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Evaluating the Reliability of Facial and Hand Measurements in Determining the Vertical Dimension of Occlusion

Salwa Omar Bajunaid[1], Bashayer Baras[2], Nuha Alhathlol[3], & Alaa Al Ghamdi[4]

Abstract

Objective: To determine the correlation between the vertical dimension of occlusion (VDO) and different facial and hand measurements, contributing in the domain of prosthodontics.
Methods: A cross-sectional study was conducted on a sample of 134 dentate individuals of age group 20-45 years, who fulfilled the defined inclusion criteria. VDO along with facial and hand measurements were measured clinically usingVernier gauge. Regression analysis wasused to find the correlation between VDO and the other measurements.
Results: Statistically, the minimum, maximum, and average vertical dimension of occlusion recorded for the participants were 52.33, 85.67, and 69 mm, respectively. The vertical distance from the outer canthus of the eye to the corner of mouth showed the strongest positivecorrelation with VDO, which was statistically significant. The distance from the outer canthus of the eye to the external auditory meatus and from the tip of the thumb to the tip of the index finger showed the least significant correlation with VDO.
Conclusion: The use of facial measurements, particularly the vertical distance from the outer canthus of the eye to the corner of the mouth, is a reliable and reproducible technique that can be used in daily clinical practice for VDO determination. It eliminates the need for subjective techniques, such as assessment the of physiologicrest position, appearance, speech, swallowing, and patient comfort, radiographs and devices that are complex and expensive.

Keywords: Edentulous Patients, Objective Techniques, Outer Canthus of the Eye, Vertical Dimension of Occlusion.

[1] Assistant Professor, Department of Prosthodontic Dental Science, College of Dentistry, King Saud University, Riyadh, Saudi Arabia. Email: dr_prosth@hotmail.com
[2]Demonstrator, Department of Restorative Dental Science,College of Dentistry, King Saud University. Email:bashayer.baras@gmail.com
[3]General Practitioner, Almas Dental Center. Email:Nuhamhathlol@gmail.com
[4]General Practitioner. Email:alaa_alghamdi@hotmail.com

Introduction

The vertical dimension of occlusion (VDO)is defined as the distance measured between two points when the occluding members are in contact (Glossary of Prosthodontics Terms). [1, 2]The concept of determining VDO was highly controversial. Two theories have been postulated; the first theory states that VDO remains constant as the teeth continue erupting to compensate for their wear, while the surrounding dental structures maintain it. [3, 4, 5]The second theory states that the eruption may not keep up with tooth wear and VDO is affected by the loss and eruption of teeth because the rate of eruption varies among people. Establishment of the vertical dimension of occlusion (VDO) is a critical step and, if not conducted properly, may result in negative consequences on the residual oral structures. Since a long time, scientists are consistently doing efforts to exploreconstant anthropometric facial measurementsto establish the correct VDO. [1, 6-9]

Depending on diverse range of factors, the facial vertical dimensionrepresentsan important variable existing in dentate patients. This vertical dimension of occlusion is obtained prior to the extraction of the teeth. The change in facial pattern is not due to the decrease in VDO; however, the change is caused by the loss of support given by the teeth and alveolar processes to the lips.[1, 7-10] The loss of teeth and resorption of alveolar bone in edentulous patients leads to a reduction or loss of vertical dimension of occlusion.[11, 12]Hence, the determination of correct vertical dimension of occlusion is an important and critical step in the treatment of these patients.[11,13-15]There are no precise or accurate methods for VDO determination, despite the advancements in materials and techniques used in the field of prosthodontics.[14] According to Zarb et al. VDO determination using a single scientifically proven technique is not possible.[15]This is considered as a significant step in the construction of removable or fixed prosthesis for the edentulous patients.

If the VDO is not correctly restored or established, rapid resorption of the residual alveolar ridges may occure. This aspect has prompted many prosthodontists tofind a constant anthropometric measurements within the face. [16] In dentulous patients, the vertical dimension of the face tend to show variations depending on multiple factors. However, in completelyorpartially edentulous patinets, this condition is magnified as the loss of vertical dimension is associated with sinking-in of the lips as compared to the situation prior to teeth loss. [17].

In a denture wearer,VDO is established with a maxillary and a mandibular base plate withocclusal wax rims. Clinical judgment plays a major role in the assessment of this important component.[14]The literature describes different means to determine the VDO for the rehabilitation of edentulous patients.[18]Some of the subjectiveand indirect methods to determine VDOincludethe use of patient's occlusal biting pressure,[9, 19]physiologic rest position, inter-occlusal distance (freewayspace),[12, 20] swallowing technique,[21]and speech using sibilant sounds.[5, 22]These subjective techniques require a great deal of skill and clinical sensitivity by the operator to determine this position.

Research has shown that physiologic rest position is highly variable and affected by several factors such as airway posture, emotional factors, and difference in head posture; therefore, itcannot be considered as a stable reference position.[10]The concept of using speech and the sound for the establishment of VDO has been debated by Harper & Misch.[23]

They claimed that the patients with dentures often wear the same prosthesis for more than 14 years and during this time lose 10 mm or more of their original VDO. Yet, all of these patients are able to say Mississippi with their existing prosthesis. If speech was related to the original VDO, these patients would not be able to pronounce the S sounds because their teeth would be more than 12 mm apart.

Other techniques and methods to determine VDO are objective and direct methods. These include facial dividers and soft tissue measurements. The use of facial measurements to determine VDO can be traced back in ancient times. [4, 24-26]Leonardo da Vinci (1452-1519) had contributed several drawings on facial proportions in the book, which were known as divine proportions. Mischhas claimed that facial and hand measurements offer significant advantages for VDO determination during prosthesis fabrication. [27]These are direct and objective techniques, rather than subjective techniques. According to Misch, the original VDO correlates with at least 12 dimensions pertaining to the face and hands. The clinician may take the average of five or more available measurements (especially when they are within 1 to 2 mm range) to determine VDO. It is followed by the wax rim or provisional acrylic prosthesis that can be adjusted to evaluate esthetics, phonetics, and the resting jaw position. Another two-dimensional objective method is the cephalometricradiograph. [7]In spite of various advancements associated with the methods and techniques in prosthodontics, no precise or universal method is recommended for assessing the VDO for edentulous patients.

This study was conducted to evaluate the reliability of various facial and hand measurements in determining the VDO. This was achieved by taking the average distance between the following hand and facial landmarks in dentate population:the distance between the tip of the thumb and the tip of the index finger when the fingers are pressed together (da Vinci), the vertical length of the nose at the midline (Glabella-Subnasion),the vertical distance from the external corner of the eye (outer canthus) to the corner of the mouth, the vertical distance from the eyebrow to the ala (wing) of the nose, the vertical height of the ear (da Vinci) and the distance from the outer canthus of the eye to the external auditory meatus of the ear (da Vinci).These measurements were then correlated to a commonly used facial distance; the Chin-Nose distance. The chin-nose distance was measured with Niswonger's method, which includesthe distance from the tip of the nose to the most prominent point of the chin. [34]This study aimed to instruct objectivity to the complete denture construction through identifying the reliability of different hand and and facial measurements.It has been assumed that if any or some of these measurements directly correlates with the existing VDO of the patient, then it can be effectively used to determine VDO in edentulous patients.

Materials and Methods

A descriptive randomized quantitative design has been implemented in accordance with the objectives for data collection. A simple random sampling was implemented to select a sample of 134 dentate individuals within age group 20-45. The participants who exhibited teeth with good periodontal support, an Angle's Class I molar relationship,no premature occlusal contacts, and possess minimum of six occluding pairs, were included in the study. Participantswho had large occlusal restorations,ahistory of orthodontic or orthognathic surgical treatment, deepopen bite, visible facial or hand deformities, and history of trauma or temporo-mandibular joint disorders were excluded.

Willis [26] has been given the credit for popularizing these measurements and McGee [4] correlated the known vertical dimension of occlusion with three facial measurements, which was claimed to remain constant throughout life. Case history was recorded and clinical examination was conducted. During the clinical examination, each individual was instructed to sit upright with head unsupported. The distance from the tip of the thumb to the tip of the index finger was recorded by three investigators (Figure 1). The VDO from the tip of the nose to the most prominent point of the chin (Figure 2A) was determined. Vernier gauge (Figure 3)was used to measure the vertical distance from the outer canthus of the eye to the corner of the mouth (Figure 2B), the vertical distance from the eyebrow to the ala of the nose (Figure 2C), the distance from the outer canthus of the eye to the external auditory meatus (Figure 2D), thevertical length of the nose at the midline (from subnasion to the glabella) (Figure 2E), andthe vertical height of the ear (Figure 2F).Three readings were taken for each of these measurements and the average was calculated.

Figure 1: Measurement of the distance between the tip of the thumb and the tip of the index finger for determination of the vertical dimension of occlusion.

Figure 2: Anthropometric measurements used for determination of the vertical dimension of occlusion (VDO). A: VDO, B: vertical distance from the outer canthus of the eye to the corner of the mouth, C: vertical distance from the eyebrow to the ala of the nose, D: distance from the outer canthus of the eye to the external auditory meatus, E: vertical length of the nose at the midline (from subnasion to the glabella), and F: vertical height of the ear.

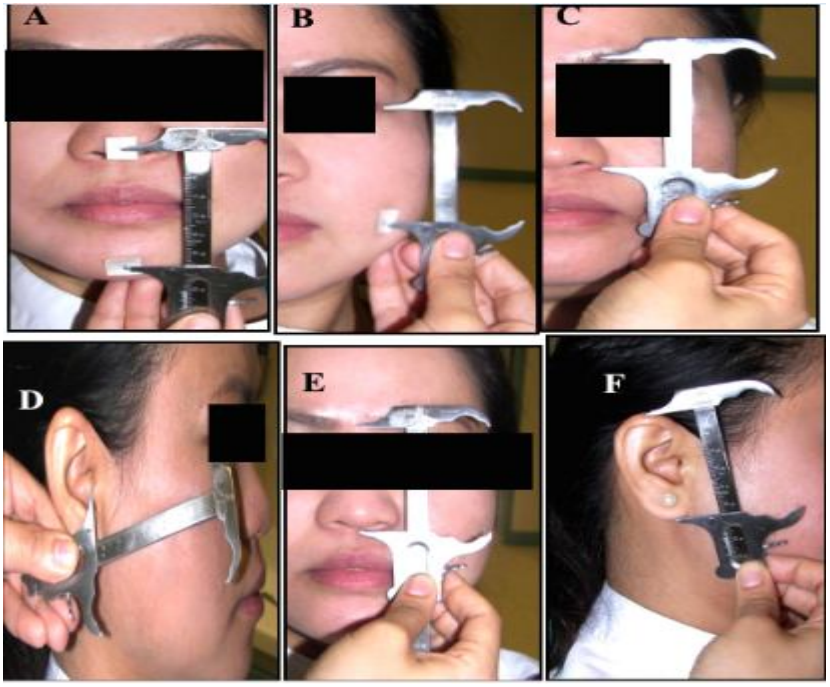


Figure 2: Vernier Gauge.

The statistical package for social sciences (SPSS) version 20.0 was used to analyze the results statistically, and the mean and standard deviations were obtained. The relationship between the vertical dimension of occlusion (VDO) of the subjects and each calculated measurement was identified using One-way analysis of variance (ANOVA).Moreover, regression analysis was applied to discover the correlation between the VDO and the various measurements. The investigators obtained an ethical clearance through the ethical committee and all subjects were provided a written informed consent for participating in the study.

Results

For each participatn, the mean of every parameter was calculated. The minimum vertical dimension of occlusion recorded for the dentate individuals was 52.33mm; whereas, the maximum value measured was 85.67mm. The average vertical dimension of occlusion recorded for these individuals was 69mm. The data was statistically analyzed using Statistical Package for Social Sciences software (SPSS)version 20.0. Results of regression analysis showed that among all measurements, the vertical distance from the outer canthus of the eye to the corner of the mouth showed the strongest positive correlation with VDO ($r2 = 0.610$) (Table 1).

Table 1. ANOVA,relationship between VDO and the distance from the outer canthus of the eye to the corner of the mouth (measure 1).

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	1294.124	1294.124	210.783	<.0001
Residual	135	828.846	6.140		
Total	136	2122.970			

Regression analysis has revealed that using the r^2 value of 0.61, VDO can be determined using the following formula;

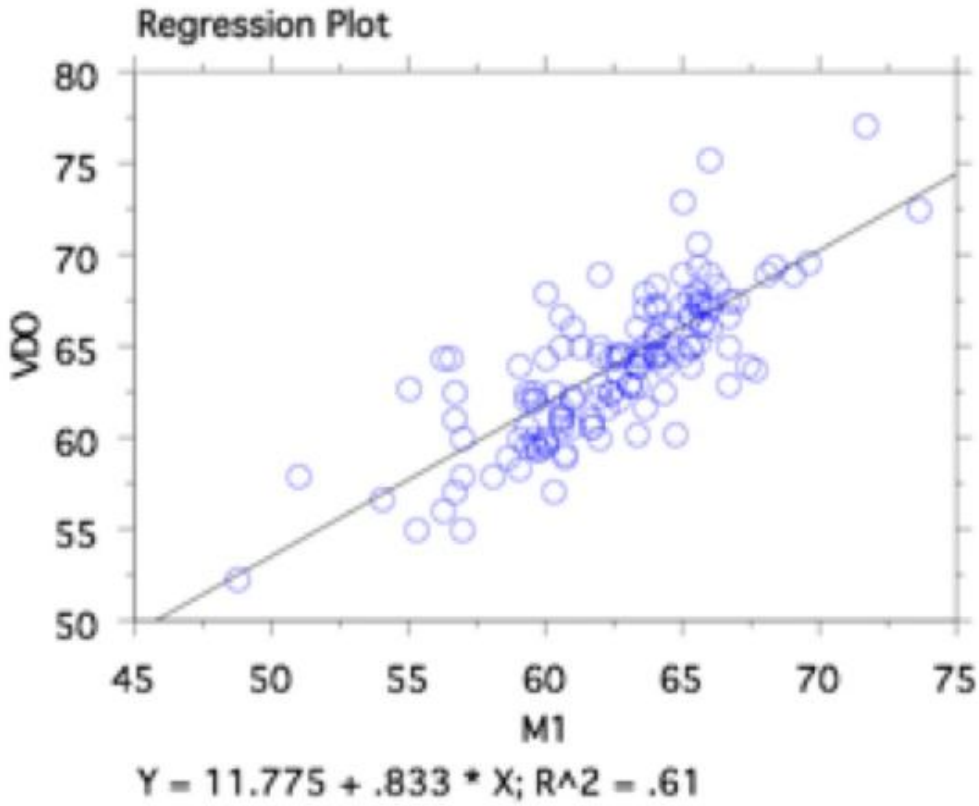
$$VDO = 0.833 * M + 11.775$$

Where; M is the **the distance from the outer canthus of the eye to the corner of the mouth**.Moreover, one-way analysis of variance (ANOVA) with the level of significance at 0.05 revealed a statistically significant p-value (<0.0001) for the mean value of this measurement (Table 2 & Figure 4).

Table 2: Results of regression analysis for the relationship between the vertical dimension of occlusion (VDO) and the distance from the outer canthus of the eye to the corner of the mouth (measure 1).

Count	137
Num. Missing	0
R	0.781
R Squared	0.61
Adjusted R Squared	0.607
RMS Residual	2.478

Figure 3: Regression Model.



The remaining parameters showed a very weak correlation with VDO, with the distance from the outer canthus of the eye to the external auditory meatus (r2 = 0.045) and the distance from the tip of the thumb to the tip of the index finger (r2 = 0.043) showing the least significant correlation.

Discussion

The study was conducted to confirm the reliability of facial and hand measurements to determine the VDO. Various methods have evolved for the measurement of the vertical dimension of occlusion in edentulous and dentulous patients. However, there is no accurate and universally accepted method to determineVDO in edentulous patients.

The determination of vertical dimension of occlusionis a critical step in the fabrication of complete dentures and the rehabilitation of dentulous or edentulous patients. However, VDO assessments rely strongly on the judgment of the clinician.[14]Several studies have advocated different methods for VDO determination, which can be broadly divided into the following:

- Physiological and subjective methods that include assessments of the physiological rest position, swallowing, phonetics, and esthetics.
- Mechanical and objective methods that include assessments of facial measurements, pre-extraction records, cephalograms andelectromyograms.[28]

Some of these techniques require complex devices and are not practical for everyday use. [29]McGee stated that it might be possible to use facial measurements of anatomic landmarks in establishing vertical dimension.[4]Therefore, this study has focused on the relationship between VDO along with facial and hand measurements in the dentate population, and determined the reliability of these measurements. The measurements obtained were selected from previous studies. [3, 26, 28, 30]The average VDO recorded for the participants in this study was 69 mm. This value was similar to those obtained by McGee, who proposed an average value of 65–70 mm for VDO. [23]For a successful prosthesis, the VDO must be determined carefully by the dentist.

The results suggested a significant positive relationship between VDO and the vertical distance from the outer canthus of the eye to the corner of the mouth (r2 = 0.610). Similar results were obtained in studies conducted by Goodfriend, McGee, Schweitzer, and Willis.[12, 23, 31, 32, 35]In 1953, Fenn et al. proposed that the vertical distance from the outer canthus of the eye to the corner of the mouth could be used for accurate VDO determination.[24]Nagpal et al. recently studied 150 dentate and edentulous subjects, and found a strong association between VDO and the distance from the left corner of the eye to the corner of the mouth in the dentate subjects. They further reported that VDO is strongly associated with the distance from the right corner of the eye to the ear. [32]In the present study, the facehas been considered to be symmetrical, in accordance with Thompson's statement that there is no truly symmetrical face. Normal asymmetry is not very evident;whereas, abnormal asymmetry is quite obvious and its frequency of occurrence puts it in a class to be treated by itself. [17]It was concluded from another study conducted on the edentulous patients that to determine VDO for a particular denture wearer, left angle of eye to angle of mouth distance and left ear-eye distance could be used with accuracy.

In a recent study conducted in dental colleges and hospitals in India (n = 400 dentate subjects) by Ladd et al., it wasfound that VDO can be estimated by measuring the distance from the index finger to the thumb.[22] However, the present study found this measurement to be the least reliable for VDO determination. Similarly, Chou et al. stated that the left ear–eye distance can predict the chin–nose distance with reasonable accuracy, [31]where this measurement found to be one of the least significant in the present study. These discrepancies between studies may have resulted from differences in the ethnic groups included in each study, which may have demonstrated different facial features.A study conducted by Geerts et al. concluded that, the caliper method is significantly more reliable for the measurement of VDO. [33]To a certain extent, the variation in measurements was because of the difference in the techniques of measurement, ethnicities of the population, and also due to the sample size involved. The results also indicated that anthropometric measurements, which include finger lengths, can be used for initial guidance to estimate the lower facial height and offer significant prosthetic advantages. The traditional methods like; the judgement of facial esthetics although sounds well subjectively, but scientifically they are non-specific. Whereas, the objective methods like; electromyography and biting forces involve the use of complex devices that cannot be used in routine life; therefore, these methods are also impractical.

There is still no positive and effective method to determine the VDO; hence, the use of facial dimensions for establishing the occlusal vertical dimension is considered to be more practical method to be used in routine life. Also the facial and hand measurements to determine VDO are widely accepted as it doesnot require great amount of time, easily mastered, are practical and no expensive equipment are needed.

Conclusion

VDO determination is one of the most critical steps in prosthesis fabrication, although there is no precise scientific method for this purpose. The results suggested that the vertical distance from the outer canthus of the eye to the corner of the mouth is a reliable and reproducible measurement for the determination of VDO. Moreover, the valuable adjunct is needed in the determination of VDO that is an imperious step for completing the denture fabrication. Furthermore, the technique is simple and economical and can be used in daily clinical practice. Further studies including larger samples of subjects from diverse ethnic groups are needed to confirm the findings. Scientific techniques will likely increase the reliability of the measurements in order to determine the VDO despite the past conventional techniques. Different techniques have been proposed to determine accurate VDO. The criteria to be considered while selecting the best method to determine VDO include accuracy and repeatability of the measurement, type and complexity of the equipment needed, and the time required to secure the measurement.

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Conflict of Interest

The authors declare no conflict of interest.

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