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Facial Measurements Aid in Determining Vertical Dimension - A Short Span Clinical Study

Running Title: *Facial Measurements Aid in Determining Vertical Dimension*

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Abstract: ***Background**: The vertical dimension of occlusion is pivotal in dental rehabilitation, vital for the durability and effectiveness of dental prostheses, and ensuring optimal occlusal harmony and patient satisfaction. Nevertheless, the lack of a universally accepted, fully accurate assessment method remains a significant challenge. **Aim**: To evaluate the vertical dimension of occlusion in individuals with normal occlusion using various facial measurements and to compare these methods to establish the most accurate technique. **Materials and Methods**: Fifty individuals with normal occlusion were selected. Four facial measurements were recorded: interpupillary distance (A), distance between inner and outer canthus (B), distance from outer canthus/pupil to mouth corner (C), and distance from glabella to subnasion (D). These measurements were compared with the Niswonger technique (E) using descriptive analysis and paired t-tests. Subjects were positioned under perpendicularly placed ruler scales. Photographs were taken from 5 feet using a tripod-mounted camera. Facial measurements were then taken from the photographs and calibrated using vernier caliper software. **Results**: Landmark A, B, C and D had a mean value of 6.51mm, 6.48mm, 6.41mm and 6.38mm respectively. Niswonger technique (E) had a mean value of 6.36mm. Measurements A and B showed significant differences compared to the Niswonger technique, while measurements C and D did not. This suggests varying reliability among anatomical landmarks for assessing the vertical dimension. **Conclusion**: Measurements C and D, demonstrate reliability in determining the vertical dimension of occlusion. These findings provide valuable insights for clinicians in treatment planning and occlusal rehabilitation, contributing to improved treatment outcomes and patient satisfaction.***

Keywords: Vertical dimension, Niswonger method, Facial measurements, Vernier caliper

1. Introduction

The vertical dimension of occlusion (VDO) pertains to the facial length, determined by the degree of jaw separation, holding crucial importance in crafting all dental restorations. Two theories have been proposed regarding this dimension: one posits a constant maintenance of the vertical dimension as teeth continuously erupt to counteract wear, while the surrounding dental structures sustain it; the other suggests that eruption might not match tooth wear, with the vertical dimension influenced by tooth loss and eruption discrepancies among individuals. [1, 2]

Various methods have been employed to measure the vertical dimension of occlusion in both dentulous and edentulous patients, ranging from pre-extraction records to functional jaw positions acquired during swallowing and phonetics, as well as the use of cephalometric radiographs and evaluation of radiopaque paste in the vestibular fornix. However, no universally accepted or entirely accurate method exists for determining the vertical dimension of occlusion in edentulous patients, with differences among techniques mainly concerning time, cost, and equipment requirements. [3,4,5]

Several landmarks have been employed for facial measurements. Niswonger favoured using the subnasal (SN) point in conjunction with the chin (C) to establish the occlusal vertical dimension (OVD). Alternatively, some authors suggest using the tip of the nose (TN) instead of SN as a reference point.[6] Carossa et al. utilized TN, while other researchers have investigated SN for facial measurements [7]. Through video recordings, Jakstat et al. determined that TN was the least mobile landmark due to the influence of facial muscles.[8]

Alternative techniques and approaches for determining the vertical dimension of occlusion (VDO) are objective and direct, such as employing facial dividers and measuring soft tissue. The use of facial measurements for VDO determination dates back to ancient times, evidenced by Leonardo da Vinci's sketches on facial proportions, known as divine proportions. Misch has asserted that facial and hand measurements offer significant advantages in determining VDO during prosthesis fabrication, as they are direct and objective methods, unlike subjective approaches.[9]

The ultimate outcome holds paramount importance. Establishing the VDO is a critical phase, and any inaccuracies may lead to adverse effects on oral structures. This concern has spurred many prosthodontists to seek a consistent anthropometric measurement within the face, one that satisfies both esthetic preferences and functional requirements without inducing degenerative changes. Regardless of the method employed, meticulous determination of the vertical dimension of occlusion by the dentist is essential for the success of the prosthesis.

Despite ongoing advancements in techniques and materials in prosthodontics, there remains no definitive method for accurately assessing the vertical dimension of occlusion in edentulous patients. "Clinical judgment" remains pivotal in evaluating this crucial component in complete denture construction. The methods for constructing successful complete dentures should strive for accuracy and be rooted in scientific principles. Present-day complete denture construction largely adheres to the same techniques and principles as those established three decades ago.
Thus this study aims to evaluate the vertical dimension of occlusion (VDO) in individuals with normal occlusion using various facial measurements and to compare these methods to establish the most accurate technique.

2. Methodology

Ethical approval was secured from the institutional ethics board before the study commenced. Written informed consent was obtained from the patient prior to participation in the study. 50 completely dentate individuals, aged between 20-25 years, with normal occlusion were selected from the institution. Vertical jaw relation is done by measuring vertical dimension at rest and occlusion. First vertical dimension at occlusion was determined by Niswonger's technique (E) (control group). Patients were asked to sit in an upright position without any head support and two points were marked in the most prominent portion of the nose and the chin. After making vertical dimension measurement it can be compared with other facial measurements. The 4 most reliable facial measurements include (1) the horizontal distance between the pupils (A); (2) the vertical distance from the external corner of the eye (outer canthus) or the pupil to the corner of the mouth (B); (3) the vertical length of the nose at the midline (from subnasion to glabella) (C); and (4) the distance from the outer corner of one eye (outer canthus) to the inner corner (inner canthus) of the other eye (da Vinci) (D). Inclusion criteria included individuals with a full set of teeth, normal occlusion, and a willingness to sign the consent form and adhere to the study protocol. Exclusion criteria comprised individuals younger than 20 or older than 25, those with systemic diseases, individuals on medication, pregnant or lactating women, those with mental or physical disabilities, and individuals participating in other clinical trials.

Standardisation of measurement:
Two graduated ruler scales were placed perpendicular to each other at one of their edges. The placement was standardized by sticking with a two-way sticker on the wall. Each subject is allowed to sit exactly under the horizontally placed scale. Photographs made with tripod stand placed at 5 feet distance with 2 rulers placed perpendicular to subject's facial plane. In each subject's photograph the exact length or height of the face is measured according to the scale on the photograph. (Figure 1) A vernier calliper software was used to coincide the measurement with the scale on the photograph. Photographs were standardized by enlarging to life size and again the facial measurement was made by merging ruler scale in photograph with digital vernier calliper in the computer. (Figure 2) Later all the measurements were noted down and compared. These measurements were analysed using SPSS (version 21.0) software. Descriptive statistics, including the mean and standard deviation, were used for all the anatomical landmarks, and a pearson's correlation coefficient and paired t-test was conducted for statistical analysis.

Figure 1: Photograph made by placing a ruler from 5 feet distance

A: Placement of ruler perpendicular to each other

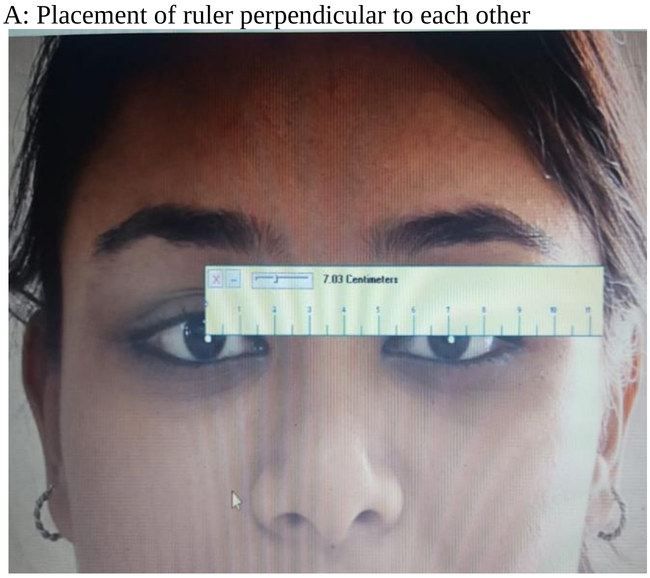

Figure 2: Measurement using vernier calliper software

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3. Results

The present study utilizes four standardized measurements of anatomical landmarks: interpupillary distance (A), the distance between the inner canthus of one eye and the outer canthus of the other eye (B), the distance from the outer canthus or pupil to the corner of the mouth (C), and the distance between the glabella and subnasion (D).

Table 1: Mean and standard deviation of various vertical dimension at occlusion using different anatomical landmarks

Anatomical landmarks	Mean + SD	Minimum	Maximum
A	6.51 + 0.39	5.79	7.60
B	6.48 + 0.39	5.45	7.35
C	6.41 + 0.26	5.93	7.00
D	6.38 + 0.34	5.65	7.37
E	6.36 + 0.33	5.65	7.00

Where A - interpupillary distance; B - distance between inner and outer canthus; C - distance from outer canthus/pupil to mouth corner; D - distance from glabella to subnasion; E - Niswonger technique

The table 1 presents measurements of various anatomical landmarks obtained from the study participants. Landmark A has a mean value of 6.51mm. Landmark B shows a mean value of 6.48mm, C with the mean value is 6.41mm. Landmark D exhibits a mean value of 6.38mm and E has a mean value of 6.36mm. These findings provide insight into the facial dimensions utilized for assessing the vertical dimension of occlusion in individuals with normal occlusion. Comparison of Mean VDO of various anatomical landmarks (A, B, C, D) with Niswonger method is depicted in Figure 2.

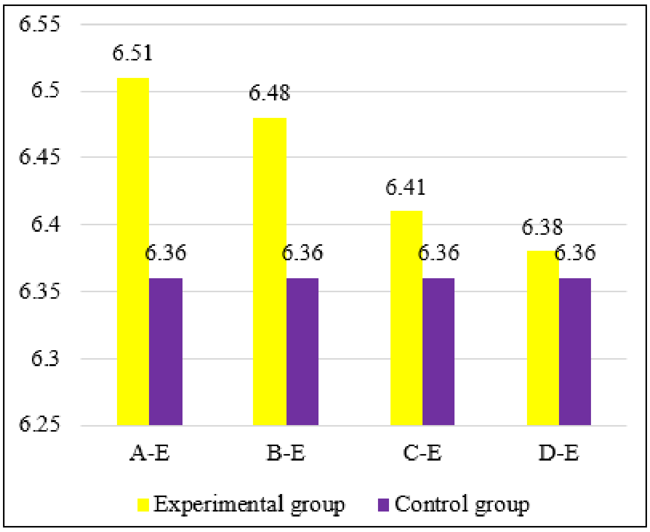

Figure 3: Comparison of Mean VDO of various anatomical landmarks with Niswonger method

The study found strong positive correlations between variable E and variables A, B, C, and D. Specifically, the correlation coefficients were 0.705 for E and A, 0.691 for E and B, 0.760 for E and C, and 0.605 for E and D, indicating robust relationships across all comparisons. All correlations were statistically significant, with p-values of 0.000, underscoring the reliability of these findings. (Table 2)

Table 1: Correlation coefficient obtained from pearson's correlation analysis

		A	B	C	D
E	Correlation coefficient	0.705*	0.691*	0.760*	0.605*
	p value	0.000	0.000	0.000	0.000

p value ≤ 0.05 is significant

Where, A - interpupillary distance; B - distance between inner and outer canthus; C - distance from outer canthus/pupil to mouth corner; D - distance from glabella to subnasion; E - Niswonger technique

A paired t-test was conducted to compare the various anatomical landmark measurements with Niswongers technique value (E). The mean difference between measurement A and E is 0.152 mm with a standard deviation of 0.276 mm, indicating a statistically significant difference (p < 0.000). The mean difference between measurement B and E is 0.127 mm with a standard deviation of 0.283 mm, indicating a statistically significant difference (p<0.003). The mean difference between measurement C and the E is 0.050 mm with a standard deviation of 0.209 mm, indicating no statistically significant difference (p <0.092). The mean difference between measurement D and the E is 0.027 mm with a standard deviation of 0.289 mm, indicating no statistically significant difference (p > 0.513). (Table 3)

Table 2: Mean difference of VDO of various anatomical landmarks measurements using paired t test

Measurement Pair	Mean difference (mm)	Standard deviation (mm)	t value	df	p value
A-E	0.152	0.276	3.901	49	.000*
B-E	0.127	0.283	0.162	49	.003*
C-E	0.050	0.209	1.717	49	.092
D-E	0.027	0.289	0.660	49	.513

P<0.05 considered significant

4. Discussion

Establishment of vertical dimension pose perennial challenges to prosthodontists across different epochs, representing a pivotal and intricate stage in prosthodontic rehabilitation. Consequently, diverse approaches have been employed for vertical dimension determination. These methods can be categorized into subjective and objective approaches, where subjective methods involve swallowing, phonetics, aesthetic evaluation, and patient comfort, while objective methods encompass bite force assessment, electromyographic analysis, and facial measurements. While traditional methods hold intuitive appeal, they lack scientific specificity.[10]

The current study sheds light on the suitability of various anatomical landmarks for accurately determining the vertical dimension, particularly in comparison to the widely employed Niswonger technique. While interpupillary distance (Measurement A) and the distance between the inner canthus to outer canthus (Measurement B) demonstrated statistically significant differences from the Niswonger value, their mean distances remained closely proximal. However, inherent differences in anatomical structures and measurement techniques likely contribute to

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this discrepancy. For instance, variations in head position and eye movement during interpupillary distance measurement can introduce variability, while factors like facial asymmetry and inter-observer variability affect the measurement of the distance between the inner and outer canthus.

Conversely, distance from the outer canthus/pupil to the corner of the mouth (Measurement C) and distance from the glabella to subnasion (Measurement D) showed no statistically significant differences compared to the Niswonger value. These findings suggest a strong alignment between these landmarks and the established standard for determining the vertical dimension. Notably, Measurement C and D offer several characteristics that contribute to their reliability as anatomical landmarks.

Measurement C is resistant to facial movement and expression variability, providing stability in clinical examinations. Additionally, its external visibility and prominent features facilitate accurate landmark identification, minimizing measurement error. Furthermore, Measurement C exhibits consistent relationships across individuals, underscoring its reliability despite variations in facial morphology.

Measurement D represents well-defined anatomical points on the craniofacial skeleton, characterized by distinct bony prominences that are easily palpable and identifiable. Unlike soft tissue landmarks, the bony nature of the glabella and subnasion minimizes the influence of soft tissue variability on Measurement D, enhancing its reliability and consistency. Moreover, the biological stability of these landmarks ensures their reliability over time, bolstering Measurement D's utility as a consistent metric for vertical dimension assessment.

The current study's findings are congruent with those of Nagpal A et al. [10], McGee GF [11], Singh DK [12], with regard to measurement C and measurement D findings yet divergent from Chou et al. [13], whose investigation involved Mongoloid and Caucasian cohorts, contrasting with our focus on South Indian subjects. Furthermore, Chou et al. delineated diverse associations contingent upon dentulousness and sex. Inconsistent findings were observed compared to Ladda R et al. [14] and Hussain S and Yazdanie N [15].

The findings of this study carry substantial clinical implications for vertical dimension assessment and treatment planning in dentistry. Identification of reliable anatomical landmarks for determining the vertical dimension, ultimately leading to improved treatment outcomes in prosthodontic procedures, orthodontic interventions, and occlusal rehabilitation. By utilizing stable and consistent landmarks, clinicians can minimize measurement errors and discrepancies, enhancing treatment predictability and patient satisfaction. Moreover, accurate vertical dimension assessment ensures proper occlusal relationships and optimal prosthetic fit, enhancing patient comfort, functionality, and overall treatment success. Additionally, the streamlined assessment process saves valuable chairside time and reduces treatment costs, benefiting both clinicians and patients.

The study's demographic characteristics may limit the generalizability of the findings, warranting replication in larger and more diverse patient populations. The study's cross-sectional design hinders the establishment of causal relationships, highlighting the necessity for longitudinal or randomized controlled trials. Lastly, external validity concerns necessitate validation of the findings in different clinical settings and patient cohorts to ensure their applicability in diverse clinical scenarios.

5. Conclusion

The findings of this study reveal the challenges inherent in accurately determining the vertical dimension of occlusion and underscore the importance of employing reliable anatomical landmarks for this purpose. Interpupillary distance (A) and Distance between inner and outer canthus (B) exhibited significant differences from the Niswonger technique (E), highlighting the variability in their reliability for vertical dimension assessment. However, distance from outer canthus/pupil to corner of the mouth (C) and distance from glabella to subnasion (D) demonstrated consistency with the Niswonger technique (E), suggesting their potential as reliable metrics for assessing the vertical dimension in individuals with normal occlusion. By utilizing stable and consistent landmarks such as distance from outercanthus/pupil to corner of the mouth and distance from glabella to subnasion, clinicians can enhance treatment predictability and patient satisfaction while minimizing measurement errors.

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