Original Article

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Facial Measurements and their Correlation with Vertical Dimension of Occlusion in Dentate Subjects: An Anthropometric Analysis

Dentistry Section

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ABSTRACT

Introduction: In the field of prosthodontics, there lies a delicate balance between the preservation of supporting structures and the restoration of physiological function while providing complete denture prostheses to completely edentulous patients. A good prosthesis requires appropriate recording of the proper maxillo-mandibular relationship, including the vertical dimension of occlusion, which is a crucial step in complete denture fabrication. The reliability of anthropometric methods to determine the vertical dimension of occlusion has been widely discussed in the literature.

Aim: To evaluate the correlation of various facial measurements with the vertical dimension of occlusion in dentate subjects.

Materials and Methods: This cross-sectional study was conducted in the Department of Prosthodontics at a Dental College in Ambala district of Haryana, India, from February 2021 to July 2023. A total of 100 subjects (50 females and 50 males) within the age range of 20-35 years were selected. Five facial parameters were selected to correlate with the vertical dimension of occlusion: the distance from glabella to subnasion, the distance from the outer canthus of one eye to the inner canthus of the other eye, the distance from the outer canthus to the rima oris, the distance from the outer canthus to the External Auditory Meatus (EAM) on the left side of the face, and the Interpupillary Distance (IPD). Facial measurements were recorded using a digital vernier calliper, while IPD was recorded using a PD ruler. Each measurement was made three times and recorded by a single operator. Once recorded, all the measurements were tabulated and subjected to statistical analysis using the Pearson's correlation coefficient test. Regression analysis was also conducted to formulate a regression equation for determining the vertical dimension of occlusion.

Results: The mean Vertical Dimension of Occlusion (VDO) for males was 59.29±6.48 mm, and for females, it was 52.34±5.92 mm. The results showed a positive and significant (p-value <0.05) correlation between the vertical dimension of occlusion and facial measurements such as glabella to subnasion (p-value for males: 0.001, p-value for females: <0.001), outer canthus to inner canthus (p-value for males: 0.01, p-value for females: <0.001), outer canthus to rima oris (p-value for males: <0.001, p-value for females: <0.001), and outer canthus to EAM (p-value for males: 0.007, p-value for females: 0.001) in both males and females. However, there was no significant correlation between IPD and VDO (p-value for males: 0.296, p-value for females: 0.66) in both genders.

Conclusion: It can be concluded that facial measurements could be taken into consideration for determining the vertical dimension of occlusion in completely edentulous patients in conjunction with other reliable methods.

Keywords: Craniofacial landmarks, Intercanthal distance, Interpupillary distance, Vertical jaw relation

INTRODUCTION

Complete dentures should restore physiological function while still preserving the supporting structures [1]. To achieve this goal, it becomes imperative to accurately record jaw relations, including the vertical dimension [2]. According to the Glossary of Prosthodontic Terms (GPT), occlusal vertical dimension indicates the superior-inferior relationship of the maxilla and mandible when the teeth are occluded in maximum intercuspation, while the vertical dimension at rest is defined as the distance between two selected points when the mandible is in a physiologic rest position [3]. Inaccurate recording of the vertical dimension can lead to an increase or decrease in lower facial height, Temporomandibular Joint Dysfunction (TMJ) disorder, myofacial pain, trauma to the underlying tissues, muscle fatigue, and impaired phonetics [4].

Various pre-extraction and postextraction methods are used to determine the vertical dimension of occlusion in edentulous patients. Pre-extraction methods include intraoral measurements, profile tracing, and cephalometric analysis. Pre-extraction records can be valuable, but the availability of pre-extraction records is not always possible. Postextraction methods include mandibular rest position, facial aesthetics and appearance, anthropometric measurements, existing dentures, phonetics, and swallowing methods [4]. Physiological rest position and swallowing are the most commonly used methods but have often been criticised [1]. The cephalometric method is an objective method that can be used but is 2D and static [1]. Silverman MM reported that measuring the occlusal vertical dimension by the phonetic method can only be applied in Class-I relationship [5]. Since postextraction methods have revealed controversies, no individual method is reliable, and a combination of methods is recommended [4].

The reliability of anthropometric methods to determine the vertical dimension of occlusion has been widely discussed in the literature. Anthropometric measurements were first observed by Leonardo da Vinci, who provided simple ratios for drawing the face. They were later utilised by Wills, Ivy, and Goodfriend as a simple, cost-effective, and non invasive technique. Goodfriend suggested that the distance between the pupil of the eye and the corner of the mouth was closely related to the distance from subnasion to gnathion. This idea was popularised by Willis. Fenn HRB et al., later proposed the use of the angle from the eye to the angle of the mouth distance as a guide to correct the vertical dimension of occlusion [6]. Chou TM et al., in their study, concluded that the eye-ear distance is reliable in predicting the vertical dimension of occlusion if measured from the subnasale to menton distance. The authors also proposed an equation for more accurate measurements [7]. Delic Z et al., also recommended the eye-ear distance as a method to determine the vertical dimension

of occlusion [8]. These observations were confirmed by Abdul RM in Iraqi adults and by Alhajj MN et al., in Yemeni males and females [9,10].

Many studies have been conducted in the past to assess the reliability of using anthropometric measurements to determine vertical dimensions in edentulous patients, with no definitive conclusion [1,2,7-10]. A clear understanding is required to find the correlation between facial measurements and the vertical dimension of occlusion. Therefore, the present study was planned to determine the consistency of various facial measurements and their relation to the vertical dimension of occlusion in dentate patients.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Prosthodontics at a Dental College in Ambala district of Haryana, India, from February 2021-July 2021. Ethical clearance for the study was obtained from the Institutional Ethical Committee before commencing the study (Ethical number-1783, dated 22/01/2021). Patients and students aged between 20-35 years who reported to the Department and were willing to participate in the study were examined and included, considering the following inclusion and exclusion criteria. Written consent was obtained from the participants.

Inclusion criteria:

- Subjects with full dentition (atleast 28 natural permanent teeth).
- Subjects with Class-I molar relationship.
- Subjects with a symmetrical face and straight profile.
- Subjects with no history of facial injury.

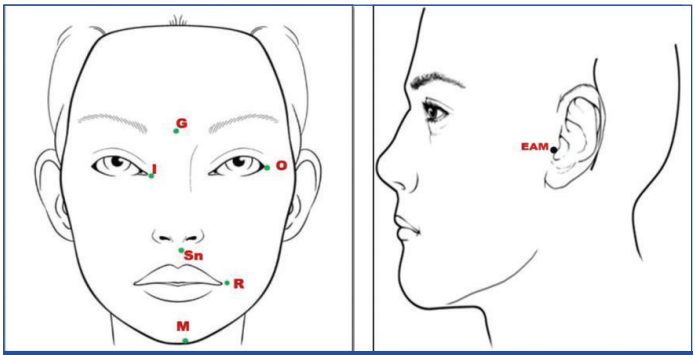
Exclusion criteria:

- Subjects who had undergone Orthodontic treatment.
- Subjects with neurological diseases pertaining to the eye, orbit, or any craniofacial deformity.

Sample size calculation: The sample size was calculated using G Power software (version 3.0.10). Based on the calculated effect size of 0.3 [6], 5% level of precision, 95% confidence level, and 90% power of the study, the minimum sample size required was 88, which was rounded up to 100. Therefore, a total of 100 dentate subjects, consisting of 50 males and 50 females, were included in the study.

Study Procedure

Once selected, the subjects were given an explanation about the aim and procedure of the study. The subjects were seated on the dental chair with proper head and back support. They were asked to look straight, and their head was adjusted so that the mandible was parallel to the floor. To record facial measurements, specific soft tissue points on the subject's face were palpated and marked with an indelible pencil [Table/Fig-1].

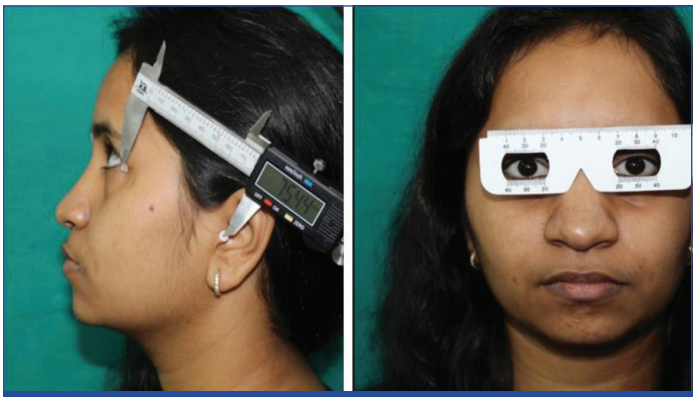


[Table/Fig-1]: Soft tissue points marked on the face.

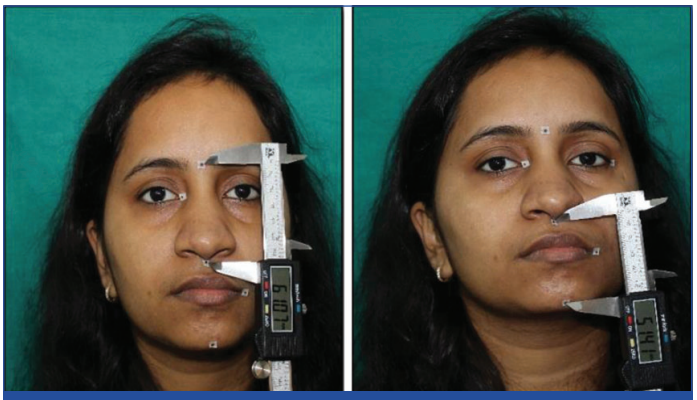
1. Glabella (G): The highest prominent point between the eyebrows and above the nose.
2. Subnasion (S): The point of the angle between the septum of the nose and the surface of the upper lip in the midsagittal plane.
3. Menton (M): The lowest midpoint of the chin.
4. Outer canthus of the eye (O): The lateral corner of the eye where the upper and lower eyelids join.
5. Inner canthus of the eye (I): The medial corner of the eye where the upper and lower eyelids join.
5. Rima oris (R): The corner of the mouth.
7. Anterior most point of the External Auditory Meatus (EAM) [8].

The subjects were asked to lightly bite on their posterior teeth in occlusion, and measurements were made using a digital vernier calliper and a PD ruler (in the case of IPD). All measurements were recorded by a single operator, and each measurement was recorded three times to minimise errors. The following facial measurements were recorded [Table/Fig-2-4].

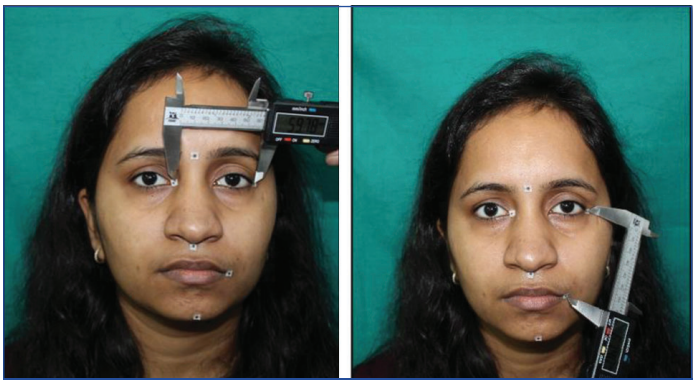
1. Subnasion (Sn)-Menton (M) distance.
2. Glabella (G)-Subnasion (Sn) distance.
3. Outer canthus (O)-Inner canthus (I) distance.
4. Outer canthus (O)-Rima oris (R) distance.
5. Outer canthus (O)-EAM distance.
6. Interpupillary Distance (IPD).



[Table/Fig-2]: Recording the distance between outer canthus to EAM using a digital vernier calliper and centre of one pupil to centre of other pupil using PD ruler. (Images from left to right)



[Table/Fig-3]: Recording distance between G-Sn and Sn-M (VDO) using a digital vernier calliper. (Images from left to right)



[Table/Fig-4]: Recording distance between outer canthus to inner canthus and outer canthus to rima oris using a digital vernier calliper. (Images from left to right)

Once recorded, all measurements were tabulated and subjected to statistical analysis to determine any association between the vertical dimension of occlusion (subnasion-menton distance) and other facial measurements [6,10,11].

STATISTICAL ANALYSIS

For statistical evaluation, the data were tabulated and analysed using the statistical software Statistical Package for Social Sciences (SPSS) (version 21.0, IBM Corp, Armonk, NY). The Pearson correlation coefficient was calculated, and the level of statistical significance was set at a p-value less than 0.05.

RESULTS

The mean Vertical Dimension of Occlusion (VDO) for males was 59.29±6.48 mm, and for females, it was 52.34±5.92 mm. The results for various craniofacial measurements for both male and female patients are presented in [Table/Fig-5].

S. No.	Variables	Females			Males		
		N	Mean	Standard deviation	N	Mean	Standard deviation
1.	VDO (Sn-M)	50	52.34	5.92	50	59.29	6.48
2.	G-SN	50	56.37	5.68	50	57.98	5.75
3.	O-I	50	62.80	4.34	50	65.74	4.56
4.	O-R	50	66.02	5.16	50	69.55	5.69
5.	O-EAM	50	71.11	4.80	50	74.73	4.61
6.	IPD	50	61.55	2.62	50	62.60	3.17

[Table/Fig-5]: Descriptive statistics of vertical dimension of occlusion (Sn-M) and various craniofacial measurements for male and female participants.

Pearson correlation analysis revealed a significant positive correlation between the vertical dimension of occlusion and all other craniofacial measurements, except for IPD [Table/Fig-6]. The outer canthus to Rima Oris (O-R) distance showed the strongest correlation with the vertical dimension of occlusion (Sn-M), with a Pearson correlation coefficient of 0.691 in females (p-value <0.001) and 0.620 in males (p-value <0.001).

S. No.	Variables	Females			Males		
		N	Pearson correlation	S	N	Pearson correlation	S
1.	G-SN	50	0.506**	<0.001**	50	0.448*	0.001*
2.	O-I	50	0.588**	<0.001**	50	0.468*	0.001*
3.	O-R	50	0.691**	<0.001**	50	0.620*	<0.001*
4.	O-EAM	50	0.438**	0.01**	50	0.379*	0.007*
5.	IPD	50	0.262	0.66	50	-0.151	0.296

[Table/Fig-6]: Pearson correlation matrix between VDO and other craniofacial measurements in male and female participants.
*p<0.05 Statistically Significant

In regression analysis, VDO was found to be significant with all craniofacial measurements, except for IPD (p-value=0.66 in females, p=0.296 in males) [Table/Fig-7]. Regression equations were derived for each significant parameter and are provided in [Table/Fig-8]. The vertical dimension of occlusion can be determined from facial measurements using these regression equations.

S. No.	Variables	Females			Males		
		R^2	SE	Sig	R^2	SE	Sig
1.	G-SN	0.527	0.130	<0.001**	0.504	0.145	0.001*
2.	O-I	0.803	0.156	<0.001**	0.665	0.181	0.01*
3.	O-R	0.793	0.120	<0.001**	0.706	0.129	<0.001*
4.	O-EAM	0.539	0.160	0.001**	0.533	0.188	0.007*
5.	IPD	0.593	0.315	0.66	-0.308	0.291	0.296

[Table/Fig-7]: Simple regression analyses for variables predicting VDO and craniofacial measurements in male and female participants.
*p<0.05 Statistically significant

S. No.	Variables	Female	Male
		Regression equation	Regression equation
1.	G-SN	22.612+0.527(G-Sn)	30.061+0.504 (G-Sn)
2.	O-I	1.946+0.803 (O-I)	15.565+665 (O-I)
3.	O-R	0.001+0.793 (O-R)	10.188+0.706 (O-R)
4.	O-EAM	13.981+0.539 (O-EAM)	19.469+0.533 (O-EAM)

[Table/Fig-8]: The regression equation to predict the vertical dimension of occlusion from different craniofacial measurements in male and female participants.

DISCUSSION

Despite advancements in materials and techniques, there is still no single method available for dentists to assess the vertical dimension of occlusion. Clinical judgement plays a crucial role in determining this important component of complete denture construction. With this in mind, the present study aimed to identify any correlation between vertical dimensions of occlusion and various anthropometric facial measurements. In the present study, the mean value of the vertical dimension of occlusion (subnasion to menton) was 59.29±6.48 mm for males and 52.34±5.92 mm for females. The mean value of the vertical dimension of occlusion was found to be greater in males compared to females. Ladda R et al., also reported similar findings in their study on the Indian population, where the vertical dimension of occlusion was greater in males (61.4 mm+4.2) than in females (56.7+3) [11].

A strong positive correlation was found between the outer canthus to rima oris distance and the vertical dimension of occlusion in both males and females (p-value <0.05). Similar findings were reported by Majeed MI et al., who conducted a study on the Pakistani population and suggested that the outer canthus to rima oris distance could be used to determine the vertical dimension of occlusion in edentulous patients [12]. Positive correlations were also found between the glabella to subnasion distance and the outer canthus to inner canthus distance, and the vertical dimension of occlusion in both males and females (p-value <0.05). These findings are consistent with a study by Brar A et al., who investigated six different facial measurements and concluded that the vertical dimension of occlusion had a strong positive correlation with the glabella to subnasion distance [1]. McGee GF also conducted a similar study using three facial measurements and found that all three measurements, including the distance from the centre of the pupil to the stomion, glabella to subnasion, and from one corner of the mouth to the other, were equal to each other and corresponded to the vertical dimension of occlusion and remained constant through ones life [13].

Regarding the outer canthus to EAM distance, a positive correlation was found between this facial measurement and the vertical dimension of occlusion in both males and females (p-value <0.05). These results align with Nagpal A et al., who suggested that the outer canthus to ear distance could be used to determine the vertical dimension of occlusion in patients without pre-extraction records [14]. Similar results were achieved by Chou TM et al., and Delic Z et al., [7,8]. On regression analysis, a significant regression equation was found with the outer canthus to EAM distance. For males, the equation was 19.469+0.533 (O-EAM), while for females, the equation was 13.981+0.539 (O-EAM).

Regarding IPD, no significant correlation was found between this parameter and the vertical dimension of occlusion in both males and females (p-value >0.05). These results are consistent with Majeed MI et al., who conducted a study on 300 dentate subjects and recommended against using IPD to measure the vertical dimension of occlusion in the Pakistani population [12].

Limitation(s)

The subjects selected for the study represented only a portion of North India, so the findings cannot be generalised to the entire

population. Future studies could focus on involving multiple centres from different parts of the country to provide more comprehensive results. Additionally, since the present study was conducted on dentate subjects to determine the relationship and linear regression equation, further studies are required to cross-verify the results of these linear equations when fabricating dentures for completely edentulous patients.

CONCLUSION(S)

Within the limitations of the present study, it can be concluded that craniofacial measurements such as glabella to subnasion, outer canthus to inner canthus, outer canthus to rima oris, and outer canthus to EAM can be used to determine the vertical dimension of occlusion. These measurements showed significant correlations ($p<0.05$) in both males and females. Regression equations, as depicted in [Table/Fig-7], have been provided, which can be used to calculate the vertical dimension in the population under consideration. Since no significant correlation was found between the vertical dimensions of occlusion and interpupillary distance in both males and females, it is not recommended to use interpupillary distance as a measure of the vertical dimension.

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