An anthropometric study to evaluate the correlation of vertical dimension at rest and length of thumb: A multi-national, multi-centre pilot study

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Abstract

Aim: A variety of anthropometric techniques have been proposed to determine the correct vertical dimension of occlusion. However, none have reported correlating thumb length (TL) with vertical dimension at rest (VDR). This study aimed to correlate the VDR to measurements of the thumb in a multi-national, multi-centric trial in participants with and without orthodontic treatment and establish a regression equation for each region.

Settings and Design: A cross-sectional multi-national, multi-centric correlation trial.

Materials and Methods: A cross-sectional study was conducted in India and Malaysia with a total of 688 participants. Measurements of thumb and VDR were obtained using a modified Willi’s gauge using a standard operating procedure.

Statistical Analysis Used: Pearson’s correlation coefficient was calculated to determine the correlation between TL and VDR. A multiple linear regression was done to correlate VDR from gender, orthodontic treatment, and length of thumb.

Results: Correlation coefficient between TL and VDR in patients with orthodontic treatment was 0.829 and 0.774 in patients without orthodontic treatment. The correlation between TL and VDR in patients with orthodontic treatment in North India was 0.484, \( P = 0.010 \) and Malaysia was 0.946, \( P < 0.001 \). There were significant correlations between TL and VDR in patients without orthodontic treatment in all regions (\( P < 0.001 \)). Regression equations were obtained for different ethnic groups for calculating the VDR.

Conclusion: There was an overall positive correlation between TL and VDR in patients with and without orthodontic treatment. The regression equations presented in this article could help clinicians in their clinical practice and researchers to conduct future trials.

Keywords: Anthropometric measurements, length of thumb, multi-centric study, regression analysis, vertical dimension at rest

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INTRODUCTION

Establishing the correct vertical dimension in the fabrication of a prosthesis is a major concern in treating edentulous patients. In addition to functional importance, establishing a correct vertical dimension in a denture patient affects the facial expressions and appearance. An appropriate vertical dimension, stable occlusal contacts which are harmonious with the stomatognathic system, and contours which adapt with surrounding facial musculature, will help complete dentures to adapt into the rest of the masticatory system.\[1\]

Vertical dimension is expressed in terms of occlusal vertical dimension and vertical dimension at rest (VDR). Rest vertical dimension is defined as “the distance between two selected points when the mandible is in the physiologic rest position.”\[2\]

Although several mechanical, physiological, and anthropometric methods have been reported in the literature, there is no ideal method for attaining vertical dimension in the clinical practice.\[3,4\] It depends upon the most reliable method that the clinician feels comfortable to practice, making it tentative, until the try-in procedure is completed. Vertical dimension at rest can be obtained using the facial measurements as a guide.\[5\] It can also be determined by dividing the frontal aspect of the face in three equal parts, with the lower third of the face corresponding to the VDR.\[6\] Stability of the vertical dimension at rest has been the most controversial aspect of prosthetic dentistry. It is debatable if the rest position of mandible remains constant throughout life or not. Uppal et al. opined that rest position remains constant throughout life irrespective of whether the patient is an infant, an adult or aged.\[6\] However, some demonstrated variability of the rest position of mandible before and after the extraction of natural teeth and after complete denture insertion.\[6\]

Not only in edentulous patients, in some dentulous adult patients undergoing orthodontic treatment, changes in lower facial height have been reported due to posterior teeth extrusion and backward rotation of the mandible.\[7\]

Despite these aspects, many clinicians use the vertical dimension at rest after tooth loss for establishing the vertical dimension at occlusion in complete denture patients. This may lead to errors in determining the correct proportions of the lower third of the face which existed preextraction. To re-establish the occlusion to the preexisting status for edentulous patients, the VDR or vertical dimension of occlusion (VDO) of the patient before tooth extraction needs to be identified for which the anthropometric measurements are popularly advocated.

A variety of anthropometric techniques using the measurement of all the digits of the hand have been proposed to determine the measurements for the correct VDO.\[8-12\] Some studies showed the existence of gender as well as racial differences in various hand anthropometric measurements.\[8,9\] However, none have reported correlating anthropometric measurements using length of thumb length (TL) with VDR. This study aimed to correlate the VDR to the length of the thumb in a multi-national, multi-centric trial which is the first of its kind.

VDR is also an essential parameter for facial reconstruction surgeries, orthognathic surgeries,\[13\] and orthodontic applications,\[14\] as it indicates the lower third of facial height. Correlating the VDR to the thumb measurement and establishing a regression equation will allow us to use this not only for the applications as mentioned above, but also for forensic applications\[15\] and future anthropometric studies.

The objective of this study was to determine the relationship between the vertical dimension at rest to the length ofthumb finger in patients with and without orthodontic treatment. Specifically, we wanted to study the overall correlation of VDR to TL and identify a regression formula to correlate VDR to TL, in different genders and ethnic groups. We followed a null hypothesis that there would be no difference in any of the parameters being tested.

MATERIALS AND METHODS

We conducted a multi-national and multi-centre trial to include a significant number of participants from the different geographical locations and different ethnic groups. This cross-sectional study was conducted in four dental institutions in India and one institution in Malaysia with a total of 688 participants.

As this was the first multinational, multi-centre trial being conducted, we did a pilot study in each centre and collected data by the purposive sampling for duration of 3 months. Ethical clearance was obtained from all the Institutional Ethical Committees. (VDC/RP/2013-10; MMC/FOD/AR/EC 2016 (F-26)); HIDS/PS/8673 (A); BVDUMC andH/Sangli/IEC/216/16). Written informed consent was obtained from all participants.

We developed a conceptual framework depicting the several factors affecting the vertical dimension of rest. In the present research, ethnicity, gender, and orthodontic treatment were considered as the independent variables. The measurement of thumb and its correlation to the VDR...
was considered as the dependent variable. The other factors such as age, status of occlusion, and muscular coordination were the erroneous variables [Figure 1].

We included dentulous individuals above 18 years old, with no developmental skeletal deformities, either in the hand or face. Patients with a history of orthodontic treatment were considered only after they completed their treatment. Patients with neuromuscular disorders, missing teeth, wearing any type of prosthesis, and having attrition were excluded from the study.

The participants from India were further divided based on the region into North India, South India, West India, and North East India. All the participants were divided into two groups: Category 1: Patients who have not undergone orthodontic treatment and Category 2: Patients who have undergone orthodontic treatment. The ethnicities studied were classified based on the region as follows:

• North Indians (Himachal Pradesh, Uttarakhand, Haryana, and Jammu and Kashmir) – Aryan race
• South India (Andhra Pradesh) – Dravidian race
• North-East India (Assam and West Bengal) – Mongoloid race
• West India (Maharashtra) – Aryan race
• Malaysia (Melaka) – Chinese/Indian/Malay races.

A virtual focus group discussion was conducted among the research coordinators of different centers to come to a consensus regarding the standard operating procedure to be used. A six-inch ruler was attached with a sliding stopper to resemble Willi’s gauge. This ruler was used for all measurements [Figure 2]. Patient was instructed to slightly bend the thumb finger. The bony prominence on the dorsal surface at the base of the finger was palpated. A line connecting the medial and lateral prominence was drawn to mark the bony landmark [Figure 3]. Measurement was made between this line and the tip of the finger keeping the thumb straight and resting on the index finger to determine the length of the thumb finger (TL) [Figure 4].

The patient was seated in an upright position with the mandible in the physiological rest position. The lower third of the face was measured between the base of nose and lower border of chin [Figure 5]. Each participant was measured three times to overcome intra-observer variability. Data were entered using Microsoft Excel and analyzed using PASW Statistics 18. Descriptive statistics such as frequency and percentage were calculated for the categorical variables such as orthodontic treatment and gender. Pearson’s correlation coefficient was calculated to determine the correlation between TL and VDR. A multiple linear regression was done to correlate VDR from gender, orthodontic treatment, and length of the thumb. The regression equation is written as follows:

Predicted VDR = b₀ + (b_\text{gender} \times \text{Gender}) + (b_{\text{orth\_treatment}} \times \text{orthodontic\_treatment}) + (b_{\text{PL}} \times \text{TL} \text{[mm]}) \quad \text{(where } b \text{ is regression coefficient and } b₀ \text{ is a constant)}.

All statistical tests were two-sided, and the level of significance was set at 0.05.

RESULTS

Table 1 shows the distribution of participants in different regions.

There was significant overall positive correlation between TL and VDR in patients with and without orthodontic treatment [Table 2]. Region wise results showed that there...
is a significant positive correlation between TL and VDR in patients who underwent orthodontic treatment in North India ($r = 0.484$, $P = 0.010$) and Malaysia ($r = 0.946$, $P < 0.001$) [Table 3]. However, for the patients without orthodontic treatment, significant positive correlation between TL and VDR was found in all regions, as shown in Table 4.

A multiple linear regression was run to predict VDR from gender, orthodontic treatment, and length of thumb in each of the races, as shown in Table 5. Regarding assumption of the test, there were linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin–Watson statistic. There was homoscedasticity, as assessed by the visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values $>0.1$. The assumption of normality was met, as assessed by Q-Q Plot among Aryan, Dravidian and Mongoloid, but not among Malay, Chinese, and Indian [Table 5].

Among Aryan race, the multiple regression model statistically significantly predicted VDR, $F(3, 139) = 45.969$, $P < 0.001$, adjusted $R^2 = 0.487$. Gender and TL were statistically significant, $P < 0.001$ but not orthodontic treatment.

Among Dravidian race, the multiple regression model statistically significantly predicted VDR, $F(3, 97) = 85.235$, $P < 0.001$, adjusted $R^2 = 0.716$. TL was statistically significant, $P < 0.001$ but not gender and orthodontic treatment.
Among Mongoloid race, the multiple regression model statistically significantly predicted VDR, $F (3, 145) = 1762.294, P < 0.001$, adjusted $R^2 = 0.994$. Gender and TL was statistically significant, $P < 0.001$ but not orthodontic treatment. Among Malay race, the multiple regression model statistically significantly predicted VDR, $F (3, 30) = 1762.294, P < 0.001$, adjusted $R^2 = 0.994$. Orthodontic treatment and TL were statistically significant, $P < 0.001$ but not gender. Among Chinese race, the multiple regression model statistically significantly predicted VDR, $F (3, 145) = 7743.188, P < 0.001$, adjusted $R^2 = 0.989$. Gender and TL were statistically significant, $P < 0.001$ but not orthodontic treatment.

Among Indian race, the multiple regression model statistically significantly predicted VDR, $F (3, 49) = 111.441$, $P < 0.001$, adjusted $R^2 = 0.864$. TL was statistically significant, $P < 0.001$ but not gender and orthodontic treatment. The regression equations for each of the races are given in Table 6.

**DISCUSSION**

To the best of our knowledge, this multicentric and multinational study is the first of its kind. Earlier studies comparing different races were done for measuring VDO unlike VDR as done in this study. We considered orthodontic treatment as a variable as previous studies showed variation in facial height in some adult orthodontic patients. Hence, we wanted to separate this as a variable to see if there were any differences in correlation of VDR to TL in patients with and without orthodontic treatment.

The correlation between the VDR and the TL was found to be strong and positive in participants with and without orthodontic treatment in the whole population of the study. Similar results were found in a study done by Basnet et al. who compared VDO to TL in the Aryan and Mongoloid races in Nepal. The results could be attributed to the different populations tested and the variation in the measurement parameters used. The previous studies have considered ventral surface and soft-tissue landmarks, which may not be consistent. In the present study, the bony landmarks on the dorsal surface used can be more definitive.

Correlation between the TL and VDR in patients who underwent orthodontic treatment based on region showed significant correlation only in Malaysia and North India. This could be due to the small sample size in the other regions of India. However, the correlation between TL and VDR in patients who did not undergo orthodontic treatment based on the region showed a significant correlation in all regions.

We attempted to do a multi-linear regression analysis to arrive at a regression equation for each race as there may be variations that could be attributed to the different facial and anthropometric characteristics of different races. The regression equations have been presented independently.
for different races and can be used as a guidance for VDR calculation.

The merit of this study compared to others is the multiple races included from different regions of India and Malaysia. Basnet et al.\[^{14}\] who studied VDO, suggested that their limitation was that only two ethnic groups (Aryan and Mongoloid) were considered in this study. Hence, the findings cannot be extrapolated to other ethnic groups or races. The strength of our study is in the inclusion of different ethnic groups and predicting the regression equation independently for each region. The results of this pilot study can be used in future studies to calculate the sample size.

As this was a cross-sectional pilot study, there was variation in sample size in each centre. There may be a possibility of mixed races among parents of the included participants. As this was a multi-centric trial, inter-observer variability could not be ruled out. We considered all patients who underwent orthodontic treatment into one category irrespective of the type of treatment received. These could be the limitations in this study.

**CONCLUSION**

Within the limitations of this study, the following conclusions can be derived:

1. There was significant overall positive correlation between TL and VDR in all patients
2. Region wise comparison showed a significant positive correlation between TL and VDR in patients who underwent orthodontic treatment in North India and Malaysia
3. There were significant positive correlations between TL and VDR in patients without orthodontic treatment in all regions.

The regression equations presented in this article could help clinicians in their clinical practice and researchers to conduct future trials.

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**Conflicts of interest**

There are no conflicts of interest.

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