

CLINICAL RESEARCH

# Influence of jaw opening on occlusal vertical dimension between incisors and molars



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Modification of the occlusal vertical dimension (OVD) is an important and significant procedure in prosthodontics. The OVD can be increased or reduced. The OVD is increased as part of a comprehensive prosthetic treatment to create sufficient intermaxillary space for interim or definitive restorations.<sup>1,2</sup> An increase in the OVD involves a complete-mouth rehabilitation and is indicated in treatments for pathological wear, overeruption, increased vertical overlap, or where loss of vertical dimension leads to posterior overclosure. Reduction of the OVD by selective grinding, for instance, is used to treat an anterior open occlusal relationship.<sup>3,4</sup>

Modification of the OVD for therapeutic needs requires preliminary planning. Because of the relative proximity of the molars to the hinge axis of the mandible, an increase in OVD in the molar area always results in a greater opening in the incisal area. Consequently, for a predictable rehabilitation outcome, preliminary planning with the aid of an articulator is beneficial. Improper estimation of the space available between opposing teeth

## ABSTRACT

**Statement of problem.** Modification of the occlusal vertical dimension (OVD) is a significant procedure in prosthodontics. Improper estimation of the space available between opposing teeth may lead to an improper framework design.

**Purpose.** The purpose of this clinical study was to evaluate the average opening ratio in the molar area in relation to the extent of opening in the incisor area.

**Material and methods.** A total 34 adults with a complete dentition and stable occlusion participated in the study. The change in vertical distance was evaluated in 3 areas: between the maxillary and mandibular central incisors, between the maxillary and mandibular canines, and between the maxillary and mandibular first molars. Digital photographs were made at the intercuspal position (ICP) and at a 2-mm and 8-mm OVD increase. The OVD opening was standardized with the aid of a Woelfel sliding guide device. The measurements were made by recording the distance between the maxillary and mandibular teeth at different openings. For calibration and quantitative evaluation of the photographs, image-processing analysis was used.

**Results.** The collected data showed that the average ratio of the opening between the first molars and the opening between the central incisors was 0.73. The average ratio of the opening between the canines and the opening between the central incisors was 0.95. The values were plotted, and a mathematical model was derived.

**Conclusions.** A vertical dimension opening of 1 mm between the central incisors resulted in 0.73 mm of occlusal clearance in the first molar region and 0.95 mm in the canines. (*J Prosthet Dent* 2019;122:115-8)

may lead to improper framework design. Therefore, the ability to compute this ratio in advance may help predict the exact amount of tooth structure that should be removed or added in any area of the dentition.

The impact of OVD modification for the rehabilitative needs of the masticatory system, including the ability of the system to adapt to the changes, has been studied.<sup>1,2</sup> However, few articles have dealt with the amount of

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## Clinical Implications

Modification of the OVD for therapeutic needs may be optimized by preliminary planning. The ratios at different locations can be evaluated in advance with the aid of the mathematical model provided here.

tooth separation in the anterior area relative to the separation in the posterior area.<sup>5,6</sup> Helsing et al<sup>6</sup> reported that the mean ratio between the incisors and first molars was 1:2 in 6 of their patients and 3:5 (1.66) in the other 2. Kaiser and Schelb<sup>5</sup> used a mathematical model to calculate this ratio. They found a ratio of 1:2 between the incisors and the molar and a ratio of 1:3 between the anterior guide pin of the articulator and the second molar. The present study evaluated clinically the average opening ratio in the molar and canine area in relation to the extent of opening in the incisor area (in mm).

The research hypothesis, based on conventional wisdom, was that the OVD opening ratio between the incisors and first molars would be 3 to 1. To test this hypothesis, the OVD opening at the first molar and canine areas was recorded after measurable separation of the incisors. The ratios at the different locations were calculated, the values were plotted, and a mathematical model was derived.

## MATERIAL AND METHODS

The protocol of the study was approved by the institutional Helsinki Committee for Human Clinical Trials (Identifier: 0630-14-HMO). All participants were healthy, and each signed an informed consent form. The study group included 34 adults (15 men and 19 women) with a complete dentition, stable occlusion, and a measured horizontal overlap and vertical overlap of between 2 and 4 mm. The vertical distance change was evaluated at 3 points: between the maxillary and mandibular central incisors, between the maxillary and mandibular canines, and between the maxillary and mandibular first molars. For reproducible results, the distances were recorded by digital photography at the intercuspal position (ICP) and in 2 increased vertical dimension positions (2 mm and 8 mm).

The OVD opening was standardized with the aid of a Woelfel sliding guide device (Amann Girrbach AG) (Fig. 1), as previously described.<sup>7-10</sup> Briefly, the Woelfel sliding guide was used to increase the OVD by 2 mm or 8 mm between the incisors and guide the mandible to the centric relation position.

The increase in OVD was evaluated by measuring the distance between the teeth at 6 marked points (Fig. 2). The arbitrarily selected points were the following: "I" on the distal transitional line angle of the mandibular right



Figure 1. Woelfel sliding guide.

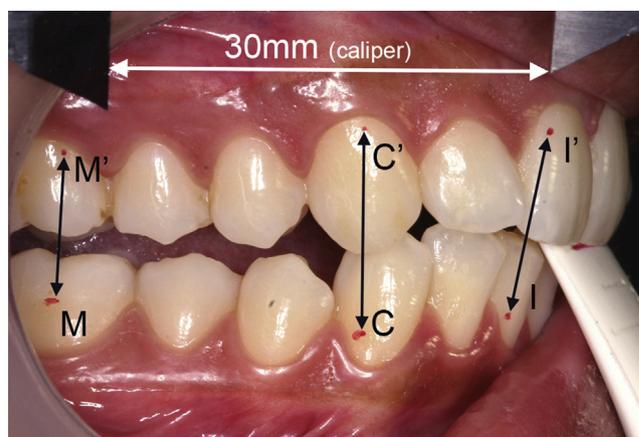
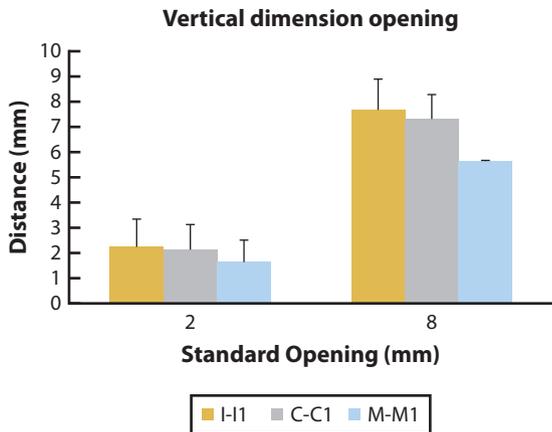


Figure 2. Jaw opening and measurement method. Digital photograph depicting point markings in 3 areas: central incisors, canines, and first molars in mandible (I, C, M) and in maxilla (I', C', M'). Woelfel sliding guide used to standardize degree of opening and distance recorded at 2-mm and 8-mm openings. For calibration and distance measurements on image, calipers placed proximal to teeth in each image. Distance (mm) between corresponding points I-I', C-C', and M-M' measured at each opening, and opening ratio between incisors-canines and incisors-molars calculated.

central incisor, "C" in the middle of the mandibular right canine, and "M" on the mandibular right first molar below the buccal groove. The maxillary teeth were marked accordingly: "I'" on the maxillary right central incisor, "C'" on the maxillary right canine, and "M'" on the maxillary right first molar. Digital photographs were calibrated using digital calipers (Mitutoyo Corp CE) at an opening of 30 mm, which was placed adjacent to the maxillary attached gingiva. Six points were marked on the teeth before the photographs were made. Using a tripod, the camera was positioned visually at 90 degrees to the calipers and the posterior teeth while the patient was seated in an upright position. For calibration and quantitative evaluation of the photographs, an image-processing analysis software program (NIH Image); National Institutes of Health) was used. The measurements



	Average	Mean	SD
$\Delta M/\Delta I$	0.73	0.73	0.036
$\Delta C/\Delta I$	0.95	0.95	0.03

$\Delta M/\Delta I$  molar opening (mm) | incisor opening (mm)  
 $\Delta C/\Delta I$  canine opening (mm) | incisor opening (mm)

**Figure 3.** Vertical dimension opening and calculated ratios. Different bars represent distances measured in millimeters between marks on molars (M, gray), canines (C, orange), and incisors (I, blue) for 2-mm jaw opening and for 8-mm jaw opening. The opening ratio  $\pm$  standard deviation (SD) calculated from molar opening divided by incisor opening ( $\Delta M/\Delta I$ ) and from canine opening divided by incisor opening  $\Delta C/\Delta I$ .

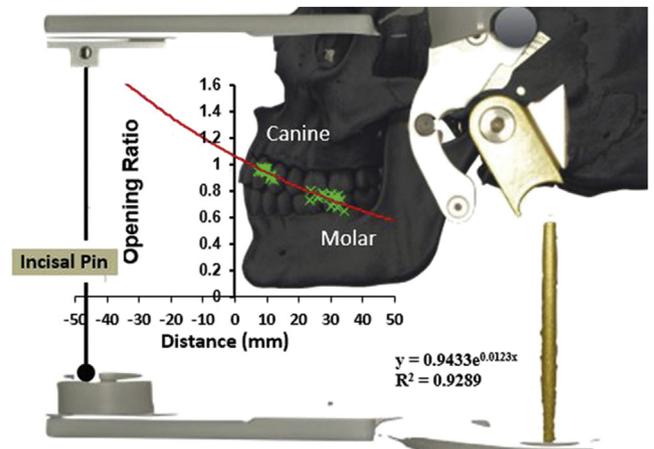
were made by recording the distance between the maxillary and mandibular teeth at the different openings.

**RESULTS**

Results were obtained from digital photographs depicting the vertical distance change at 3 points: between the central incisors ( $\Delta I$ =difference between I and I' measured in mm), between the canines ( $\Delta C$ =difference between C and C' measured in mm), and between the first molars ( $\Delta M$ =difference between M and M' measured in mm) (Fig. 2).

A 2-mm vertical dimension opening in the incisor area resulted in an approximately similar opening in the canine area and a reduced opening in the first molar area (1.6 mm) (Fig. 3). An 8-mm vertical dimension opening in the incisor area resulted in an approximately similar opening in the canine area and a reduced opening in the first molar area (5.6 mm) (Fig. 3).

The collected data showed that the average ratio of the opening  $\Delta$  between the first molars and the opening  $\Delta$  between the central incisors was 0.73; for example, a 1-mm vertical dimension opening between the central incisors resulted in 0.73-mm occlusal clearance in the first molar region. The average ratio of the opening  $\Delta$  between the canines and the opening  $\Delta$  between the central incisors was 0.95 mm (Fig. 3). No significant



**Figure 4.** Exponential trend line representing opening ratio at given distance from central incisor. When positioned in articulator point X=0, central incisor position. Points between anterior guide pin and central incisors will have negative values, and points distal to incisors will have positive values. The y-axis represents opening ratio. Each point (X>0) represents  $\Delta M/\Delta I$  or  $\Delta C/\Delta I$  ratio of participant, calculated for point in canine or molar area. Trend line equation calculated to approximate extent of opening in canines or molars, depending on extent of central incisor opening or anterior guide pin opening.

differences were found between the average ratio in women (n=19) and men (n=15). The mean  $\pm$  standard deviation distance recorded between I' (central incisor) and M' (first molar) was 29.9  $\pm$  2.7 mm and that between I' (central incisor) and C' (canine) was 9.4  $\pm$  1.4 mm.

An exponential trend line that followed the collected data was plotted (Fig. 4). A trend line equation was formulated to approximate the extent of the opening in the incisors or molars, depending on the extent of the anterior guide pin opening  $y=0.9433e^{0.0123x}$  ("x" represents the distance from the central incisor and "y" represents the calculated ratio of vertical separation at that distance from the central incisor). An approximation for each millimeter of anterior guide pin opening is shown in Table 1.

**DISCUSSION**

Assessment of the change in vertical dimension is essential to achieve a comprehensive treatment plan for each patient. The need for OVD alteration has been well recognized for prosthetic treatment. Consequently, attention has been previously drawn to the effect of vertical changes in the molar area related to changes made in the incisor area. The control of vertical opening is a manageable factor available to the prosthodontist. In the present study, a controlled appraisal showed that an opening of 1 mm in the molar area resulted in a vertical separation of 1.42 mm in the incisor area (or a 1-mm opening in the incisal area resulting in a separation of 0.73 mm in the molar area). Given these findings, the research hypothesis that the average vertical dimension

**Table 1.** Relative occlusal clearance at first molar, depending on anterior guide pin opening

Distance of Anterior Guide Pin From Central Incisor (mm) <sup>b</sup>	Anterior Guide Pin Opening (mm) <sup>a</sup>				
	1 mm	2 mm	3 mm	4 mm	5 mm
30	0.5	1.1	1.6	2.2	2.7
40	0.5	1.0	1.4	1.9	2.4
50	0.4	0.8	1.3	1.7	2.1
60	0.4	0.7	1.1	1.5	1.9

<sup>a</sup>Extent of occlusal clearance between first molars depending on extent of opening of anterior guide pin in articulator, measured in mm. <sup>b</sup>Distance of anterior guide pin from central incisor measured in mm.

opening ratio of molars to incisors is 1:3 was rejected. Predicting the outcome of OVD alteration can provide important information for the evaluation of treatment options and for treatment success.

Although the importance of treatment planning has been widely discussed, the authors are aware of only a few publications dealing with the monitored assessment of vertical dimension alteration. Wright<sup>11</sup> showed on mounted stone casts that if the anterior guide pin opening was 1.5 mm, the amount of occlusal adjustment required on the second molar was less than 1.5 mm.

The present clinical evaluation included a group of volunteers for whom intraoral measurements were recorded directly, thus eliminating the distortion that may occur in indirect measurements from mounted casts. Moreover, although a large amount of data was collected, the results showed low variance. The low standard deviations and proximity of the median and means found in the present study indicate the validity of the model and the results. These findings laid the grounds for computing and predicting changes in the vertical dimension.

The use of mounted casts on an articulator is still the best way of planning any change in the OVD. Increase of the OVD in an articulator is achieved and monitored with the aid of the anterior guide pin. The prosthodontist would like to know the effect of an increase or decrease of the anterior guide pin on centrals and molars, but this becomes difficult to predict, particularly when many teeth are missing. The equation formulated to calculate the amount of molar or incisal separation was based on the extent of the anterior guide pin opening on any articulator. In addition, the equation takes into consideration the distance from the area of the dentition in question from the anterior guide pin. Table 1 shows the calculated separation in the molar areas for different anterior guide pin changes at various distances of the central incisors from the anterior guide pin. The equation allows predictable calculation of the amount of separation independent of the mounting method used.

The importance of this ratio is evident in an extensive oral rehabilitation. An example is a large anterior open occlusal relationship treated by reducing the vertical

dimension. Monitored estimation of the amount of tooth structure to be removed will influence the kind and extent of treatment needed. It is important to be able to predict whether a minor occlusal adjustment will suffice or whether there is a need to provide complete-coverage restorations for all the teeth and to perform crown-lengthening preprosthetic periodontal surgery.

A limitation of this study was the influence of the mandibular position on the relative movement of teeth at the occlusal level. Intraoral measurements partially overcome this limitation. The use of the Woelfel jig was an attempt to direct the volunteers in the present study to the centric relation position.

## CONCLUSIONS

Based on the findings of this clinical study, the following conclusions were drawn:

1. Modification of the OVD for therapeutic needs may be optimized by preliminary planning.
2. The ratios at different locations can be calculated in advance with the aid of the mathematical model provided here to calculate the degree of incisor or molar separation for a specific opening at the articulator anterior guide pin.

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