

## Occlusal Vertical Dimension Index to Simplified Vertical Dimension Measurement

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### Abstract

The aim of this study was to develop occlusal vertical dimension index to simplified vertical dimension measurement. Many dentists have difficulty in determining the exact vertical dimension of their patients. Hayakawa developed a formula to determine vertical dimension but had been made from a study using Japanese subjects, so that the accuracy if it is used for Indonesian people are still doubtful. This study consist of 2 stages, the first stage, wanted to develop a specific index for the Deutero-Malay race in Indonesia that can be used to predict vertical dimension of the patients. The second stage of this study were comparing the accuracy of occlusal vertical dimension obtained from the OVD index with subject's actual occlusal vertical dimension. There were 63 subjects included in the first stage of study and also another 63 subjects included in the second stage of the study. This is a cross-sectional study and the factors being observed for the relationship with vertical dimension were interpupillary distance, inter zygomatic distance, zygomatic-chelion, sex, profile, palm length, pupillary-subnasion distance and pupillary-chelion.

The result of this study is OVD index to predict specific vertical dimension for Deutero-Malay race as follows,  $sn-gn = 36.65 + 4.58 (\text{gender}) + 0.46 (p-p)$ .

*Clinical article (J Int Dent Med Res 2016; 9: (Special Issue), pp. 334-338)*

**Keywords:** Occlusal vertical dimension, index, vertical dimension measurement.

**Received date:** 28 September 2016

**Accept date:** 29 October 2016

### Introduction

Losing teeth and acquiring a denture is not a pleasurable condition for any individual. Nevertheless, the agony of the patient can be lessened to some extent by providing a denture which restores the original facial appearance and functions of natural teeth. Unquestionably, establishing a correct vertical dimension of a face is one of the important factors to be considered in accomplishing this objective. Literature review depicted that many methods have been described and used by professionals over the years for the purpose of vertical dimension determination, but none of them is fully accepted or considered entirely correct.<sup>1</sup>

The vertical dimension is the distance between the upper and lower jaw in certain circumstances. There are two classifications of vertical dimension: the occlusal vertical dimension and the physiologic vertical dimension. The occlusal vertical dimension is determined by the occluding original teeth, whereas the physiologic vertical dimension is the position of muscles which open and close the mouth are in minimal contraction to maintain the mandibular position. Studies have shown that the position of physiologic vertical dimension is a relatively stable position to maintain for a long period. Nevertheless, certain conditions such as tooth loss, the aging process, general health condition and head position could affect the physiologic vertical dimension.<sup>1-3</sup>

In patients who require a complete denture, the process of determining vertical dimension could be performed through several methods, such as the mechanical method by using patient's teeth record before extraction, X-rays imaging, facial measurement, and linearity between the upper and lower jaw ridge. Another method is the physiological method by

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determining the physiologic resting position, phonetic, aesthetic, swallowing, and patient comfort. Dentists usually use several methods simultaneously in determining vertical dimension, the result of various measurement is in a wider range than the horizontal relation. So the proper clinically acceptable occlusal vertical dimension is referred as a zone.<sup>1-4</sup>

Determination of occlusal vertical dimension by using physiologic rest position of the mandible, biting force, swallowing or phonetics are effective, but they are affected by skill, mental tension, posture and also by the quality and stability of the occlusion rims. This method are complicated and easily lead to errors and finally will give impact to treatment failure.<sup>2-4</sup>

Therefore Hayakawa based on his study has developed an index to determine vertical dimension through a quick and simple method, by considering factors such as interpupillary distance (p-p), inter zygomatic distance (zy-zy), sex, profile, palm length, pupillary-subnasion distance (p-sn), and pupillary-chelion (p-ch). The factors being observed were thought to be related to vertical dimension.<sup>3</sup> This is very practical but was established based on the measurements of Japanese subjects. Therefore it is not known whether it could be applied to the Deutero-Malay population who are physically different than the Japanese.<sup>3</sup>

Based on this fact, the aim of this study was to establish Occlusal Vertical Dimension Index (OVD Index), specific for Indonesian population and other Deutero-Malay population. This index will be useful especially for dentists in determining vertical dimension for patients requiring dentures. This index not only could be used by Indonesian dentists but also dentists in neighboring countries such as Malaysia, Thailand, The Philippines, etc. who has racial similarity. After developing OVD index, we use the OVD index in dentate subjects and compared with the accuracy of occlusal vertical dimension obtained from the OVD index of subject's actual occlusal vertical dimension.

### Materials and methods

The study design was cross-sectional, and the subjects were 63 students and employees of Faculty of Dentistry Universitas Indonesia between the age 18 to 54 years old. The inclusion criteria are Deutero-Malay race, no

missing teeth and have occlusal vertical dimension. Angle Class 1 jaw relationship, symmetrical face, and normal palm. The factors being observed for a relationship with vertical dimension were the interpupillary distance (p-p), inter zygomatic distance (zy-zy), zygomatic-chelion (zy-ch) distance, gender, profile, palm length, pupillary-subnasion distance (p-sn) and pupillary-chelion distance (p-ch). The vertical dimension in this study was measured from subnasion to gnathion (sn-gn). The measurement was performed using Hayakawa modification tool using millimeter plastics block and a chin-holder standard to simplify measurement. Each measurement was performed three times by the same operator, to obtain an accurate result.

All collected data was analyzed using bivariate and multiple linear regression to study the relationship between above factors with vertical dimension measured from subnasion to gnathion, and also to examine factors that have most influence on the determination of vertical dimension. The p-value of 0.25 was determined to screen factors that could be included in the multivariate analysis, while significant in multivariate analysis was determined as  $p \leq 0.05$ . After OVD index has been obtained, a trial of this OVD index was applied on different subjects. The subjects were 63 students from the Faculty of Dentistry Universitas Indonesia, with similar inclusion criteria with the first stage study.

### Results

All subjects in this study have already filled in the inform consent form, and the ethical commission from Faculty of Dentistry Universitas Indonesia had approved this study. The study was performed on 63 subjects with the mean age 28 years (range between 18 to 54 years of age), consisting of 34 females and 29 males. The profile was one of the factors included in the analysis, and in this study, 49.2% of subjects had a straight profile, 47.5% convex, and the rest 3.40% were concave in profile. Other factors being analyzed in its relationship with vertical dimension (subnasion to gnathion / sn-gn) were interpupillary distance, inter zygomatic distance, gender, palm length, a distance between pupil to subnasion, distance between pupil to chelion and zygomatic-chelion. The mean value of several measurements is shown in table 1.

Variable	Mean ± SD	minimum	maximum
Sn-Gn	67.40±6.055382		
P-P	62.25±3.2748		70
P-SN	45.95±3.7738		56
P-CH	69.75±4.54	60	82
Zy-Zy	142.87±5.78	126.50	153
Zy-CH	64.41±8.7643		80
Palm length	177.65±11.17	156	208

**Table 1.** Mean value of several measurements.

The mean of various factors being observed and compared to the mean of sn-gn distance, it was shown that the mean of sn-gn distance were between 2.36 mm to 5.14 mm to the p-ch, p-p, and zy-ch distance. (table 1). Pearson's correlation test was performed to screen factors that could be included in the multivariate analysis, with  $p=0.25$  significance. The result of this analysis is shown in Table 2.

Variable	Coefficient	Correlation	p
(sn-gn)- age	0.13	0.32	
(sn-gn)-(p-p)	0.34	0.01*	
(sn-gn)-(p-sn)	0.01	0.95	
(sn-gn)-(p-ch)	0.21	0.10*	
(sn-gn)-(zy-zy)	0.34	0.01*	
(sn-gn)-(zy-ch)	0.06	0.64	
(sn-gn)-( palm length)	0.04	0.78	
(sn-gn)-( sex)	0.44	0.00*	

\* Significancy level  $p \leq 0.05$

**Table 2.** Correlation between several measurements and vertical dimension.

From the bivariate analysis, it occurred that only variables p-p, p-ch, zy-zy, palm length, and also gender and profile, could be included in multivariate analysis. The final multivariate analysis result is shown in Table 3.

Variable	B	Coefficient	Std Error	t	p
Sex	4.58		1.38	3.31	0.00
P-P	0.46		0.21	2.16	0.04
Constanta	36.65		13.13	2.79	0.01

**Table 3.** Final model of multivariate analysis measurements for predicting vertical dimension.

From multivariate analysis result we obtained a measurement of vertical dimension,  $sn-gn = 36.65 + 4.58 (\text{gender}) + 0.46 (p-p)$ , 0 for female, 1 for male, p-p and sn-gn distances in mm.

In the second stage of the study, the OVD was tested to another 63 students from Faculty of Dentistry Universitas Indonesia, the result of univariate analysis could be seen in Table 4. It was shown that the mean age of subjects was 22 years old, and the mean of occlusal vertical dimension was 63,43 mm.

Variable	mean± SD	Min	Max
(n=63)			
Age	21.75 ±1.92	19	26
p-p	60.92 ±2.85	53.33	68.33
p-Ch	68.02 ±4.44	58.67	79
DVO	63.43 ±2.97	58.67	70.17

**Table 4.** Mean value of several measurements in second stage study.

	Mean ± SD	Min	Max	(n=63)
OVD subjects	63.43±2.97	58.67	70.17	
OVD from Hayakawa	60.20±2.90	54.07	67.35	
OVD from OVD Index	65.55±2.59	61.18	72.66	

**Table 5.** Mean value of vertical dimension measured by different methods.

	Mean differences 95% CIp		
OVD Hayakawa – OVD	3.23	6.54-4.16	0.00*
OVD index- OVD	2.12	0.93-3.31	0.00*
OVD index- OVD Hayakawa	5.35	4.16- 6.54	0.00*

\*Posthoc Tukey Test, p value <0.05

**Table 6.** Mean differences between vertical dimension measurements.

In Table 5 we could see OVD differences in various measurements. We could conclude that OVD from OVD index measurement is closer to the real OVD of subjects compare to OVD using Hayakawa measurement. The result of the one-way ANOVA test showed a significant difference between the three methods of measurements ( $p=0.00$ ). Posthoc Tukey Test was performed to determine the significant difference in measurement. From the above table

we could conclude that both OVD measurements using Hayakawa and OVD index were significantly different than the actual OVD of the subject, but from the difference in mean, it could be seen that the OVD index was closer to the actual OVD of subjects. The result of the posthoc Tukey test can be seen in Table 6.

From table 6 we can summarize that OVD measurement using Hayakawa or OVD index have a significant differences from subjects' OVD. But the mean difference shows that OVD index was closest to real OVD. The mean difference was 2.12 mm, it means that the measurement was in the range of Physiologic vertical dimension.

## Discussion

Hayakawa found a prediction model for sn-gndistance (vertical dimension)=  $16+0.65(p-ch)$ . This means Hayakawa predicted vertical dimension based on the distance between the pupil to chelion (p-ch). While in this study, the occlusal vertical dimension could be predicted using interpupillary distance (p-p) measurement and gender. This difference in result is thought to be due to the profile differences between Deutero-Malay and Mongoloid race (Japanese).<sup>3</sup>

The result of this study has similarity with the result of a study by Lada, et al, The result showed a correlation of OVD and Interpupillary distance especially in male, Variation of OVD and interpupillary distance were within the range 2-4mm. Measurement of OVD by measurement of interpupillary distance is valid and reliable.<sup>4</sup>

McGee correlated OVD with various anthropometric measurements. According to them, original OVD is most often similar to the distance from the outer can thus of one eye to the inner can thus of the other eye, the vertical height of the ear, twice the length of one eye, the horizontal distance between the pupils, and the vertical length of the nose at the midline.<sup>5</sup> Lada stated that the variations between OVD and finger lengths are within the range of 2-4 mm, OVD prediction through this method is reliable and reproducible. Also, the method is simple, economical, and non-invasive; hence, it could be recommended for everyday practice.<sup>1</sup> This study showed the different result; there was no correlation between palm length and OVD ( $p=0.78$ ). A different method of measurement was maybe responsible for the differences.

Sheppard in his study stated that edentulous mandibular rest position does not seem particularly suitable for determination of the vertical dimension of occlusion and appears somewhat less suitable when facial measurements are used.<sup>6</sup> The result of this study showed contradictive result; that facial measurement could be used to measure OVD. OVD index could be used as a rough guide to determine vertical dimension since from the R-square value of 0.25 in the multivariate model it could be concluded that many other factors also have roles in determining vertical dimension. In a clinical practice, this could be applied to the determination of vertical dimension using other methods, to provide a rough guidance of the patient's vertical dimension.

OVD measurement using OVD index is in standard deviation range of subject's OVD. According to this result, OVD index can also be used as a confirmation tool. After dentist determined patient occlusal vertical dimension using several methods, they can use this OVD index for confirmation. OVD index gives OVD measurement closer to the subjects real OVD than OVD measured using Hayakawa due to differences in race.

In clinical practice the most frequently used tests that aid dentist establishing correct OVD are visual observation of the space between the rims when the mandible is in its physiologic rest position (freeway space), judgement of the overall esthetic facial support and phonetic test that include observations when "s" sound enunciated repeatedly and swallowing method. OVD index will be used for confirmation of other methods.<sup>2,7,8</sup>

An anthropometric study in Nepal showed that the distance between rimaoris to pupil distance has higher correlation to OVD than other facial measurements.<sup>9</sup> Several studies showed correlation between OVD and anthropometric measurement of fingers.<sup>10-14</sup>

Establishing correct OVD is crucial, excessive inter-arch distance when are in occlusion make the lips cannot lightly touch when the patient is at rest. The patient might appear to be stretching the lower lip to get contact. This position doesn't allow the muscles that elevate the mandible to complete their contraction. Therefore these muscles will continue to exert force to overcome this obstacle. This often results in damage to the supporting tissues that



includes soreness, possible ischemia, and eventual resorption. Excessive OVD may also result in some facial distortion because the patient has difficulty closing the lips together properly. On the other hand, an excessive too much interocclusal distance can also cause problems. This reduced OVD at tooth contact can cause temporomandibular Joint damage, facial distortion, loss of muscle tone and possibly angular cheilitis.<sup>7</sup>

Many studies advise a 2-mm to 4-mm freeway space as normal. This method of using freeway space to determine vertical dimension has been used for decades in making dentures. It is important to note, that freeway space is only being used to mount the models and set the teeth for the denture try-in. At the try-in, phonetics and esthetics are used to refine final incisal edge position. After reviewing many different techniques for determining vertical dimension, it can be concluded that vertical dimension is a highly adaptable position, and there is no single correct vertical dimension.<sup>15,16,17</sup> This OVD index could be applied before the determination of vertical dimension using other methods, to provide a rough guidance of the patient's vertical dimension or as a confirmation of other methods.

### Conclusions

OVD index has been obtained to predict specific vertical dimension for Deutero-Malay race as follows,  $sn-gn = 36.65 + 4.58 (\text{gender}) + 0.46 (p-p)$ . In a clinical setting, this index could be applied before the determination of vertical dimension using other methods, to provide a rough guidance of the patient's vertical dimension or as a confirmation of other methods.

### Acknowledgements

The publication of this manuscript is supported by the Directorate of Research and Community Engagement Universitas Indonesia.

### Declaration of Interest

The authors report no conflict of interest.

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