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Digital photographs analysis in predicting physiologic vertical dimension using apikal (aplikasi dimensi vertikal - vertical dimension application) software

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Abstract

Objective: Determine indirect measurements through digital photographs of the face to predict physiological vertical dimensions and determine correlation of physiological vertical dimensions measurement directly on faces with indirect measurements through digital photographs of faces.

Material and Methods: This was observational analytic with cross sectional study design. The subjects were 50 students of faculty of dentistry, Hasanuddin University who met the inclusive criteria. Measurement of digital photographs was analyzed using Apikal software (Vertical Dimension Application)

Results: Kruskal Wallis test on faces and digital photographs obtained p value 0.537 and 0.157 ($p > 0.05$) respectively, mean the distance in the subnation-gnation (Sn-Gn) and distance from the interpupil line to the lip commissure (IP-Ka and IP-Ki) on the face and digital photographs did not have significant differences. From pearson correlation test, obtained $p = 0.000$ ($p < 0.05$) mean there was correlation between manual measurements with Apikal measurements on IP-Ka, IP-Ki, and Sn-Gn reference points with r values of 0.703, 0.711, 0.800 respectively, which means the correlation is strong and positive.

Conclusion: Measurement of physiological vertical dimensions indirectly on digital photographs can be used to predict physiological vertical dimensions using apikal software and there is a significant correlation between direct measurements on the face and indirectly on digital photos with strong correlation and positive values.

Keyword: Photograph, Physiologic, Software

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Introduction

Dental and oral health is an important part of general health for every individual. Healthy teeth and mouth can have an impact on good diet and nutritional status. One reference point of oral health can be seen from the number of teeth that can be maintained over the life span. According to the World Health Organization (WHO), adults must have at least 21 teeth that function well to be able to maintain a good diet and nutrition, because of that, the replacement of missing teeth is important for patients who want to restore aesthetic and functional.[1,2]

Tooth loss can occur due to various factors, such caries, periodontal disease, trauma, orthodontic and prosthodontic indications, impaction, hypoplasia, supernumerary teeth, high tobacco consumption, certain metabolic diseases such diabetes, cardiovascular disorders, lower respiratory system diseases can also contribute to tooth loss. That aside health conditions, socioeconomic conditions, willingness to go to the dentist, lifestyle, education level, age, even the area of residence can also affect tooth loss.[2]

The age grouping as follows: young adult age 18 or 29-25 years, full adult age (middle years) or maturity, 25-60 years or 65 years, elderly (geriatric age) more than 65 years or 70 years. Increased age is often associated with a higher amount of tooth loss. While data from BRFSS in 2004-2006 shows that the population that lost more than 6 teeth was 23% in the high school or junior high school, elementary and non-school education groups, 15% in tertiary education.[3]

One of the consequences partial or total tooth loss is alteration of vertical dimensions which will affect jaw relation, causing disturbances in mastication function, phonetics, and appearance. Denture fabrication is important to restore the vertical dimensions and the success of denture depends on the accuracy of vertical dimensions determination. Therefore, the determination of vertical dimensions is one of the important stages in fabrication of dentures that aims to restore alteration in vertical dimensions due to tooth loss. This determination is foundation in dental care, from the diagnosis to the treatment of the stomatognathic system, prosthodontic rehabilitation procedures, and other rehabilitative procedures. The error in determining the vertical dimension can make the denture

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uncomfortable for the patient, and in the long term has the potential to damage elements in the stomatognathic system, thus this stage should not be significantly neglected so stomatognathic and aesthetic functions can be achieved.[4,5]

According to the Glossary of Prosthodontic Terms, the vertical dimension is the distance between two anatomical signs, in half of upper face and half of the lower face. This anatomical sign is a point located at the tip of the nose and the tip of the chin, where one of the points is in the movable tissue and the other point is in the immovable tissue.[6,7] This is determined by the muscle relation using physiological resting position of the lower jaw as reference point, thus knowledge of physiological resting positions is very important in determining adequate vertical dimensions.[8]

There are various methods of establishing jaw relation or VD measurement. VD measurements can be assessed directly or indirectly. Direct DV measurement consists of facial measurements, ingestion, phonetic methods, mastication force, tactile methods and Hayakawa formula. Many face measurement methods for measuring VD makes dentists' choices more varied, such as using the Willis, McGee, Hurst and Hamm methods. The tools used also vary, such as the Sorensen profile scale, Willis bite gauge, Boley gauge, and TOM gauge.[4] Indirect VD measurements such as with photographs media. Photographs can be cephalometric photos, old photos of patients and digital photos of the patient's face. Digital photos are now stated to be a good representation, and are significantly more accurate than cephalometric analysis when measurements on soft tissue are required.[9]

The photographs itself is familiar in the medicine especially dentistry. Many studies have used digital photos as a comparison of measurement tools, especially when dealing with faces. Like the statements of Kiekens MAR and Miyamoto who examined the proportion of the golden ratio of the face by measuring the results of digital photographs.[10,11]

According to Gomes, PVD measurements on the subject of students in Brazil using digital photos, they found that the physiological vertical dimensions of faces can be done digitally on face photographs using a digital photo camera with a shooting distance of 56 cm between the tip of the nose with a camera lens with a height of 112 cm at a tripod. It is stated that the distance from the corner of the eye to the corner of the lip is the same as the distance from the base of the nose (to the tip of the chin using the HL image ++ 97 software.[9]

That PVD measurements in dental student of Indonesian University subjects using digital photographs, they found that the distance from the corner of the eye to the corner of the lips and the distance from the nose to the tip of the chin can be done directly on the face and indirectly on digital photographs using Adobe Photoshop.[4] Although this research has been done in Brazil and in Indonesia, the software used in research in Brazil is difficult to find and the software used in research in Indonesia is an application that is generally used for editing photos so as to determine the vertical dimensions must be done manually, so the authors look for alternative programs that are more efficient and specifically used to measure the physiological vertical dimensions.

Therefore, the author would try to make an application having similar function as the program in measuring PVD.

Material and Methods

The study was conducted at Faculty of Dentistry Hasanuddin University and carried out in August-September 2018. The research subjects were dental student of Hasanuddin University aged 20-23 years old who had symmetrical faces and had class I jaw relationship. After determining the research subjects, direct data collection and photos were taken digitally. For direct data collection, the subjects were given oral and written instructions, then instructed to fill out informed consent. The patient sits in relaxed position in Frankfurt plane parallel to the floor and the body remains upright. Furthermore, the measurement of PVD using the Willis method, PVD measurement could be performed in two ways. First, the patient was instructed to open his mouth wide and then hold it until discomfort arose from the masticatory muscles, then the patient was instructed to close his mouth slowly until it reached resting position and the patient felt comfortable. Second, the patient was instructed to pronounce one of the non-vocal letter's "M" repeatedly until the jaw position was estimated to be the most relaxed or rested position. Then, measured the distance of the subnation to gnation with a digital caliper. After that, measured the distance from the interpupil line to the lip commissure (left and right), then recorded it. Measurement of vertical dimensions was repeated 5 times to minimize the bias of measurement results. The physical dimension obtained from measurements is then recorded. Whereas for taking data through digital photographs, photographs were taken on the subject with the stipulation of a distance of 56 cm between the camera lens and the tip of the nose of the patient, the camera was on a tripod, the patient's head was fixed to minimize the occurrence of distorted photographs and the image resolution of the sample used in this study is 750 x 500 pixels. Then measured the distance from the interpupil line to the lip commissure (left and right) and the

distance of the nose base to the tip of the chin in the photo through vertical (Apikal) application and tabulation of measurement results both directly and in digital photos, then analyzed the measurement results through SPSS 24.0 for windows.

Data collection and analysis

In this study the Kolmogorov-Smirnov normality test was conducted to determine whether the data obtained were normally distributed. Furthermore, the Kruskal Wallis test, because this research was conducted at three reference points. After that the different test was used to determine the PVD on digital photos was similar as the PVD value manually. Then further test of Pearson's correlation was performed to see whether there is a significant correlation.

Results

This research was conducted in August-September 2018 at Faculty of Dentistry Hasanuddin University Makassar. Total 50 students were taken using the purpose sampling method that met the inclusion criteria. The number of subjects was 39 female and 11 males with an age range of 20-22 years. On research subjects with physiological resting positions, PVD measurements were taken on the face either directly using digital caliper or indirectly through digital photographs by measuring the distance from the interpupil line to the lip commissure (IP-Ka and IP-Ki), and also on the subnation point and other signs are in the gnation (Sn-Gn).

Based on observations and recording of data, the mean and standard deviation of both the face and photographs were calculated. Subsequently, the data would be processed using the SPSS 24.0 for windows program and presented in several tables which can be seen as follows.

The measurements on the face and digital photographs tested using Kruskal Wallis test. This test is used because the data are not normally distributed according to the Kolmogorov-Ssmirnov test with $p = 0.003$ and 0.01 ($p < 0.05$) respectively. This test was used to determine significant differences from the three reference points. It was obtained that $p > 0.05$ (0.537) and (0.157), meant that three reference points, the distance on the subnation-gnation (Sn-Gn) and distance from the interpupil line to lip commissures (IP-Ka and IP-Ki) on faces and digital photographs didn't differ significantly table 1.

The results of measurements on the face and digital photographs were then tested for normality. The results of the Kolmogorov-Smirnov normality test for PVD measurements on faces and digital photos of the IP-Ka variable resulting in $p=0.019$ ($p<0.05$), meant that data were not normally distributed, whereas in the IP-Ki and Sn variables –Gn $p = 0.2$ ($p>0.05$), which meant that the data was significant or normally distributed. Furthermore, on the IP-Ka variable, it was tested using the Mann Whitney test and obtained manual measurements with mean 64.51 and Apikal measurements with mean 64.62 and $p=0.850$ ($p>0.05$), indicated that there was no difference the average IP-Ka between manual and Apikal measurements.

The IP-Ki and Sn-Gn variables were tested using independent t test. This test was chosen because data normally distributed. In the IP-Ki obtained manual measurements with mean 65.50 and Apikal measurements with mean of 64.00, the statistical test obtained $p=0.510$ ($p>0.05$) indicated that there was no difference in the mean IP-Ki between manual measurements with Apikal. Whereas in Sn-Gn the results of manual measurement with mean 63.91 and Apikal measurements with mean 62.99, the statistical test results obtained $p=0.271$ ($p>0.05$) which indicated that there was no difference in Sn-Gn average between manual measurements with Apikal measurement table 2.

Table 1 Kruskal Wallis test results of DVF measurements on the face and photographs

Group		Manual	Apikal
IP-Ka	Mean	64.51	64.62
	SD	3.86	3.94
IP-Ki	Mean	64.50	64.00
	SD	3.82	3.80
Sn-Gn	Mean	63.91	62.99
	SD	4.01	4.33
P value		0.537	0.157

*Kruskal-Wallis test

Table 2 Test results for measurements of PVD on faces and photographs

	IP-Ka		IP-Ki		Sn-Gn	
Group	Mean	SD	Mean	SD	Mean	SD
Manual	64.51	3.86	64.50	3.82	63.91	4.01
Apikal	64.62	3.94	64.00	3.80	62.99	4.33
P value	0.850**		0.510*		0.271*	

*Independent t test
**Mann Whitney test

Table 3 H Pearson correlation test results of PVD on the face and digital photos

Reference point	P value	R value
IP-Ka	0.000	0.703
IP-Ki	0.000	0.711
Sn-Gn	0.000	0.800

* Pearson correlation test

Correlation test used pearson correlation test. This test was chosen because the two variables qualify as non-paired numeric variables with> 2 groups, and had normal data distribution. The results showed correlation between manual and Apikal measurements. In the IP-Ka, p=0.000 (p<0.05), which implied there was a correlation between manual measurements with Apikal measurements on the IP-Ka with an r=0.703, meant correlation was strong and positive table 3. In the IP-Ki reference point, p=0.000 (p<0.05), implied that there was correlation between manual measurements with Apikal measurements in the IP-Ki reference point with r=0.711, meant the correlation was strong and positive table 3. In the Sn-Gn reference point, p=0.000 (p<0.05), which meant there was correlation between manual measurements and Apikal measurements on the Sn-Gn reference point with r=0.800, indicated that the correlation was strong and positive table 3.

Discussion

This research was conducted using samples of dental students of Hasanuddin University, in order to ease to contact the study subjects and assuming that the subjects understood the research procedures, as well as allowing collected data from same place. Collecting data in similar condition was required when taking the face photographs of subjects, face, since it was mandatory to take photographs with certain distance and lightning so as adequate space was needed. Therefore, the place of taking photographs was the same for all subjects.

In this study, gender had not been considered, but given the majority of dental students of Hasanuddin University were female, the subjects of this study were 39 female and 11 males. The age range of research subjects was 20-22 years, assuming that at that age there has not been much loss of teeth which is one of the causes of vertical dimension changes. At that age too, growth and development can be said to have been maximized, as Van Den Bosch said, that eye growth reaches a perfect stage at the age of 10 years. At the age of 12-25 years there is an extension of the eye width by 10% and then at the age of 35-85 years will occur the opposite is the reduction in eye width of approximately the same magnitude.[28]

In this study, there were several subject conditions that must be considered before conducting the research procedure; subject who was undergoing orthodontic treatment, using both removable and fixed denture, asymmetrical appearance on the face due to trauma or surgery. These criteria were applied to avoid the difficulty of measuring PVD, which can lead to inaccurate measurement results. The existence of orthodontic wire, extensive fillings, removable or fixed denture was considered causing altered vertical dimension due to premature contact or alteration of jaw relations. Asymmetrical face either due to trauma or surgery, especially on the commissure of the lips and eyes will also affect the measurement resulting in measurement error.

The number of subjects in this study were 50 students who had met the inclusion and exclusion criteria. This research was conducted with the aim to determine the relationship between variables, in this case the measurement variables directly on the face and indirect measurements through digital photos using Apikal software.

This study began with direct measurement of the face by observing the position of the subject, the head perpendicular to the Frankfurt plane and the position of the jaw in rest position, then the face was photographed in the same position or state. As for when the photo shoot was done, there were a number of things to consider, including the position of the head and the distance of image taking. The position of the head which is recommended when taking photographs is parallel to the Frankfurt plane. This position is exactly the same as the standard position for shooting a patient's face profile according to Bengel that the Frankfurt place must be parallel to the horizontal plane of the photo with the patient looking forward, relaxed position, while closing his/her jaws and lips lightly. The lines drawn between orbital points must also be parallel to the horizontal plane of the photo. This is because the position of the head that leads backward will enlarge PVD and vice versa if the position of the head slightly bent will reduce PVD. Therefore, a head fixation tool was needed to prevent this so that measurement errors did not occur. Then the shooting distance of the subject is 56 cm from the camera lens to the subject's nose according to Gomes and with a lens magnification of 35 mm. This was to prevent image distortion that would result in the results of apikal software analysis.

Furthermore, to find out whether the apikal software could be applied to predict PVD, a statistical test was performed by comparing the measurement results manually with the results of digital photographs analysis through the Apikal software. The first statistical test was the Kruskall Wallis test which aims to determine whether there were significant differences from the three reference points (IP-Ka, IP-Ki, and Sn-Gn) both in manual measurements and in digital photographs. Then a different test was performed using the Independent t test for normally distributed data and the Mann

Whitney test for not normally distributed data. Both of these tests aim to determine whether there were significant differences related to the results of manual measurement with the results of digital photo analysis for each group of variables. Lastly, performed Pearson correlation test. This test aims to determine whether there was significant correlation between the results of manual measurement with the results of digital photo analysis for each group of variables.

The Kruskal Wallis Test show that the mean values on faces and digital photographs obtained p> 0.05 (0.537) and (0.157), mean that the three reference points were the distance on the subnation-gnation (Sn- Gn) and also the distance from the interpupil line to the lip commissure (IP-Ka and IP-Ki) on the face and digital photos did not have significant differences. This is in accordance with the Willis method which stated that the distance from the pupils to the corners of the lips is similar as the distance from the base of the nose to the tip of the chin, this result it is expected to be an alternative choice in determining PVD by only measuring the distance of the interpupil line to the lip commissure.9 Although in certain cases it has not been fully implemented due to other factors that play a role such as facial index.

The Mann Whitney test and independent t test on the variables IP-Ka, IP-Ki and Sn-Gn obtained p values >0.05 (0.850), (0.510) and (0.271), which shows no difference the significant mean of the three variables both manual measurements and digital photo measurements using Apikal software, mean that the software can be applied in analyzing digital photos in PVD measurements.

Pearson correlation test results between manual and Apikal measurements on the three measurement reference points obtained p value (0.000) <0.05, which means there was a correlation between manual measurements with Apikal measurements with r values of each 0.703 (IP-Ka), 0.711 (IP-Ki), 0.800 (Sn-Gn), which means the correlation was strong and positive. So, the higher the mean PVD measurement manually, the higher the average PVD measurement result on measurements through Apikal software.

The drawback of this research is that it had not specifically categorized measurement results based on race, gender, and shape and/or face index and in terms of the use of application software that cannot be used generally because the software is not compatible for all personal computers and was still in the development process with the hope in the future this application can be used easily in android-based application.

Conclusion

Measurement of the distance from the interpupil line to the lip commissure (left and right) and the distance from the subnation to the gnation can be performed directly on the face and indirectly on a digital photograph using Apikal software, in determining the physiological vertical dimensions. There is a strong and positive correlation between direct measurements on the face with indirect measurements on digital photographs using Apikal software, concluded that digital photographs analysis can be applied to predict physiological vertical dimensions by using Apikal software.

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Conflict of Interest

The authors report no conflict of interest.

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