# Facial and Hand Landmark Measurements for Making Accurate Occlusal Vertical Dimension Determinations

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**Abstract**

The aim of this study is to create a more accurate method of measurement for determining occlusal vertical dimension (OVD). Many dentists face difficulties in determining correct OVD, especially in fully edentulous patients or patients who no longer have stable tooth contact. Hayakawa has created a formula for predicting occlusal vertical dimensions in the Mongoloid race of the Japanese population, and earlier studies have been conducted by Kusdhany et al. on the Deutero-Malay race of Indonesia. This is a cross-sectional study, and the measurements of certain facial and hand landmarks are compared to the measurement of OVD from the base of nasal septum to the inferior of the chin (Sn-Gn). The facial landmarks measured are inner zygomatic distance (Zy-Zy), inner to outer eye corner distance, interpupillary distance (P-P), pupil to mouth corner distance (P-Ch), tragus to eye corner distance (Tr-Cn), vertical ear length, palm length, thumb length, index finger length, little finger length, and the width of four fingers. The result of this study is the following multivariate analysis-based formula for measuring OVD: Sn-Gn = 28.01 + 0.44 (P-P) + 0.29 (Tr-Cn) + (−0.23 (width of four fingers)) + 5.98 (sex) [unit mm]. This formula can be used as a baseline for creating a more accurate measurement of OVD in edentulous patients.

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## Introduction

Tooth loss is an inevitable process that reduces masticatory function. People seek dentures to replace missing teeth not only for aesthetic reasons but also to improve their masticatory function. According to Huang W.J. and Katoh Y., dentures are sought not only by young adults desiring attractive facial appearances but also by the elderly.[1] The relation of the upper and lower jaws and their movements must be recorded correctly. If it is not, the result of the inaccurate registration will be to deteriorate rather than improve the patient's masticatory function.[2]

The Glossary of Prosthodontic Terms defines vertical dimension as the distance between two selected anatomic or marked points, one on a fixed and one on a movable member (usually one on the tip of the nose and the other on the chin). Occlusal vertical dimension is the vertical dimension when occluding members are in contact, and rest vertical dimension is the vertical dimension when the mandible is in a physiologic rest position.[3,4] The repetitive contracted length of the elevator muscle determines the vertical dimension of occlusion.[5]

Proper tooth arrangement and OVD are the keys to dento facial proportions that are acceptable in function and aesthetics,[6] especially in an edentulous patient.[7] Measuring the vertical distance between the upper and lower jaws is one of the most crucial steps in duplicating the upper and lower jaw relation in a fully edentulous patient or one without any tooth contact. In edentulous patients, it is almost impossible to reproduce the OVD of the dentate condition.[8] Many methods of assessing and recording the vertical jaw relation in edentulous patients have been presented and evaluated. Some are considered obsolete, while others are being reintroduced using more sophisticated devices,[8]

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but an exact method of determining OVD has not yet been found.[9] Determinations of OVD are subjective, depending on the patients' psychological condition and the mobility of landmarks, which are in soft tissue.[10] The great diversity of OVD-determining methods still results in vague conclusions, as clinical judgement determines which methods are recommended by some authors.[11] When no accurate pre-extraction records exist, the dentist must rely upon aesthetic appearance, supplemented by aids that are often misleading.[12] According to Hayakawa, OVD is determined by a morphological harmony of the face in order to come close to the dentate condition.[8]

OVD has been compared to facial measurements, and hand measurements show significant correlations to OVD in a number of countries, races, and ethnic cities around the world.[2,13,14] Based on his study, Hayakawa created a formula using OVD indicators to create correct measurements of OVD. This formula has been applied clinically[8] and followed up by the research of Kusdhany et al. on the Deutero-Malay race in Indonesia.[15]

## Methods

This study has been approved by the Ethical Committee of the Faculty of Dentistry of Universitas Indonesia. All subjects included in this study provided informed consent. This was a cross-sectional study conducted on students of the Faculty of Dentistry of Universitas Indonesia and students of the Faculty of Dentistry of Trisakti University, all between the ages of 18 and 35. These studies were conducted on healthy dentate subjects who had no missing teeth and no facial or hand deformities. The subjects included in this study were native Indonesian people and members of the Mongoloid race. The landmark distances that were compared to OVD were inner zygomatic distance (Zy-Zy), the distance from the inner corner of one eye to the outer corner of the other eye, inter pupillary distance (P-P), pupil to mouth corner distance (P-Ch), tragus to eye corner distance (Tr-Cn), vertical ear length, palm length, thumb length, index finger length, little finger length, and the width of four fingers (Fig. 1).

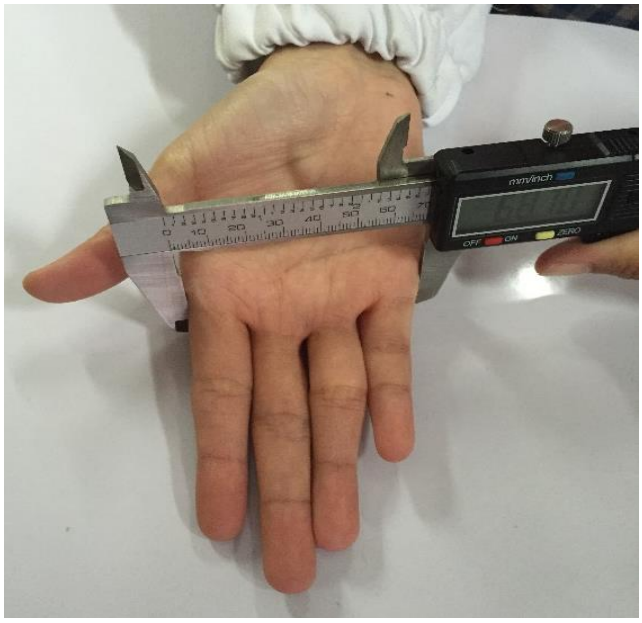

**Figure 1**. Measurement of the width of four fingers using a digital vernier caliper.

The measurements were conducted using a Hayakawa tool[8] that had been modified using engraved plastic attached to a wooden table with a chin holder to reduce the possibility of movement during the performance of facial and OVD measurements (Fig. 2).

**Figure 2.** Modified hayakawa index in laser-engraved plastic with chin holder.

A digital pupilometer was used to measure inter pupillary distance. A digital vernier caliper with an accuracy of 0.01 mm was used to measure hand landmarks, vertical ear height, and tragus to eye corner distance. All measurements on hands, ear heights, and tragus to eye corner distances were averages of the numbers from the left and right. Each measurement was repeated three times by the same operator to achieve a more accurate result.

All collected data were analyzed using univariate, bivariate, and multiple linear regression analyses to study the relationships between the measured variables and OVD and to determine which variable had the most influence in determining OVD. Factors to be included in the multivariate analysis were screened with a p value of 0.25, and their significance level in the multivariate analysis was determined by $p \leq 0.05$.

## Result

All 101 subjects were recorded. The sample size was sufficient for numeric-analytic correlation, with 5% for a type I mistake and 10% for a type II mistake, with a correlation coefficient of 0.35. This study examined 84 female and 18 male subjects. The factors whose correlations to OVD (subnation to gnation: Sn-Gn) were analyzed were inner zygomatic distance (Zy-Zy), inner to outer eye corner distance, inter pupillary distance (P-P), pupil to mouth corner distance (P-Ch), tragus to eye corner distance (Tr-Cn), vertical ear length, palm length, thumb length, index finger length, little finger length, and the width of four fingers. The Sn-Gn distance was measured while each subject was in an intercuspal position.

Normality tests were performed in a univariate analysis for each independent measurement to determine its spread with $p>0.05$ before it was included in the bivariate analysis. In this analysis, we found that inner to outer eye corner distance had an abnormal data distribution, and it was excluded from the bivariate analysis.

The mean values of the various observed factors and the average value of the Sn-Gn distances are shown in Table 1. Pearson's correlation to Sn-Gn was calculated to screen factors to be included in the multivariate analysis, with a significance of $p=0.25$ (Table 2).

The bivariate analysis showed that only the variables Zy-Zy, P-Ch, P-P, Tr-Cn, vertical ear length, palm length, the width of four fingers, and sex could be included in the multivariate analysis.

**Table 1**. Mean values of face and hand measurements.

| Variable | Mean ± SD | Minimum | Maximum |
|---|---|---|---|
| Sn-Gn | 66.49 ± 5.44 | 55 | 91 |
| Zy-Zy | 105.67 ± 9.17 | 85 | 135 |
| P-Ch | 67.63 ± 4.92 | 57.67 | 83.00 |
| P-P | 60.22 ± 3.68 | 47.90 | 70.33 |
| Tragus to eye corner | 76.27 ± 5.14 | 60.45 | 92.84 |
| Vertical ear length | 9.94 ± 4.51 | 47.76 | 69.56 |
| Palm length | 172.93 ± 9.46 | 155 | 200.5 |
| Thumb length | 58.76 ± 4.63 | 44.83 | 73.02 |
| Index finger length | 67.71 ± 5.06 | 51.94 | 83.12 |
| Little finger length | 55.08 ± 4.93 | 42.37 | 70.60 |
| Width of four fingers | 73.16 ± 6.07 | 59.99 | 90.34 |

In the first step of the multivariate analysis, the variables Zy-Zy, P-Ch, vertical ear length, and palm length were shown to be statistically insignificant and were removed in the second step, linear regression analysis. The final model of the multivariate analysis is shown in Table 3. The formula from this final model is Sn-Gn = 28.01 + 0.44 (P-P) + 0.29 (Tr-Cn) + (−0.23 (width of four fingers)) + 5.98 (sex) [unit mm], with 1 for female and 2 for male. This formula possesses multiple coefficients of determination ($R^2$)= 0.306.

**Table 2**. Correlations between several facial and hand measurements and vertical dimensions.

| Variable | Coefficient Correlation | p |
|---|---|---|
| (Sn-Gn)-(Zy-Zy) | 0.318 | 0.001* |
| (Sn-Gn)-(P-Ch) | 0.385 | 0.001* |
| (Sn-Gn)-(P-P) | 0.398 | 0.001* |
| (Sn-Gn)-(Tragus to eye corner) | 0.274 | 0.006* |
| (Sn-Gn)-(Vertical ear length) | 0.255 | 0.010* |
| (Sn-Gn)-(Palm length) | 0.263 | 0.008* |
| (Sn-Gn)-(Thumb length) | 0.103 | 0.305 |
| (Sn-Gn)-(Index finger length) | 0.084 | 0.402 |
| (Sn-Gn)-(Little finger length) | 0.080 | 0.424 |
| (Sn-Gn)-(Width of four fingers) | 0.214 | 0.031* |

* Significancelevel p≤0.05

**Tabel 3.** Final model of multivariate analysis measurement for predicting OVD.

| Variable | B Coefficient | Std Error | Correlation Coefficient | t | p |
|---|---|---|---|---|---|
| P-P | 0.44 | 0.14 | 0.29 | 3.11 | <0.01 |
| Tragus to eye corner | 0.29 | 0.11 | 0.27 | 2.72 | <0.01 |
| Width of four fingers | −0.23 | 0.11 | −0.26 | −2.72 | 0.03 |
| Sex | 5.98 | 1.51 | 0.41 | 3.97 | <0.01 |
| Constant | 28.01 | 9.51 | | 2.94 | <0.01 |

## Discussion

OVD has been shown to have a significant correlation to facial measurements in Aryans and in the Mongoloid race of Nepal, in which pupil to mouth corner distance had the most significant correlation.[14] In their Indonesian study, Kusdhany et al. found that in the Deutero-Malay race, the variable that correlated most strongly to OVD was inter pupillary distance, but compared to using the Hayakawa formula with modified OVD indicators, the result was closer to the physiologic vertical dimension.[15] Ladda et al. created a formula to determine OVD through the inter pupillary distance measurement, but this can only be applied to male subjects, with a range of variation between 2 and 4mm.[16] In this study, we found a significant correlation between a number of facial landmark measurements and OVD. These measurements were inner zygomatic distance, pupil to mouth corner distance, inter pupillary distance, tragus to eye corner distance, and vertical ear height.

A study in India found a correlation between finger measurements and OVD.[2,13] According to Aruna J. et al., the length of the little finger is almost equal to OVD, making it a simple, innovative, non invasive, economical, and reproducible method of measurement, with no need for sophisticated equipment.[13] Based on his study, Hayakawa created a formula using OVD indicators to predict the correct measurement of OVD, and this formula has been applied clinically to Japanese people.[8] The hand landmark measurements in this study found that there were only two variables (palm length and the width of four fingers) that significantly correlated to OVD, while no finger length measurements (thumb, index finger, and little finger length) showed any correlation.

Hayakawa's prediction formula for OVD is as follows: Sn-Gn = 3.96 + 1.16 (sex) + 1.45 (profile) +0.11 (palm length) + 0.91 (P-Ch) + 0.10 (P-P) +0.10 (Zy-Zy) – 0.93 (P-Sn) [unit mm].[8] This formula is claimed to be suitable for the Mongoloid population in Japan and can be used clinically for a rough measurement of OVD.[8] In this study, OVD can be determined using (P-P), (Tr-Cn), the width of four fingers, and sex. This result is different from those of Hayakawa and Kusdhany et al., who included the profile variable in their OVD equations because the majority of

their subjects' profiles were convex and straight, while few subjects had a concave profile. This measurement was included as being representative of the Mongoloid race and providing a more reliable formula for determining OVD.

Hayakawa's studies on the determination of OVD included many more coefficients of determination than did this study. The equipment used was more complicated, and such a study could not be performed by only one person.

In clinical practice, several methods can be used to confirm a determination of OVD. These include using phonetics (observation of the "s" sound), tactile sense, facial dimensions, deglutition, and aesthetic appearance.[12] The phonetics method is conducted through a simple measurement of the closest speaking space (the "s" sound), which is claimed to be constant throughout life.[17] If the OVD determination score is far from the measurement of this speaking space, caution and further study are necessary. If the OVD, measured from Sn-Gn, is greater than the speaking space, the OVD could be too high, which will cause a distorted face and weakness in the lips. On the other hand, if the measured OVD is much smaller than the speaking space, the vermillion border will look thinner, wrinkles around the lips will be more visible, and the chin will appear protruded.[8]

Determining the correct OVD is crucial in the treatment of edentulous patients receiving new sets of dentures. It is important to make sure all muscles are in harmony in order to achieve the maximum masticatory function for every patient, even though it is not possible to duplicate the function of the original dentition.

## Conclusion

The OVD formula discovered here can be used to determine OVD in edentulous patients of the Mongoloid race. The formula is as follows: Sn-Gn = 28.01 + 0.44 (P-P) + 0.29 (Tr-Cn) + (−0.23 (width of four fingers)) + 5.98 (sex) [unit mm]. In clinical applications, this formula can be used for a basic determination of OVD before using other methods to confirm, in order to increase patient comfort and minimize patient visit time.

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