precede facial skeletal adaptations.<sup>20</sup> Linder-Aronson<sup>21</sup> suggests that, for certain subjects, mandibular retrognathism, increased vertical facial height, open bite, and crossbite may be due to chronic environmental factors such as airway obstruction, and that treatment should be directed at eliminating or reducing the environmental effects on jaw position and dental occlusion.

#### Biologic adaptation.

Once growth is complete, maintenance of the vertical dimension of occlusion is determined by the adaptive capacity of the biologic system to insult or injury. Adaptive responses can occur within the temporomandibular joint (TMJ), the periodontium, and the dental occlusion. In most cases, it is the soft tissues of the TMJ and periodontal ligament that initially respond to acute micro- and macrotrauma. The fluid compartments that are maintained within the extracellular matrix rapidly shift in response to variations in strain patterns. The first response within the TMJ to compressive forces is a shift in the fluids within the disc and retrodiscal tissues. Once the strain is relieved, the fluid will

return to its original position and the morphology of the tissues is maintained. However, prolonged strain with these tissues will result in an alteration of the architecture of the collagen and noncollagen proteins and ultimately a change in tissue morphology.

Strains beyond the levels of adaptation for the soft tissues will then result in morphologic adaptive changes within the cartilage and bone that may be apparent radiographically. Strains beyond the adaptive capacity of the tissues will result in degeneration, a loss in vertical support, and structural changes that have the potential to impact the vertical dimension of occlusion. Using a 3-dimensional model of the mandible and TMJ articulation, strain patterns within the TMJ have been shown to increase with an increase in the vertical face height.<sup>22</sup> Ito et al<sup>23</sup> has demonstrated superior repositioning of the mandibular condyle with anterior splints in the absence of posterior occlusal contact. In a study reported by Araki et al,<sup>24</sup> the reduction of the crowns of the maxillary molars resulted in degenerative changes in the mandibular condyles. Vertical adaptive responses have been outlined by McNamara<sup>25</sup> as adaptive changes within muscle, alterations in the central nervous system, changes at the muscle-bone interface, and changes within bone and cartilage. Enlow et al<sup>26</sup> and Harper et al<sup>27</sup> have previously attributed adaptive changes within the TMJ to extracapsular forces.

Okeson<sup>28</sup> states that orthopedic stability exists when the stable intercuspal position of the teeth is in harmony with the musculoskeletally stable position of the condyles in the fossae. As the discrepancy between an orthopedically stable TMJ and maximum intercuspation of the teeth increases, there is an increased risk for intracapsular TMJ disorders to occur. The concept of orthopedic stability takes into consideration the temporomandibular joint, the integrity of the masticatory muscles and ligaments, and the skeletal-dental relationships. Loss of occlusal vertical dimension may be due to attrition of the dentition, which may be acute (iatrogenic) or chronic and may involve parafunctional activities. A decrease in the vertical dimension of occlusion may also be associated with internal derangement of the TMJ or osteoarthritis. However, there is no epidemiologic evidence to suggest that dental attrition is necessarily associated with signs or symptoms of TMD.

Clinical implications.

It is difficult to resolve the opinion of DeBoever and Carlsson<sup>14</sup> that precision-mounted study casts are not necessary as an adjunct to the diagnosis of TMD or that occlusal reconstruction is not indicated in the treatment of TMD. Although occlusal reconstruction may not be the definitive treatment for a particular TMD, it is appropriate to establish a sound structural and balanced functional base as an adjunct to overall patient management. Rivera-Morales and Mohl<sup>29</sup> outline guidelines for the restoration of vertical dimension that include the careful mounting of study casts to a semiadjustable articulator using jaw-relation records. This process is then followed by diagnostic waxup and diagnostic occlusal adjustment on additional or duplicated mounted casts. In this regard, it is prudent to accurately assess the status of the structural occlusion in conjunction with the dynamics of the functional occlusion using sophisticated mounting procedures.

Such information could contribute to a better understanding of the potential for addressing structural issues and provide information regarding factors relating to the adaptive capacity of the patient. The goal of occlusal reconstruction should be to achieve a structural balance to facilitate physiologic adaptation and rehabilitation.

Nitzan<sup>30</sup> reported that intra-articular pressures in the human TMJ were significantly

reduced after placement of an interocclusal appliance. Although a reduction in intra-articular pressure may relieve pain resulting from intracapsular derangement and inflammation of the retrodiscal tissues, it is not necessarily correlated with a reduction in pain of extracapsular origin. As Dawson<sup>31</sup> points out, condylar access to centric relation is not dependent on vertical dimension, and increasing the vertical dimension does not unload the joints if the starting point is a centric relation position. This message is critical and requires an understanding of the relationship of the dental occlusion and condylar position within the TMJ.

For any given patient, the mandibular condyle can be in 1 of 3 positions within the TMJ. The first position, classically defined as centric relation, implies that the condyle within the fossa is in its most superior position against the eminence with the disc properly aligned. This position does not depend on tooth position or vertical dimension. The second possible position is an acquired centric position. In this position the condyle and disc are properly aligned; however, this assembly is positioned anteriorly along the translation pathway. Finally, the condyle may be in a deranged reference position within the fossa. In this position the condyle may be in its most superior position against the eminence; however, the disc is not properly interposed between the condyle and fossa. The latter 2 positions may very well contribute to an alteration of the normal occlusion, and the vertical dimension of occlusion is affected by each of these condylar positions. It is important to define the status of this centric reference position prior to initiation of occlusal therapy.

The current gold standard for the diagnosis or treatment of TMD has been suggested by Clark et al<sup>32</sup> to be a global history and clinical examination. Although none of the ancillary investigations or imaging techniques has proven diagnostic validity,<sup>33,34</sup> the additional information and documentation may provide a quantifiable starting point and a basis for the assessment of treatment outcomes. In this regard, along with conventional radiographic and magnetic resonance imaging of the TMJ, functional analysis using condylar movement tracking devices may be useful as a means of quantifying the range of condylar translation and analyzing the pattern of the translation pathway.<sup>35</sup> Condylar movement analysis can be used subsequently as a method for assessment of treatment outcomes.<sup>36</sup>

In many cases it is possible to increase the vertical dimension of occlusion if 2 foundational principles are maintained. First, the starting point for reconstruction of the vertical dimension of occlusion must be with the mandibular condyles in centric relation. Second, reconstruction must be within the range of neuromuscular adaptation for each individual patient. The difficulty is determining both of these parameters on an individual patient basis, accurately recording the centric reference point and transferring this information to an instrument that simulates the patient's functional occlusion. The prudent course under these circumstances is to take a diagnostic approach and formulate a hypothesis based on information from the history, clinical examination, and investigations of condylar position and status of the neuromuscular envelope. This hypothesis can then be tested using reversible intervention modalities such as occlusal splints, removable prostheses, or fixed transitional crowns prior to definitive alteration of the vertical dimension of occlusion. The need for modification of the initial hypothesis may become evident, or definitive treatment may be initiated. The critical message for the clinician who has the ultimate responsibility for this decision-making process is to establish frequent outcome assessment protocols and to approach the practice of dentistry as a clinical scientist.

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### **Objective vs Subjective Methods for Determining Vertical Dimension of Occlusion**

Occlusal vertical dimension is defined as the distance measured between two points when the occluding members are in contact.<sup>1</sup> In a denture wearer it is initially established with a maxillary and mandibular base plate and wax rim; in a dentate person it is evaluated prior to reconstruction and usually maintained. The determination of occlusal vertical dimension (OVD) is not a precise process, and many professionals arrive at this dimension through various means.<sup>2</sup> Many determine OVD with subjective means, such as the use of resting interocclusal distance, and speech-based techniques using sibilant sounds. Niswonger proposed the use of the interocclusal distance (freeway space), which assumes that the patient relaxes the mandible into the same constant physiologic rest position.<sup>3</sup> The practitioner then subtracts 3 mm from the measurement to determine the OVD. There are 2 aspects that often make this incorrect. First, the amount of freeway space is highly variable in the same patient, depending on several factors including head posture, emotional state, presence or absence of teeth,

parafunction, and time of recording. Second, interocclusal distance at rest varies 3 to 10 mm from one patient to another. As a result, the distance to subtract from the freeway space is unknown for a specific patient. Therefore, the physiologic rest position should not be the primary method to evaluate OVD.

Silverman<sup>5</sup> stated that approximately 2 mm should exist between the teeth when the S sound is made. Pound<sup>6</sup> further developed this concept for the establishment of centric and vertical jaw relationship records. While this standard is accurate, it does not correlate to the original OVD of the patient. Denture patients often wear the same prosthesis for more than 14 years and during this time lose 10 mm or more of their original OVD. Yet, all of these patients are able to say Mississippi with their existing prosthesis. If speech was related to the original OVD, these patients would not be able to pronounce the S sounds because their teeth would be more than 12 mm apart. Patients with temporomandibular joint dysfunction with surgical increases in OVD and patients with severe atrophy with long-term dentures demonstrate that OVD may vary more than 20 mm, yet most of them are able to speak clearly.

Facial measurements to determine OVD can be traced back to antiquity, where sculptors and mathematicians followed the golden proportion, later specified as a ratio of 1.618:1. Later, Leonardo da Vinci (1452-1519) in his book *Anatomical Studies* contributed several observations and drawings on facial proportions and the lower one third of the face, which he called divine proportions. He wrote: The distances between the chin and the nose and between the hairline and the eyebrows are equal to the height of the ear and a third of the face. The distance from the outer canthus of one eye to the inner canthus of the other eye is equal to the height of the ear and to one third of the face height. In addition, he said facial height (from chin to hairline) is equal to the height of the hand, and the nose is the same length as the thumb (and also the same length as the distance between the tip of the thumb and the tip of the index finger). Many professionals, including oral surgeons, plastic surgeons, artists, orthodontists, and morticians, use facial or body measurements to determine OVD. A review of the literature confirms that facial measurements can be compared and help to establish the original OVD.

The original occlusal vertical dimension is most often similar to the following dimensions:

1. The horizontal distance between the pupils<sup>7</sup>
2. The vertical distance from the external corner of the eye (outer canthus) or the pupil to the corner of the mouth<sup>7</sup>
3. The vertical distance from the eyebrow to the ala of the nose
4. The vertical length of the nose at the midline (from subnasion to glabella)<sup>7</sup>
5. The distance from one corner of the lips to the other (cheilion to cheilion), following the curvature of the mouth (more often in Caucasians)<sup>7</sup>
6. The distance from the eyebrow line to the hair line (in females) (da Vinci)
7. The distance from the outer corner of one eye (outer canthus) to the inner corner (inner canthus) of the other eye (da Vinci)
8. The vertical height of the ear (da Vinci)



9. The distance between the tip of the thumb and the tip of the index finger when the fingers are pressed together (da Vinci)

10. Twice the length of one eye

11. Twice the distance between the inner canthus of both eyes

12. The distance between the outer canthus and the ear (da Vinci)

Facial measurements, as a start to determine OVD, offer significant prosthetic advantages.<sup>8,9</sup> These are objective measurements rather than subjective criteria (such as resting jaw position or swallowing). With so many measurements available, the clinician may take the average of 5 or more (especially when they are within a 1 to 2 mm range). Once the initial OVD is determined, the wax rim or acrylic temporaries may be used to evaluate speech, swallowing, and resting jaw position. Since there is no absolute method to determine OVD for all individuals, the facial and finger measurements are attractive because they require no radiographs or other special measuring devices.

Since OVD is not a specific measurement for the majority of patients, it may be slightly modified in the transitional stages of treatment and evaluated relative to patient acceptance and the condylar disc assembly. Esthetic requirements may mandate a slight decrease in OVD to make the patient appear more Class III, or a slight increase to make the jaw relationship more Class II. The latter is often useful in maxillary implant reconstruction cases because a slightly open OVD usually places a more axial direction of load on premaxillary implants in centric relation occlusion. Maxillary anterior implants are often placed more palatally than the roots of the natural teeth. A decrease in OVD is often used for mandibular anterior implants opposing natural dentition because a more closed OVD places a more axial force direction on these implants. Crestal stresses on bone are reduced when an axial load is applied to implants.<sup>10</sup> In addition, bone is strongest in compression, 30% weaker in tension, and 65% weaker in shear. A 30-degree off-axis load reduces the strength of bone by 10% to 20%, and a 60-degree off-axis load reduces bone strength 30% to 50%.<sup>11</sup> Furthermore, an axial load decreases the stresses to the abutment screw, which decreases the risk of screw loosening.<sup>9</sup> During the last 2 decades, I have slightly altered OVD to improve force direction on anterior implants. Only 3 patients have expressed difficulty adjusting to the OVD, which in all cases was slightly more open than facial measurements indicated.

Facial and body parts often have dimensions that are consistently similar to each other. The original OVD is similar to at least 12 other dimensions on the face and hands and may be objectively determined in most patients. The condylar disc assembly position is maintained in a broad range of OVD. As a result, this dimension may be slightly modified to improve appearance, help stabilize a denture,<sup>9</sup> or improve the direction of force on an implant.

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