INTRODUCTION

The jaw-related concept used in removable complete dentures is still in its infancy to scaffold our decision for all the prosthetic rehabilitation procedures. Among the various jaw relations done, determination of the vertical dimension of occlusion (VDO) is the most critical aspect of denture fabrication. According to Glossary of Prosthodontics Terms (GPT), vertical dimension of occlusion is defined as the distance between two selected anatomic or marked point usually one on the tip of the nose and the other on the chin when in maximal intercuspal position.¹

Determining the ideal VDO is a multifaceted task, as it relies on a delicate balance between anatomical considerations and the patient’s individual characteristics.

Restoring the physiologic VDO is believed to achieve balance and harmony of the lower third of the face and ensure most ideal function. As a consequence of edentulism there is loss of VDO, which can impair masticatory function, phonetics, esthetics and facial appearance.²³ It is believed that the vertical dimension restored should be the same as probably what existed prior to edentulous situation.⁴

Various methods have been proposed to determine VDO like determining vertical dimension at rest by Niswonger, pre-extraction records, cephalometric records, facial measurements, etc.⁵¹³

Since none of the methods can accurately determine VDO, several methods are recorded to reach a conclusion and decision is based on clinical judgment. Thus, there is a need to explore new approaches to estimate the lost VDO. This study was performed to provide objectivity and to investigate the application of formula derived from Lateral Profile Photographs (LPP) of fully dentate subjects for determining the VDO in partially and totally edentulous patients.

METHODS

A single-center institutional-based cross-sectional study was conducted at the College of Medical Sciences, Bharatpur, Chitwan, Nepal. Using non-probability convenience sampling, 50 participants aged 20-30 years with specific dental parameters were selected. LPPs were obtained, and angular measurements were recorded to establish correlations and regression models.

RESULTS:

Statistical analysis revealed a significant correlation between measured angles and VDO. Strong and positive relationships were identified between Stn-Stsn-Stgn and Stn-Stsn-Stg angles and between Stp-Stg-Stgn and Stp-Stg-Stsn angles. The study’s regression models successfully predicted Stn-Stsn-Stgn and Stp-Stg-Stgn angles using Stn-Stsn-Stg and Stp-Stg-Stsn as predictor variables.

CONCLUSIONS:

The study underlines the potential of LPPs as a practical tool for estimating VDO, presenting an accessible alternative to conventional techniques. The observed correlations emphasize the intricate interplay of craniofacial parameters, reinforcing the importance of accurate VDO determination for successful dental treatments.

ABSTRACT

Background: Dentistry’s evolving focus on fixed prostheses contrasts with the relative infancy of the jaw-related concepts in removable complete dentures, particularly in determining the vertical dimension of occlusion (VDO). The criticality of VDO in prosthetic rehabilitation underscores the need for stable parameters. However, due to the lack of a stable paradigm, the precise determination of VDO remains a contentious issue. This study proposes the utilization of lateral profile photographs (LPPs) to estimate VDO in edentulous patients.

Methods: A cross-sectional study was conducted at the College of Medical Sciences, Bharatpur, Chitwan, Nepal. Using non-probability convenience sampling, 50 participants aged 20-30 years with specific dental parameters were selected. LPPs were obtained, and angular measurements were recorded to establish correlations and regression models.

Results: Statistical analysis revealed a significant correlation between measured angles and VDO. Strong and positive relationships were identified between Stn-Stsn-Stgn and Stn-Stsn-Stg angles and between Stp-Stg-Stgn and Stp-Stg-Stsn angles. The study’s regression models successfully predicted Stn-Stsn-Stgn and Stp-Stg-Stgn angles using Stn-Stsn-Stg and Stp-Stg-Stsn as predictor variables.

Conclusions: The study underlines the potential of LPPs as a practical tool for estimating VDO, presenting an accessible alternative to conventional techniques. The observed correlations emphasize the intricate interplay of craniofacial parameters, reinforcing the importance of accurate VDO determination for successful dental treatments.
conducted at the College of Medical Sciences and Teaching Hospital, Bharatpur-10, Chitwan, Nepal over a period of 6 months. The study was approved by the institutional Review Committee (COMS-TH IRC: Ref No.: 2022-021). This study encompassed all undergraduate students, hospital staffs working in the institute and patients visiting the hospital who fulfill the inclusion criteria.

The sample size of 50 participants was determined through a calculation involving a standard deviation of 5.03, a Z-score of 1.96, and an error of 1.5, employing a non-probability convenience sampling method. The inclusion criteria for the subjects were: age limit between 20-30 years, presence of full complement of teeth, Class I molar and canine relation, non-attrited teeth and absence of temporomandibular disorders whereas, the exclusion criteria were facial asymmetry and orthodontic treatment done in the past. Informed consent was taken of all the participants who fulfilled the inclusion criteria.

Lateral Profile Photographs (LPPs) were taken following a standardized protocol. Participants were positioned in a natural head posture, with their lips gently closed, and their facial expressions at rest. The LPPs were captured using camera (Canon EOS, 35 mm leans, 30.3 mp), ensuring proper lighting and focus. Five critical soft tissue reference points were identified on each LPP and marked using a pointed marker, i.e., Nasion (Stn): The top of the nose bridge; Subnasale (Stsn): The point between the nose and upper lip; Porion (Stp): The external ear canal’s uppermost point; Gnathion (Stgn): The most inferior point of the chin; Gonion (Stg): A point on the jawline. The vertical dimension of occlusion was clinically determined using conventional methods. This served as the reference VDO measurement.

Angular measurements were made between the reference points to capture the facial and dental relationships, i.e., Angle A (Stn-Stsn-Stg-Stgn): The angle between nasion, subnasale and gnathion; Angle B (Stn-Stsn-Stg): The angle between nasion, subnasale and gonion; Angle C (Stp-Stg-Stgn): The angle between porion, gonion and gnathion; Angle D (Stp-Stg-Stsn): The angle between porion, gonion and subnasale. The angles between the reference points were measured using the protractor and the vertical dimension of occlusion was measured using the two reference points (stsn and stgn) with a standardized mm scale.

The recordings was tabulated in a suitable record file. Descriptive statistics were computed for each angular measurement (Angles A, B, C, and D) and the clinically determined VDO.

Correlation analysis was conducted to assess the relationships between the measured angles and the VDO using Pearson’s correlation coefficient (r). Simple linear regression models were developed to predict VDO based on the angles, yielding regression equations for estimating VDO from LPP data. Intra- and inter-examiner reliability tests were conducted for angular measurements to ensure the accuracy and consistency of data collection. Data entry was done in SPSS- V 17 software (Chicago, IL, USA). The correlations between the angles, Stn-Stsn-Stg-Stgn (AngleA) and Stn-Stsn-Stgn (Angle B) : Stn-Stsn-Stgn (Angle C) and Stp-Stg-Stgn (Angle D) were determined using Pearson correlation test. For predicting Stn-Stsn-Stgn and Stp-Stg-Stgn angles from Stn-Stsn-Stg and Stp-Stg-Stsn respectively, simple regression analysis was carried out. The predicted angles were transferred on to Lateral profile photographs and VDO constructed on the photograph. The actual and predicted VDO values were again correlated using Pearson correlation test.

RESULTS

A total of 50 participants were recruited with age range from 20-30 years with the mean (SD) of 25.3±2.89. The mean values for Stn-Stsn-Stg and Stn-Stsn-Stgn were 160±24.21, ranged from 145 degrees to 169 degrees and 114.3±6.095 with range of 99 degrees to 125 degrees respectively, whereas mean values for Stp-Stg-Stg and Stp-Stg-Stsn were 117.90±5.687 ranged from 108 degrees to 138 degrees, and 81.48±4.514, ranged from 73 degrees to 98 degrees respectively. The mean actual VDO-LP measurement was 40.15 millimeters, with a standard deviation of 3.453 millimeters with minimum and maximum value of 32.3 mm and 46.8 mm respectively.

The correlation coefficient (r) between the Stn-Stsn-Stgn and Stn-Stsn-Stg angles was statistically significant and highly positive (r = 0.78, P < 0.01), with a coefficient of determination (r²) of 0.61, indicating that 61% of the variation in the Stn-Stsn-Stgn angle could be explained by the variation in the Stn-Stsn-Stg angle (Fig.1). Similarly, the correlation coefficient between the Stp-Stg-Stg and Stp-Stg-Stsn angles was statistically significant and positive (r = 0.77, P < 0.01), with a coefficient of determination (r²) of 0.59, indicating that 59% of the variation in the Stp-Stg-Stg angle could be explained by the variation in the Stp-Stg-Stsn angle (Fig. 2).

In other words, the results suggest that there is a strong and positive relationship between the Stn-Stsn-Stgn and Stn-Stsn-Stg angles, as well as between the Stp-Stg-Stg and Stp-Stg-Stsn angles. This means that changes in one angle are likely to be associated with changes in the other angle. The coefficient of determination (r²) indicates that a significant proportion of the variation in one angle can be explained by the variation in the other angle.

We developed linear regression models to predict the Stn-Stsn-Stgn and Stp-Stg-Stsn angles using the Stn-Stsn-Stg and Stp-Stg-Stsn angles as the predictor variables. Each model was represented in the form of y = a + bx, where ‘y’ represents the dependent variable (either Stn-Stsn-Stgn or Stp-Stg-Stgn), ‘a’ represents the independent variable (either Stn-Stsn-Stg or Stp-Stg-Stsn), ‘a’ is the y-intercept, and ‘b’ is the slope of the regression line. The resulting regression equations were as follows:

The following equations were obtained:

\[
\text{Stn-Stsn-Stgn (in degrees)} = 1.12x-66.43
\]

\[
\text{Stp-Stg-Stgn (in degrees)} = 0.613x+9.200
\]

\[
\text{Stn-Stsn-Stg (in degrees)} = 1.12x-66.43
\]

\[
\text{Stp-Stg-Stsn (in degrees)} = 0.613x+9.200
\]
These equations indicate that there is a strong and positive linear relationship between the Stn-Stsn-Stgn and Stn-Stsn-Stg angles, as well as between the Stp-Stg-Stgn and Stp-Stg-Stsn angles. The slope of the regression line in each equation represents the change in the dependent variable per unit change in the independent variable.

Using the new equations, the predicted Stn-Stsn-Stgn and Stp-Stg-Stgn angles were transferred into the LP (Figure 3). This was done to predict the VDO-LP (vertical dimension of occlusion on the lower posterior teeth using predicted angles). The predicted VDO-LP measurements was 38.92±3.44 mm and ranged from 32.8 to 48.8 mm. The correlation between the predicted and actual VDO-LP for all participants was strong and positive, i.e., r² 0.884 (p<0.01) which signifies that prediction of the VDO in partially and totally edentulous patients is possible through Lateral Profile Photographs (LPP).

**DISCUSSION**

Vertical dimension of occlusion (VDO), also known as occlusal vertical dimension (OVD), is the vertical distance between the maxilla and the mandible when the teeth are in maximum intercuspation. It is an important measurement in dentistry, as it affects the patient’s bite, esthetics, and speech. VDO can be measured in a variety of ways, but the most common method is to use a facial caliper. The caliper is placed on the patient’s face at two reference points, and the distance between the two points is measured. This measurement is then used to calculate the VDO.¹⁴⁻¹⁷

Owing to the lack of reliable parameters, the most critical and contentious aspect of complete denture construction is the determination of the maxillo-mandibular relations especially the occlusal vertical dimension.¹⁸ The resulting imprecision creates a whole series of problems, both esthetic and functional thus, compromising the success of prosthetic rehabilitation.

One of the most critical step in the fabrication of complete denture is jaw relation which also includes establishing the vertical dimension of occlusion.⁷ The VDO better described as comfort zone is result of musculoskeletal balance during growth; the muscle organization clearly related to the skeletal and facial morphology. For dentate patients, the VDO is established by occluding the mandibular and maxillary teeth. For individuals with lost teeth, establishing VDO is very crucial and critical.¹⁹ Any error is recording the proper vertical height may impair functional and esthetic harmony of maxillofacial structure.

VDO is a critical parameter in dentistry, but determining the ideal VDO is a complex task. Methods to establish the occlusal vertical dimension can either be subjective or objective. The subjective methods comprise evaluation of esthetics, phonetics, swallowing and patient comfort. These methods are judgemental and scientifically non-specific. The objective methods like electromyography, biting forces, are not practical as they need complex devices. Other methods like facial measurements, facial proportions by Willis gauge, pre-extraction measurements, cephalometrics, finger length have also been used in the past.²⁰ But due to facial asymmetry, the use of few anatomical landmarks can be questionable.²¹ So, recently 2D and 3D studies of various facial landmarks has been done.²² A cephalometric analysis can be used as it represents solid parameters to define OVD, but patients compliance for it may be less and also the radiation hazards may be another pitfall.²³
However, as the facial soft tissue morphology is easy to locate and is more substantiated, this study was proposed to correlate the facial angles formed by joining various landmarks, to predict one from another and thus find suitable OVD.

Lateral profile photographs are easy to obtain and require no specialized equipment or training. This research could lead to a more accessible and affordable method for determining VDO, as it would not require expensive equipment or the expertise of a radiologist or other technician. Lateral profile photographs are non-invasive and pose no risk to the patient. There are many methods for determining VDO but none of them are free from errors.\textsuperscript{6,11} In this study, we conducted measurements on 50 participants aged 20 to 30 years (mean age ± SD: 25.3±2.89). The Stn-Stsn-Stgn angle had an average value of 160±4.21 (ranging from 145 to 169 degrees), while the Stn-Stsn-Stg angle averaged 114.3±6.095 (ranging from 99 to 125 degrees). Additionally, the mean actual VDO-LP measurement measured from Stsn to Stgn was 40.15 millimeters, with a standard deviation of 3.453 millimeters. The minimum value recorded was 32.3 mm, and the maximum value was 46.8 mm.

The mean values for Stp-Stg-Stgn and Stp-Stg-Stsn were 117.90±5.687 ranged from 108 degrees to 138 degrees and 81.48±4.514 with range of 78 to 98 degrees respectively. The age of research participants and measurements of reference facial landmarks of our study are consistent with a similar study conducted by Vinnakota et al. where mean age of the participants was 22.4 (range of 20–27 years).\textsuperscript{13} The mean values for Stn-Stsn-Stg and Stn-Stsn-Stg were 160.4 ± 5.03 (range from 149 to 170) and 104.8 ± 3.7 (range from 98 to 115), respectively.

Our analyses revealed significant and highly positive correlations between the Stn-Stsn-Stg and Stn-Stsn-Stg angles ($r = 0.78$, $p < 0.01$), indicating that 61% of the variance in the Stn-Stsn-Stg angle could be explained by the variance in the Stn-Stsn-Stg angle. Similarly, a significant positive correlation was observed between the Stp-Stg-Stgn and Stp-Stg-Stsn angles ($r = 0.77$, $p < 0.01$), with an $r^2$ of 0.59, suggesting that 59% of the variation in the Stp-Stg-Stgn angle could be accounted for by the variation in the Stp-Stg-Stsn angle. This finding on correlation between Stp-Stg-Stgn and Stp-Stg-Stsn angles is identical with the study conducted by Vinnakota et al.\textsuperscript{11}

Using the formula we derived, the two angles Stn-Stsn-Stgn and Stp-Stg-Stgn were predicted and were traced on the LPP. The meeting point was marked on LPP and its distance from Stsn was used as predicted VDO. The strong and positive correlation between the predicted and actual VDO-LP for all participants ($r^2 = 0.884$, $p < 0.01$) suggests that the prediction of VDO in partially and totally edentulous patients is possible through lateral profile photographs (LPP). This finding is significant because it provides an easy, non-interventional and cost-effective method for estimating VDO, which can be useful for a variety of clinical applications, such as treatment planning and outcome assessment. As there are very limited identical studies till now, our finding is identical with the study conducted by Vinnakota et al who reported positive correlation between the predicted and actual VDO based on LPP.\textsuperscript{13}

In essence, our findings indicate a robust and positive relationship between the Stn-Stsn-Stgn and Stn-Stsn-Stg angles, as well as between the Stp-Stg-Stgn and Stp-Stg-Stsn angles. This implies that alterations in one angle are likely associated with changes in the other.

In conclusion, the vertical dimension of occlusion (VDO) serves as a critical parameter in dentistry, significantly impacting a patient’s bite, esthetics, and speech. In a study by Piancino et al reported the interlink between facial structures, muscle activity and chewing forces.\textsuperscript{24} Inadvertent increase or decrease of lower facial height may interfere with these association and may affect the quality of life.\textsuperscript{25} While conventional methods for VDO determination often lack precision and can be interventional, our study highlights the potential of lateral profile photographs as a non-interventional, accessible, and cost-effective alternative. The strong correlations identified between various facial angles emphasize the interconnected nature of craniofacial parameters, underlining the need for accurate VDO measurement for ensuring optimal functional and aesthetic outcomes in dental treatments.

Based on the findings of our study, we recommend the integration of lateral profile photographs as a reliable and convenient method for assessing the vertical dimension of occlusion (VDO) in clinical practice. This approach not only eliminates the need for specialized equipment and training but also minimizes the risks associated with interventional techniques. Additionally, the strong correlations observed between specific facial angles emphasize the importance of a comprehensive evaluation of various craniofacial parameters in dental treatments. Therefore, it is essential for clinicians to prioritize accurate VDO determination, utilizing advanced techniques such as lateral profile photographs to ensure precise measurements and optimal treatment outcomes for patients requiring dental interventions. Furthermore, further research and clinical validation are warranted to establish standardized protocols and guidelines for the integration of lateral profile photographs in routine dental assessments, thereby enhancing the overall quality of dental care.

The study was done in an institutional set up in Bharatpur, Chitwan hence may not be generalizable to entire country.

CONCLUSION

The vertical dimension of occlusion (VDO) serves as a critical parameter in dentistry, significantly impacting a patient’s bite, esthetics, and speech. While conventional methods for VDO determination often lack precision and can be interventional, our study highlights the potential of lateral profile photographs as a non-interventional and accessible method. The strong correlations identified between various facial angles emphasize the interconnected nature of craniofacial parameters, underlining the need for accurate VDO measurement for ensuring optimal functional and aesthetic outcomes in dental treatments.

CONFLICT OF INTEREST: None

FINANCIAL DISCLOSURE: None
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