A Mathematical Method to Calculate the Vertical Dimension for Fully Edentulous Malaysians Patients

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Abstract: - Recording of vertical dimension for patients who seek oral and occlusal rehabilitation is one of the main steps of the treatment. Many methods were proposed for the profession yet none can be used solely to determine the vertical dimension. Teaching and assessment of vertical dimensions for undergraduates should be monitored by extra simple-use techniques. The aim of this study was to find a simple, reliable, fast method to record and assess the vertical dimension by dental students and practitioners. Data were collected from 115 young volunteers from MAHSA University with natural healthy occlusion. Their age range was 18-25 years. The distances from endocanthion to commissure of the mouth (IC-MC), nasion to gnathion at occlusion (NA-GN occ), and at rest (NA-GN rest) were measured by 3 examiners. The records were correlated using the Pearson correlation method at ($\rho<.01$, 2-tailed), and a linear regression model was calculated. In addition, the ratios between the two measurements were calculated to find the Golden number. The results revealed the presence of a significant linear relationship between the vertical dimension, measured from the nasion to gnathion at occlusion and rest positions with IC-MC distance ($r =0.90$, and $r =0.89$ at $\rho<.01$ respectively). On the other hand, regression analysis yielded two linear formulae that can be used to predict the vertical dimension at occlusion and rest in edentulous patients. In conclusion, a new technique was presented to assess the vertical dimension as a tailored method for Malaysian patients.

Key-Words: - Rest Vertical dimension, Vertical Dimension of Occlusion, New technique for vertical dimension Recording

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1 Introduction

The vertical dimension is the height of the lower part of the face. Technically, it is the distance between two selected anatomic or marked points, one on a fixed and one on a movable member (one on the tip of the nose and the other on the chin), [1]. For successful prosthodontic treatments and rehabilitation, a precise determination of the vertical dimension of occlusion (VDO) and vertical dimension at rest (VDR) is considered one of the most important steps, adding to that, its difficult assessment during the construction of complete denture, [2]. An increase or decrease in the vertical dimension may cause problems in mastication, speech, and temporomandibular joints as well as rapid bone destruction of the jaws, [3].

Many methods based on craniofacial measurements were suggested for the determination of the VDO, such as direct measurements on the soft tissues of the cranium and the face, [4], [5], [6], [7], using old photographs, [4], radiographs (Cephalometric methods) or photo-cephalometric techniques, [8]. Although there are many methods to determine the vertical dimension, the acceptability of any method depends largely upon the skill, experience, and judgment of the dentist. Therefore, a need exists for a simple, reliable method to determine accurately the vertical dimension to facilitate dental restorations, [9]. The aim of this study was to propose an easy method for recording the vertical dimension of occlusion and at rest based on simple mathematical analysis to help dental students and dentists in their daily clinical practice.

2 Problem Formulation

The application of some equations cited in dental literature on Malaysian samples was unsuccessful due to a high discrepancy in recording VD. Therefore, we conducted this research to find a better model.

The hypothesis postulates that a high correlation may exist between some facial measurements and VD. This assumption is validated, then a linear regression equation/s could be generated to predict

the VD in a simple precise way during partial or total oral and dental rehabilitation.

3 Material and Methods

The ethical committee of MAHSA University College approved this research. The participants were informed about the aim of the research and they were asked to sign a written consent for participation. Data were collected from 115 healthy subjects, their age range varied between 18-25 years (mean: 21.45±2.21). The inclusion criteria were the presence of complete natural dentition, absence of teeth attrition, and sign or symptoms of temporomandibular joint dysfunction. Each subject was asked to sit on a dental chair in an upright position and under well-illuminated conditions without headrest support. Three dentists examined the subject's health status and recorded the findings on an examination record sheet that included personal data in addition to the selected facial measurements.

Before proceeding with recording, the assigned facial references were marked by a black dot on a small square paper Fig. 1 A, B.

Fig. 1 A, B: Making the facial references and measuring the distances using a digital caliper

The vertical dimension of occlusion (VDO) was recorded when the patient closed (bite) in maximum intercuspation. While, the vertical dimension at rest (VDR) was measured at the end of the swallowing cycle, and the pronunciation of the (M) sound without applying pressure to the soft tissues, [10]. Each record was repeated three times by each examiner separately using two digits precision calipers. The VDO and VDR were measured using Nasion to Gnathion (NA-GN) distance as a reference. In addition, the distance between the inner canthus of the right eye to the mouth commissure (IC- MC) was measured.

Data were analyzed using SPSS software version 17.0 (SPSS Inc., Chicago, IL, USA). Inter-examiner reliability test for the readings of the three examiners was performed to reveal their consistency ($\rho<.01$, 2-tailed). Descriptive statistics tests were used to disclose the features of the sample and the normality of distribution. Parametric correlation and linear regression analysis were used to reveal the presence of statistical relation of VDO and VDR with some facial measurements and to find the best curve fit of the data. After formulae generation, the accuracy percent of VDO prediction was calculated at 1 mm, 2 mm, 3 mm, 4 mm, and 5 mm discrepancy.

4 Results

The inter-examiners' reliability in recording the distances was highly significant for the records gathered by the three investigators Table 1.

Table 1. Reliability results among 3 examiners
Correlation is significant at $\rho<.01$ level (2-tailed)

Variables	IC-MC	NA-GN occ	NA-GN rest
1st and 2nd examiners	.985	.974	.985
2nd and 3rd examiners	.987	.984	.987
1st and 3rd examiners	.984	.978	.984

The features of the sample are shown in Table 2. The data showed normal distribution.

Table 2. The features of the sample
IC; Endocanthion, MC; Mouth commissure, NA; Nasion, GN; Gnathion, Rest; Physiologic rest position, Occ; Occlusion

	No.	Min	Max	Mean	SD	Kurtosis	SE
Age	115	18	28	21.45	2.209	-.238	.447
IC-MC	115	55	79.7	65.85	4.603	.030	.447
NA-GN Rest	115	95.3	127.3	112.1	6.973	-.609	.447
NA-GN Occ	115	93	125.7	110.1	6.963	-.611	.474

The relationships between the IC-MC and NA-GN at occlusion and rest positions were linear and significant ($r = .90$, $r = .89$, DF=115, $\rho<.000$,2-tailed) respectively Table 3.

Table 3. The correlation between the IC-MC and NA-GN during occlusion and at rest

Facial records –VD	R-Coeff	Sig.2-t	N
IC-MC /NA-GN (occ)	.90**	.000	115
IC-MC /NA-GN (rest)	.89**	.000	115

The application of regression analysis for the IC-MC and NA-GN during occlusion and rest yielded 2 linear models that can be used to calculate the VDR and VDO using the IC-MC distance as a reference measurement on edentulous patients Table 4, Table 5.

Table 4. Regressions and Coefficients of Correlations: IC-MC and NA-GNat rest

Model	Unst. Coef		St.C	t	Sig.	Correlations		
	B	Std. E	Beta			Z-ord	Part	Part
Cons	23.794	4.383		5.429	.00			
IC-MC	1.340	.066	.885	20.189	.00	.885	.885	.885

Cons; constant, Uns. Coef; unstandardized coefficient, StdE; standard error, St.C; standard coefficient, Sig; significance, Z-ord; zero order,Part; partial

a- Dependent variable: NA-GN (rest) b- Independent: IC-MC measurement, c- Constant = 23.79 d- Factor = 1.34

Table 5. Regressions and Coefficients of Correlations: IC-MC and NA-GN at occlusion

Model	Unst.Coef		St.C	t	Sig.	Correlations		
	B	Std. E	Beta			Z-ord	Part	Part
Cons	20.869	4.179		4.994	.000			
IC-MC	1.355	.063	.896	21.397	.000	.896	.896	.896

Cons; constant, Unst. Coef; unstandardized coefficient, StdE; standard error, St.C; standard coefficient, Sig; significance, Z-ord; zero order,Part; partial

a- Dependent variable: NA-GN (occlusion) b- Independent: IC-MC measurement, c- Constant = 20.87 d- Factor = 1.36

To predict the VDR from IC-MC:

$$Y = 1.36 (X) + 20.87 \quad (1)$$

Y is the NA-GN distance (at occlusion) and X is the IC-MC distance in mm.

To calculate the VDR from IC-MC:

$$Y = 1.34 (X) + 23.79 \quad (2)$$

Y is the NA-GN distance (at rest) and X is the IC-MC distance in mm.

When the ratios between the mean records of NA-GN and IC-MC at rest and occlusion were calculated, two simple indices or Golden ratios resulted.

Mean of (NA-GN rest) / Mean of (IC-MC) in mm= 1.68 (3)

Mean of (NA-GN occlusion) / Mean of (IC-MC) in mm= 1.65 (4)

The mean difference between the measured actual VDO (Nasion-Gnathion) and the predicted VDO was ± . 25 mm. In addition, the mean difference between the true VDR and the calculated VDR was ± .03mm. The results were not significant (DF: 114, ρ= .913, and ρ= .277 respectively). The distribution consistency of the predicted VDO records in relation to the true records is shown in Table 6.

Table 6. The distribution of predicted results using the newly generated formulae for VDO.

Error range mm.	No. cases	Percent
0 – 1	31	27%
0 – 2	50	44.5%
0 – 3	70	61%
0- 4.5	106	92.2%
0 – 5	109	94.8%
> 5	6	5.2%

Reestablishing the correct vertical dimension in edentulous patients is one of the important steps in denture construction. Therefore, simplifying the recording technique of VDO and VDR is a very desirable achievement to reduce the time needed for rehabilitation procedures as well as the undesirable effects of incorrect VD measurements.

Teaching and practicing prosthetic rehabilitation involves many clinical diagnostic and laboratory procedures. For simplifying the pedagogic practice and understanding the application of the clinical steps in prosthodontics, the syllabus is usually divided into consecutive steps preceded by lectures,

briefings, and demonstrations on manikins or patients to make students customize with, understand and correctly apply the technique in their daily clinical practice. However, because of the VD's inconsistent nature and the presence of many opinions regarding the most suitable method for recording, it is always considered a difficult step to finish by the student or a new practitioner confidently. Therefore, a new reliable, simple recording and verification method dramatically enhances the teaching and learning outcome as well as the practice in oral rehabilitation and shortens the clinical sessions.

Generally, there are many methods to determine the vertical dimension of occlusion after the patient is edentulous. All of these methods are not 100% reliable. So, a combination of 2 or more methods is advisable to achieve consistent results.

The anthropometric methods are still retaining a privileged situation in recording especially when experience is inadequate, and time is an important task. The simplicity of applying this technique increases its development by many researchers, [4], [6], [14]. Some recording techniques for VD were neglected or vanished but still used for research purposes due to their complexity and health safety such as radiographs (Cephalometric methods) or Photo-cephalometric methods, [8]. In this study, craniofacial biometric references were selected and used in a pilot study to calculate the vertical dimension at rest and occlusion because facial measurements are quite promising and unique simple devices are needed by everyone, [11]. Therefore, by correlating some vertical measurements, a simple and applicable mathematics-based recording method was revealed. This method was considered quite promising since no complicated devices are needed and unique to everyone, [11].

The proposed method showed 95% precision in the recording. In addition, nearly 92% of the cases were within an acceptable error range of measurements on soft tissue (4%), [12] and 95% were within the tolerable increase or decrease of VD which is 3-5 mm. (Table. 6), [13]. Collecting and analyzing clinical treatment over a prolonged time provides an excellent in-depth solution for any clinical problem as in this research, [15]. Therefore, the next research work object proposes to focus on the relation of the occlusal plane to facial biometrical landmarks to find a simpler method of recording the teeth levels and orientation.

5 Conclusion

Within the limits of this research, the following results have been concluded:

A new reliable method to predict the vertical dimension in edentulous patients was described. It depends mainly on the presence of a high linear correlation between the IC-MC and the NA-GN measurements at occlusion and rest positions. Two linear formulas were established.

$$\text{NA-GN (at occlusion)} = 20.87 + 1.36 \times (\text{IC-MC}) \quad (1)$$

$$\text{NA-GN (at rest)} = 23.79 + 1.34 \times (\text{IC-MC}) \quad (2)$$

In addition, the Golden ratios between the means of IC-MC and NA-GN records were calculated to simplify the calculation of VD at rest and occlusion. The golden ratios were evident

$$\text{NA-GN (at rest)} / \text{IC-MC in mm} = 1.68 \quad (3)$$

$$\text{NA-GN (at occlusion)} / \text{IC-MC in mm} = 1.65 \quad (4)$$

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

-Laith Al-Samawi, carried out the statistical analysis, writing, and submission of the manuscript. Moreover, Laith Al-Samawi was responsible for the supervision of the procedures.
-Hana Al-Ani, was responsible for the supervision of the experimental procedures, guidance, and planning of the project.
-Humam Laith, was responsible for the patient selection of the study, collection of data, and submission to analysis.

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Conflict of Interest

The authors have no conflict of interest to declare that is relevant to the content of this article.