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. 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.

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 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. However, few articles have dealt with the amount of
tooth separation in the anterior area relative to the separation in the posterior area. Hellsing et al 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 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 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. 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 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 ImageJ; National Institutes of Health) was used. The measurements...
between the canines and the opening between the central incisors was 0.73; for example, a measured in mm), and between the incisors (the vertical distance change at 3 points: between the central incisors or molars, depending on the extent of the anterior guide pin opening. The collected data showed that the average ratio in women (n=19) and men (n=15). The mean ±standard deviation distance recorded between I’ (central incisor) and M’ (first molar) was 29.9 ±2.7 mm and that between I’ (central incisor) and C’ (canine) was 9.4 ±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.

**RESULTS**

Results were obtained from digital photographs depicting the vertical distance change at 3 points: between the central incisors (ΔI= difference between I and I’ measured in mm), between the canines (ΔC= difference between C and C’ measured in mm), and between the first molars (ΔM= 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 Δ between the first molars and the opening Δ 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 Δ between the canines and the opening Δ between the central incisors was 0.95 mm (Fig. 3). No significant differences were found between the average ratio in women (n=19) and men (n=15). The mean ±standard deviation distance recorded between I’ (central incisor) and M’ (first molar) was 29.9 ±2.7 mm and that between I’ (central incisor) and C’ (canine) was 9.4 ±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...
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.

REFERENCES


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