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Research Report

Correlation of the vertical dimension of occlusion with five distances between facial landmarks among those of Batak Toba ethnicity

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ABSTRACT

Background: *The normal vertical dimension of occlusion (VDO) results in orofacial and temporomandibular joint (TMJ) biomechanical balance. If the VDO changes due to attrition, full edentulism, accidents involving the lower third of the face and even improper denture manufacturing will result in the disruption of mastication, speech and aesthetic functions. Therefore, the right technique is needed to predict the correct VDO.* ***Purpose:*** *To identify the correlation values and regression equation of the VDO for five distances between facial landmarks among people of Batak Toba ethnicity.* ***Methods:*** *This research is an analytical study with a cross-sectional design. A purposive-sampling technique obtained 30 Batak Toba subjects, consisting of 15 males and 15 females aged 19–24 years. The data were analysed by an independent t-test, one-way ANOVA, the Pearson correlation, and linear regression ($p<0.05$).* ***Results:*** *A significant difference distance in the VDO ($p=0.0001$, $p<0.05$) was observed between male subjects (72.96±3.75mm) and female subjects (65.24±5.12mm). A positive and significant correlation was observed between the VDO distance and the facial landmark distances, where the criteria for significant correlation were the RO–Pu distance being {r male=0.723(p=0.02) and female=0.650(p=0.09)} and the OC–RO distance being {r male=0.689(p=0.004) and female=0.615(p=0.015)}; the moderate correlation criteria were the OC–IC distance being {r male=0.476(p=0.045) and female=0.428(p=0.043)}, the E–E being {r male=0.435(p=0.043) and female=0.458(p=0.047)}, and the EH being {r male=0.398(p=0.051) and female=0.414(p=0.051)}. The regression equation for the VDO distance in males is {[22.694 + 0.673 (RO–Pu)], [24.371 + 0.642 (OC–RO}* and in females is *{[23.017 + 0.616 (RO–Pu)], [21.795 + 0.632 (OC–RO)]}.* ***Conclusion:*** *The distances of RO–Pu and OC–RO have the strongest correlation with the VDO in people of Batak Toba ethnicity.*

Keywords: *correlation value; facial landmark distance; vertical dimension of occlusion*

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INTRODUCTION

The 2017 glossary of prosthodontic terms defines the vertical dimension of occlusion (VDO) as the vertical distance measured between two anatomical points, one on the maxilla and the other on the mandible, when the mouth is closed and the teeth are in maximum intercuspal occlusion.[1] Theoretically, measurement of the VDO distance can be performed in two ways: measuring the distance between the most prominent point on the nose (the pronasale) to the most prominent point on the chin (the gnathion) and measuring the distance between the base of the nose (the subnasale) to the base of the mandible (the menton). In this study, the VDO measurement method is the distance between the pronasale and the gnathion. The VDO distance is affected by ethnicity due to the genetics involved in jaw and bone growth, eruption and occlusion of the teeth and the position of the temporomandibular joint (TMJ), which provides a good balance between orofacial biomechanics and the TMJ for mastication, phonetic and aesthetic functions.[2–4]

In cases of severe dental attrition, full edentulism and accidents involving the lower third of the face, there can be a loss of the normal VDO distance, meaning that it is necessary

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to determine the correct VDO to restore the mastication, phonetic and aesthetic functions.[2–4] Determination of the VDO can be done during pre-extraction or post-extraction. The pre–extraction method can be performed by facial photographs, facial silhouettes, cephalometric radiographs, articulation models or the Swenson method, while the post-extraction method can be performed by the Niswonger method, electromyography, biometrics, the Willis method, using the closest speaking space, ingestion, or using finger length or the distance between facial landmarks. In this study, the chosen method for determining the VDO was the one associated with the five distances between facial landmarks.[2–7] This method was chosen based on the theory that faces remain relatively unchanged throughout the course of a life, as well as the fact that it is non-invasive, simple, low-risk and inexpensive; it also does not require special tools and does not involve radiation exposure, so it can be recommended for daily practice as a guide for reconstructing the lower third of the face.[2, 4]

There are 14 known distances between facial landmarks that can be correlated to the VDO distance. The study of Majeed et al.[3] in Saudi Arabia showed that only seven landmarks have a correlation to the VDO in both males and females, but in the study of Basnet et al.[2] it is recommended that only five facial landmarks have a strong correlation to the VDO distance, which are: the distance of the rima oris to the pupil (RO–Pu), the outer canthus of the right eye to the inner canthus of left eye (OC–IC), the outer canthus of eye to the rima oris (OC–RO), the outer canthus eye to the external auditory meatus ear (E–E), and the ear length (EH). A regression equation can then be obtained to predict the VDO distance. The study of Majeed et al.[3] on the population of Saudi Arabia obtained the following regression equation in men: VDO = [27.07 + 0.655 (RO–Pu)], VDO = [20,323 + 0.675 (OC–RO)], VDO = [42.12 + 0.402 (OC–IC)], VDO = [45.31 + 0.354 (E–E)], and the following in women: VDO = [34.91 + 0.347 (RO–Pu], VDO = [24.22 + 0.471 (OC–RO)], VDO = [45.63 + 0.207 (OC–IC)], VDO = [39.54 + 0.263 (E–E)], VDO = [42.72 + 0.238 (EH)].

Based on the previous description that ethnicity is one of the factors affecting the VDO and the fact that this research has never been done on Batak Toba people, researchers are interested in conducting studies into the correlation value and conversion of the VDO of five distances between facial landmarks of Batak Toba people aged 19–24 years. The purpose of this study is to identify the correlation values and regression equation of the VDO to five facial landmarks among those of Batak Toba ethnicity.

MATERIALS AND METHODS

This is an analytical study with a cross-sectional design. The research was conducted in the laboratory of the Department of Oral Biology, Faculty of Dentistry, Universitas Sumatera Utara (USU). The hypothesis test formula obtained 30 samples, divided into 15 male and 15 female and consisting of students at the Faculty of Dentistry, Universitas Sumatera Utara. The sample was then selected using a purposive-sampling technique that matches the inclusion criteria. The inclusion criteria were: being aged 19–24 years; being of Batak Toba ethnicity for two generations; possessing a complete set of 28 teeth, including Molar 2–Molar 2 in the maxilla and mandible; having a straight face-profile; having an Angle's class I occlusion; and having had no restoration on the incisal and occlusal surfaces. The exclusion criteria were: having attrition of more than ⅓ of the incisal or occlusal surfaces; having a bruxism habit; having large, carious lesions on the occlusal surface; having malocclusion; having TMJ abnormalities; having intraoral or extraoral abnormalities; a history of severe trauma, surgery, or facial abnormalities in the area of the eyes, nose, lips or ears; and having used or currently be using orthodontic and prosthodontic treatments. Ethical clearance was obtained from the USU Medical Faculty Health Research Ethics Commission (No. 849/TGL/KEPK FK USU-RSUP HAM/2019).

Clinical examination was performed by looking at the condition of the teeth and the relationship of the molar occlusion. Then, in subjects who fit the criteria, measurements were taken with digital callipers of the VDO distance (Figure 1) and the five distances between facial landmarks (Figure 2). The data were analysed using SPSS version 20.0 software (Student Edition, IBM America) and were tested by an independent t-test, one-way ANOVA, the Pearson correlation, and linear regression ($p<0.05$).

RESULTS

The purpose of this study on 30 people of Batak Toba ethnicity with Angle's class I occlusion between 19–24 years of age was to obtain: the mean value of the VDO and the five distances between facial landmarks, the conversion value, the correlation value and the regression equation of the VDO distance with the five distances between facial landmarks. There was no significant difference in the mean VDO distance and the five distances between facial landmarks between each age group ($p>0.05$) (Table 1), but

Figure 1. The VDO measurement: A. Pronasale–gnathion and B. Subnasale–menton.

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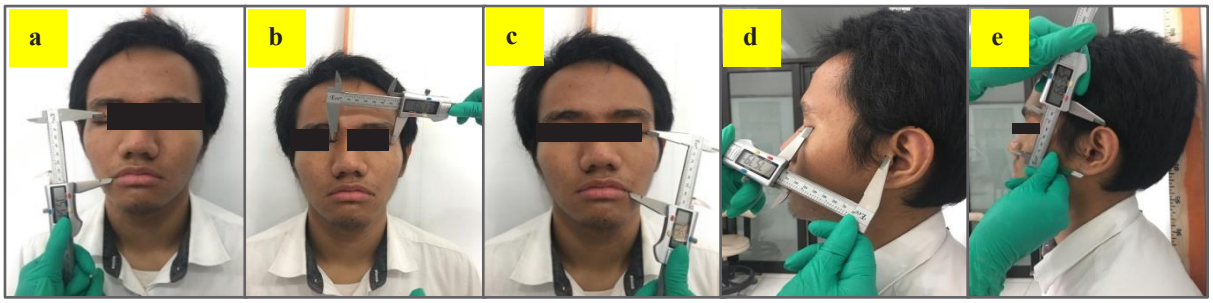

Figure 2. The facial landmark measurements: a. RO–Pu, b. OC–IC, c. OC–RO, d. E–E, e. EH.

Table 1. The mean VDO distance and distances between five facial landmarks in those of Batak Toba ethnicity aged 19–24 years with Angle's class I occlusion

Character	Age (Years)	$\overline{X}$ ±SD (mm)	p-value
VDO	19	70.84±8.31	0.451
	20	68.61±4.73	
	21	64.83±6.69	
	22	69.87±5.67	
	23	73.52±4.98	
	24	70.43±7.14	
RO–Pu	19	71.91±6.71	0.218
	20	71.91±4.79	
	21	68.27±5.55	
	22	72.15±5.63	
	23	77.97±2.51	
	24	67.01±8.39	
OC–IC	19	71.67±3.79	0.130
	20	70.88±4.72	
	21	67.25±3.90	
	22	72.39±4.50	
	23	75.07±0.34	
	24	65.77±7.38	
OC–RO	19	73.03±7.36	0.352
	20	72.45±4.89	
	21	69.45±5.47	
	22	72.83±5.39	
	23	77.45±4.25	
	24	66.89±8.56	
E–E	19	80.17±3.39	0.622
	20	76.52±4.79	
	21	77.34±2.59	
	22	76.70±7.52	
	23	79.52±2.01	
	24	81.09±1.39	
EH	19	80.17±3.39	0.622
	20	76.52±4.79	
	21	77.34±2.59	
	22	76.70±7.52	
	23	79.52±2.01	
	24	81.09±1.39	

Table 2. The mean VDO distance and five distances between facial landmarks in those of Batak Toba ethnicity aged 19–24 years with Angle's class I occlusion, separated by gender

Character	Male $\overline{X}$ ±SD (mm)	Female $\overline{X}$ ±SD (mm)	p-value
VDO	72.96±3.75	65.24±5.12	0.0001*
RO–Pu	74.69±4.03	68.54±5.40	0.001*
OC–IC	73.39±3.28	68.03±4.48	0.001*
OC–RO	75.66±4.02	68.78±4.98	0.0001*
E–E	80.13±2.96	75.43±4.76	0.003*
EH	59.07±3.24	58.12±5.04	0.545

Table 3. Pearson's correlation coefficient between the VDO distance and the distances between five facial landmarks of those of Batak Toba ethnicity with Angle's class I occlusion, separated by gender

Character	Male		Female	
	Pearson's®	p-value	Pearson's®	p-value
RO–Pu	0.723	0.002*	0.650	0.009*
OC–IC	0.476	0.045*	0.428	0.043*
OC–RO	0.689	0.004*	0.615	0.015*
E–E	0.435	0.043*	0.458	0.047*
EH	0.398	0.051*	0.414	0.050*

Table 4. Conversion values the VDO distance to the five facial landmark distances in the Batak Toba ethic aged 19-24 years with Angle's class I occlusion

Age	Conversion value				
	RO–Pu	OC–IC	OC–RO	E–E	EH
19-24	69.10±4.93	69.09±4.60	69.10±4.82	69.10±4.58	69.12±4.54
19	69.35±6.33	69.71±4.79	69.63±6.48	70.57±4.66	70.86±4.12
20	69.10±4.47	69.00±4.66	69.09±4.39	68.13±4.87	68.57±4.79
21	66.61±5.28	66.51±4.64	67.01±5.13	68.31±3.89	67.27±4.44
22	69.71±3.95	70.56±4.32	69.80±3.69	69.02±6.57	69.74±4.86
23	73.85±3.97	72.53±2.46	72.99±4.64	70.85±2.48	71.12±3.04
24	66.21±4.93	66.05±7.53	65.73±7.74	69.10±4.58	68.68±8.77
p-value	0.462	0.479	0.579	0.890	0.837

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Table 5. Conversion values the VDO distance to the five facial landmark distances in the Batak Toba ethic aged 19-24 years with Angle's class I occlusion based on gender

Character	Conversion Value		p-value
	$\overline{X}$ Male ±SD (mm)	$\overline{X}$ Female ±SD (mm)	
RO–Pu	72.97±2.71	65.24±3.33	0.0001*
OC–IC	72.96±2.16	65.23±2.70	0.0001*
OC–RO	72.94±2.58	65.26±3.15	0.0001*
E–E	72.98±1.98	65.23±2.69	0.0001*
EH	72.98±1.90	65.25±2.63	0.0001*

Table 6. Regression equation the VDO distance with the five facial landmark distances in the Batak Toba ethnic with Angle's class I occlusion based on gender

Gender	V. Dependent	V. Independent	Regression Equation
Male	VDO	RO–Pu	Y=22.694+0.673 (RO–Pu)
		OC–IC	Y=24.593+0.659 (OC–IC)
		OC–RO	Y=24.371+0.642 (OC–RO)
		E–E	Y=19.373+0.669 (E–E)
		EH	Y=38.254+0.588 (EH)
Female	VDO	RO–Pu	Y=23.017+0.616 (RO–Pu)
		OC–IC	Y=24.210+0.603 (OC–IC)
		OC–RO	Y=21.795+0.632 (OC–RO)
		E–E	Y=22.534+0.566 (E–E)
		EH	Y=34.910+0.522 (EH)

there were significant differences between the results for males and females ($p<0.05$), except for the EH distances, which showed no differences based on gender ($p>0.05$) (Table 2). There was significant positive correlation between the VDO distance and the facial landmark distances; the strong correlation criteria (r=0.50–0.75) were the distance of the RO–Pu and the OC–RO, while the moderate correlation criteria (r=0.26–0.50) were the distances of the OC–IC, the E–E and the EH (Table 3).

In this study, there was no significant difference in the conversion value of the VDO distance with the five distances between facial landmarks in each age group 19–24 years ($p> 0.05$) (Table 4), while based on gender there was a significant difference, as in men it was significantly longer than in women ($p< 0.05$) (Table 5). There was a difference in the regression equation of the VDO distance with the five distances between facial landmarks between male and female (Table 6).

DISCUSSION

The results of this study, based on 15 men and 15 women of Batak Toba ethnicity aged 19–24 years with a class I occlusion, show no significant difference in the mean VDO distance and the five distances between facial landmarks between each age group. This might have happened due to the theory of Laksmapappa that states that the maximum bone-growth rate will stop at the age of 18 years.[8] After reaching the age at which bone growth is complete, the size of the bones, including those in the face, will not change and will remain stable until age 24 (as an estimate) is reached. In addition, the bones in the head and face area, except for the mandible, are connected with connective tissue fibrosis (synarthrosis), meaning that the skull bones do not allow movement and that dead joints can stimulate osteoblasts. This means that when the growth of the head and face bones is complete, there will be no change, or only a minimum amount of shrinkage throughout life.[9, 10]

Farkas also states that the growth of the ear's length reaches a peak and stops at the age of 15, meaning that between 19 and 24 years of age, the size of the ear does not increase.[11] According to Khanehzad *et al.*, at the age of 25 and over, the VDO distance has begun to decrease due to attrition of use of the incisal and occlusal surfaces of the teeth, resulting in the shortening of the incisal and occlusal surfaces of the teeth, followed by reduction in the intercuspal distance, which in turn makes the VDO distance shorter.[12] In this study, the subjects have Angle's class I occlusion, which is a normal occlusion with maximum intercuspation, meaning that the mandibular condyle is in the centre of the mandibular fossa, where all muscle and innervation functions are expected to work properly; the normal pattern of mandibular bone growth results in a normal lower third of the face.[13] This is why there is no difference in the VDO distance and the five distances between facial landmarks between age groups.

There were differences in the mean values of the VDO, RO–Pu, OC–IC, OC–RO and E–E distances between gender, as for men they are significantly greater than for women. The results of this study are consistent with previous studies that mention that the VDO distance in men is significantly greater than in women.[2–4, 16] Sex is one of the most important factors in influencing the process of growth and development, especially in the bones, due to the role of sexual hormones.[14]

According to Hauspie, generally, bones in men are bigger than in women. Genetically, men are dominated by testosterone, which increases the speed of protein synthesis in the body for the formation of bones' organic matrix secreted by osteoblasts during the process of bone mineralisation as part of bone growth and bone mass formation more than women, meaning that the bones in men become larger.[14,15] On the other hand, women are

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dominated by oestrogen, which is important for menstrual regulation and the reproductive cycle and stimulates the proliferation of breast-glandular epithelial cells; its role in the process of bone growth is that it is responsible for epiphyseal closure, so that bone growth stops faster in women and cause bones in women to be smaller than in men because there is no increase in size due to the closure of the epiphyses. Thus, all bones, including facial bones, are smaller in women than in men.[13, 16] This causes a significant difference between the distances of the VDO, RO–Pu, OC–IC, OC– RO and E–E in men and women.

In this study, there was no significant difference in the distance of EH between men and women. The results of this study are consistent with the statement of Alexander *et al.*, that the length of the ear is not affected by gender, but is influenced by genetic factors inherited from both parents and ethnicity.[11] Therefore, the EH distance in this study is no different between male and female because the subjects of this study are Mongoloid.

There was no significant difference in the conversion value between the VDO distances of the five distances between facial landmarks for each age group, while based on gender there was a significant difference: the distances in men are significantly longer than in women. This result is in accordance with the data above showing that the VDO distance was not significantly different between each age group, but there was a significant difference between men and women, which is known to be related to hormonal factors.[16]

In this study, the RO–Pu and OC–RO distances have a strong correlation with the VDO distance, while the OC–IC, E–E and EH distances have a moderate correlation based on gender. This is supported by Leonardo da Vinci's theory which states that face height vertically consists of the upper, middle, and lower third faces in the same ratio. The author assumes that the distance of RO-Pu and OC-RO is in the middle third of the face and both have the same height in other words that the distance of RO-Pu and OC-RO is considered almost close to the same result, then the VDO distance is the bottom third of the face . This statement is appropriate because the proportion of the middle third of the face (RO-Pu and OC-RO distance) with the lower third of the face (VDO distance) is the same, therefore the correlation becomes stronger.[3, 17-19] The distances of OC–IC, E–E and EH have a moderate correlation with the VDO distance. There is no existing study that explains the reasons why the OC–IC, E–E and EH distances do not have too strong a correlation to the VDO distance. Therefore, further research is needed regarding the correlation between the distances of OC–IC, E–E and EH to the VDO distances. However, researchers tend to assume that this is because the OC–IC distance is affected by the varying conditions of people's eyelid shapes, the E–E distance is affected by facial convexity and the thickness of the soft tissue that protects the zygomatic bones or cheeks, and the EH distance is affected by the varying anatomic shape and position of the earlobe in each individual, so that the correlation with face height is moderate.[10]

The regression equation is obtained to determine the distance of the VDO using five distances between facial landmarks, but it cannot be used as a standard in determining the VDO distance in the Batak Toba ethnicity. This is because the number of samples in this study, 15 men and 15 women, is still too small. In addition, this study is limited to those who have two-generation Batak Toba ethnicity, whereas most researchers set limitations of using research subjects with three or more generations of Batak Toba ethnicity to obtain a purer ethnicity. This has happened because this research was conducted in a city where many intermarriages have taken place, making it difficult to obtain subjects with pure Batak Toba ethnicity of three generations or more. Therefore, further research needs to be done on the conversion of the VDO distances with five distances between facial landmarks in those of Batak Toba ethnicity with more samples, based on age, gender, diet and having three or more generations of Batak Toba ethnicity. In conclusion, the five facial landmark distances have a correlation to the VDO in those with Batak Toba ethnicity: the RO–Pu and OC–RO distances have a strong correlation, while the OC–IC, E–E and EH distances have a moderate correlation.

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