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RESEARCH ARTICLES

Reference values for Down's cephalometric analysis in Papuans

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ABSTRACT

The assessment of craniofacial structures is a part of orthodontic diagnosis and treatment. One of the most frequently used cephalometric analysis is the Down's analysis. It consists of 10 parameters, five of which are skeletal and the other five are dental. Down method has based his findings on 20 Caucasians, which have physical characteristic differences from Papuans. Indigenous Papuans are people of Melanesian descent consisting of indigenous tribes in Papua province and/or people who are accepted and recognized as Papuans by indigenous Papuans. The use of cephalometric values in different racial types may result in an incorrect orthodontic diagnosis and treatment plan. According to those, the objectives of this study were to determine the reference values for the Down's cephalometric analysis in Papuans, to evaluate the differences that exist between Papuan adult males and females, and to compare the mean difference between the present study and the established value of the Down's norms. A study was conducted on 16 lateral cephalograms of who were selected based on some inclusion criteria. The Down's method was used for the cephalometric analysis. After the data collection, the data was verified and analyzed statistically using SPSS program with a confidence level set at 5% ($p \leq 0.05$) to obtain the mean, range, and standard deviation. The data normality was first analyzed using the Shapiro-Wilk test with a p-value ≥0.05. The t-test was used to compare the two sexes and compare the samples of this study with the Down's mean. The result showed that the normal cephalometric values of Papuans were different from the normal values used in the Down's analysis. The values obtained in this research are expected to be a reference in conducting a Down's cepahlometric analysis in Papuans for orthodontic treatment purposes.

Keywords: cephalometric; down's analysis; Papuans

INTRODUCTION

Cephalometric analysis is useful in clinical terms for evaluating dentofacial proportions and classifying malocclusion. Cephalometric analysis can observe the pathological conditions and changes that lead to pathology.[1] Cephalograms can be divided into two types, namely lateral cephalograms that provide a lateral view of the skull, and frontal cephalograms that provide an anteroposterior view of the skull. In the world of orthodontics, lateral cephalograms are the most commonly used in cephalometric analysis. Lateral cephalometric radiograph helps predict the growth of craniofacial region, establish facial types, make diagnosis or analyze craniofacial abnormalities, plan orthodontic treatment, and evaluate the treatment results by quantifying the changes brought about by the treatment.[2,3]

There are various methods of cephalometric analysis that can be used for the diagnosis, planning, and evaluation of orthodontic treatments. One of the most frequently used cephalometic analysis is the Down's analysis. The Down's method uses the Frankfort Horizontal Plane as the reference plane. A cephalometric analysis with the Down's method consists of 10 parameters, five of which are skeletal and the other 5 are dental. The Down's method is made simple to interpret by plotting the analysis results into a polygon called a wiggleogram. If the polygon tends to the left, the patient has retrognatic skeletal tendecy and if it tends to the right, the patient has a prognatic skeletal tendency. Plotting cephalometric results on polygons will provide a quick quantitative and qualitative overview. The Down's normal values refer to Caucasians. This method was first put forward by William Downs by looking for a basic description of the skeletal pattern in subjects with normal occlusion. The rationale of this method is that when the description of normal skeletal patterns

is found, then abnormal conditions can be known by comparing it to the normal reference. Downs had based his findings on 20 Caucasian individuals aged 12-17 years old from both sexes who havd normal occlusion and balanced facial proportions.[1,2]

Since Down presented his method, this procedure has been regularly used by orthodontists who routinely use cephalograms in case analysis. The Down's norms should be used only as a guidance and not as an absolute value for each patient.[4] The use of this cephalometric value in specific different racial groups could reveal an improper diagnosis and orthodontic treatment plan since human face is typical and no facial structure is exactly the same.[5] The structure of the face is strongly influenced by the cranial base. Each patient could have different cephalometric and dental relationship measurement results.[6] Previous research found the differences in the development of facial soft tissue in monozygotic twins that have the same genetic material. This finding indicates that the mechanism of the development of the human face is very complex and strongly influenced by genetic conditions and environmental factors.[7]

Humans live on Earth in a variety of natural environments and show a variety of visible physical features. Birth characteristics such as skin color, hair color and shape, facial shape, and so on cause the emergence of racial or human understanding based on various physical characteristics in general.[8] Cited from Ember and Ember (2000), the spread of human populations in various continents in the world causes variations in human features. The difference or variation of the human population is due to the difference in the biological traits that they have, either visible or invisible. External or visible traits include the color of their skin, height, and body shape. Racial factor is an important concept in studying the variation in the human population. Traditionally, experts have categorized humans into three main races, namely the Caucasoid, the Mongoloid, and the Negroid.[9]

Cited from Mall and Mazumbar (2012), the Caucasoid race mostly settles in Europe, North Africa, the Middle East, Pakistan, and India. In general this racial type has physical features as follows: fair skin color, thin lip texture, thick fur, and straight or wavy hair. Negroid in general has physical features as follows: strong skin pigmentation (black skin), wide and thick lips and nose, curly hair, brown to black eyes.[9] The Negroid consists of the African Negroid that inhabits the African Continent, the Negrito that inhabits Central Africa, the Malay Peninsula and the Philippines, the Melanesian that inhabits Papua/Irian and Melanesia.[8] Papuans inhabit Indonesia's eastern island and consist of 254 indigenous tribes.[10] According to Indonesian Law No. 21 of 2001 concerning Special Autonomy for Papua Province, Indigenous Papuans are people of Melanesian descent consisting of indigenous tribes in Papua province and/or people who are accepted and recognized as Papuans by indigenous Papuans.[11]

The role of racial factor, population groups, and cultural diversity is very influential on the shape of facial profiles.[12] The differences in populations make the differences in the measurements for various craniofacial structures and these have motivated researchers to investigate the cephalometric norms of different racial and ethnic groups in different countries for different populations such as Bangladeshi,[4] African American,[13] Mongolian and Korean,[14] Indian,[15] Chinese,[16] including in Indonesia such as Deutero-Malay Indonesians.[17] No study to date has been undertaken for Papuan adults using the complete parameters of the Down's analysis; and importantly, the result of this study can be compared with other racial groups whose results have been published using the Down's analysis. The primary purposes of this research were to determine the cephalometric reference values of Papuan adults using the Down's analysis, to evaluate the differences existing between Papuan adult males and females, and to compare the mean difference between the present study and the established value of the Down's norms.

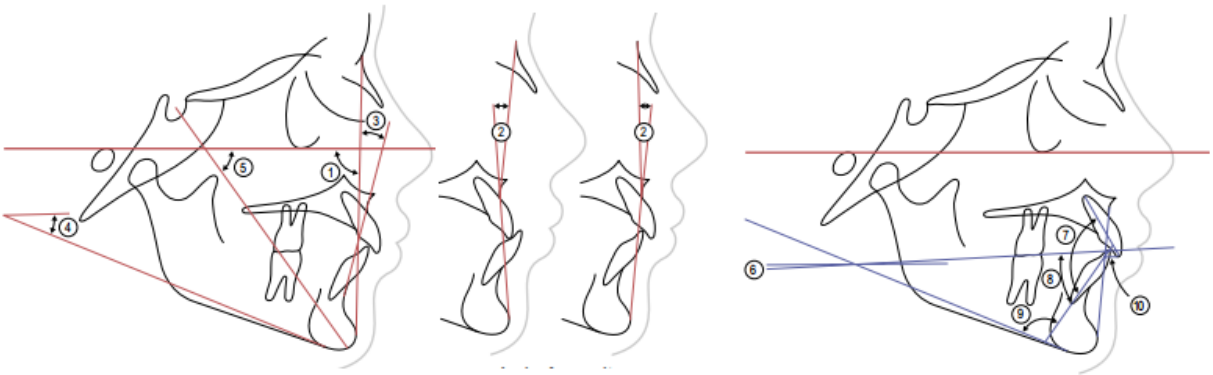

Figure 1. The Down's analysis with the reference landmarks identified. 1) facial angle, 2) angle of convexity, 3) AB plane angle, 4) mandibular plane angle, 5) Y axis angle, 6) occlusal plane angle, 7) interincisal angle, 8) LI to occlusal plane angle, 9) LI to mandibular plane angle, 10) UI to A.Pog plane angle

MATERIALS AND METHODS

The study was carried out using the standardized lateral cephalograms of 16 Papuan participants (8 males, 8 females) in Semarang, Central Java. The selection criteria for the participants were as follows: pure-blooded descendants of indigenous Papuans from the two generations above, from the age range of 18-25 years old, never having or currently not undergoing any orthodontic treatment, never having orthognathic surgery, having permanent dentition, never having a permanent tooth extracted except third molars, class I molar, not wearing dental prostheses, not having tooth malposition, malrelation, and facial hard tissue abnormalities. Two well-trained and experienced orthodontists undertook the selection.

Ethical approval (No.196/B.1-KEPK/SA-FKG/V/2020) was obtained from the KEPK Dentistry Faculty of UNISSULA, Semarang. A consent letter was obtained from all the participants after explaining the purpose of the research. All lateral cephalometric radiographs were taken in centric occlusion with the lips-in-repose position and the Frankfort horizontal plane (FHP) oriented horizontally according to the natural head position. The ear-rods of the Cephalostat machine were placed in the external auditory meatus to stabilize the head. Tracing of the cephalometric radiographs were made by hand using a sharp 2H pencil on acetate tracing paper and illuminator. Eraser was avoided as much as possible. The skeletal and dental landmarks were determined as described by Down's analysis (Figure 1). All landmarks were identified and traced by the first and second author.

The reliability of the method was analyzed by calculating the Dalhberg's formula, to determine the difference between the two measurements:

$$ME = \sqrt{\sum(x1-x2)^2/2n}$$

The first measurement was did by the first author, while the second author did same measurement on the second turn, and n was the number of the repeated records.18 After the data collection, the data was verified and analyzed statistically using SPSS program with a confidence level set at 5% ($p \leq 0.05$) to obtain the mean, range, and standard deviation. The data normality was first analyzed using the Shapiro-Wilk test with a p-value ≥ 0.05. If the data was distributed normally ($p \geq 0.05$), the t-test was then performed. The t-test was used to compare both sexes and compare the samples of the present study with the Down's mean.

RESULTS

The reproducibility of the measurements was assessed by comparing measurements. The Dahlberg's formula was used to determine the method error. The result of the Dahlberg's formula for the present study is presented in Table 1.

According to Table 1, the result of the Dahlberg's formula showed that the highest technical error of the data measurement was 0.28 and the lowest was 0.03. The measurement

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Table 1. The result of Dahlberg's formula

Angular variables	Dahlberg's value	Linear variable	Dahlberg's value
Facial angle	0.03	Upper Incicivus to A.Pog Plane	0.06
Angle of convexity	0.09		
AB plane Angle	0.15		
Y axis Angle	0.28		
Mandibular plane angle	0.12		
Occlusal plane angle	0.15		
Interincisal angle	0.12		
Incisivus mandibular to occlusal plane angle	0.06		
Incisivus mandibular to mandibular Plane angle	0.06		

Table 2. Mean, maximum, minimum, and standard deviation of cephalometric values for the Papuan samples according to the Down's analysis (N=16)

Parameters	Minimum	Maximum	Mean	Standard deviation
Facial angle	80.5°	97.5°	91.09°	4.18°
Angle of convexity	8.5°	19.0°	12.84°	3.34°
AB Plane ngle	-3.0°	-14.0°	-8.21°	3.06°
Y Axis Angle	54.5°	64.5°	57.9°	2.53°
Mandibular Plane Angle	16.0°	31.5°	22.56°	4.12°
Occlusal Plane Angle	3.5°	10.0°	6.40°	1.89°
Interincisal Angle	99.5°	125.5°	115.31°	7.05°
Insisivus Mandibular to Occlusal Plane Angle	49.0°	68.0°	60.0°	4.35°
Insisvus Mandibular to Manidbular Plane Angle	96.0°	114.5°	104.81°	5.1°
Upper Incicivus to A.Pog Plane	7 mm	15 mm	10.81 mm	2.56 mm

tolerance of the Dahlberg's formula did not exceed 0.46 mm for the linear variables and 0.74 for the angular variables. All the variables in this research had a small technical error of measurement and considered acceptable.

The result of the normality test using the Shapiro-wilk statistical analysis showed that all the data was normally distributed. Descriptive statistics (mean, maximum, minimum, and standard deviation), t-test, and 95 percent confidence intervals of cephalometric measurements and sexual dimorphism were carried out, with the results presented in Table 2, 3, and 4. The mean established values according to the Down's analysis are also presented to show the difference with the present study (Table 3).

Table 3 shows that several statistically significant ($p<0.05$) differences were noticeable in the results of the present study regarding the cephalometric mean for the selected Papuan population when compared to the established values of the Down's analysis. The exception was for the mandibular plane angle (MPA) with a p value greater than 0.05, which means there was no significant differences between MPA Papuan population and Caucasian population by Down.

Most of the means of the Down's variables for Papuan males and females had insignificant difference ($p>0.05$), except for the interincisal angle and linear measurement of the upper incisivus to A.Pog Plane. The Papuan females were found to have significantly smaller interincisal

Table 3. A comparison of craniofacial values between the Papuan samples and the Down's established values

Parameters	Down's Analysis				
	Down's established values		Present study		t-test
	Mean	SD	Mean	SD	Level of significant
Facial angle	87.8°	3.6°	91.09°	4.18°	.007
Angle of convexity	0°	5.09°	12.84°	3.34°	<.001
AB plane angle	-4.6°	3.67°	-8.21°	3.06°	<.001
Y axis angle	59.4°	3.82°	57.9°	2.53°	.033
Mandibular plane angle	21.9°	3.24°	22.56°	4.12°	530 (*)
Occlusal plane angle	9.3°	8.3°	6.40°	1.89°	<.001
Interincisal angle	135.4°	5.76°	115.31°	7.05°	<.001
Insisivus mandibular to occlusal plane angle	104.5°	3.48°	60.0°	4.35°	<.001
Insisvus mandibular to mandibular plane angle	91.4°	3.78°	104.81°	5.1°	<.001
Upper incicivus to A.pog plane	2.7 mm	1.8 mm	10.81 mm	2.56 mm	<.001

(*): no significant differences

Table 4. A comparison of Down's variables between Papuan males and females

Parameters	Down's analysis				
	Papuan male		Papuan female		t-test
	Mean	SD	Mean	SD	Level of sig.
Facial angle	90.93°	3.46°	91.25°	5.03°	.806
Angle of convexity	12.25°	3.19°	13.43°	3.59°	.331
AB plane angle	-7.43°	3.98°	-9.00°	1.66°	.304
Y axis angle	59.0°	2.91°	56.81°	1.60°	.007 (*)
Mandibular plane angle	21.7°	5.00°	23.37°	3.13°	.391
Occlusal plane angle	6.31°	1.90°	6.50°	2.01°	.789
Interincisal angle	119.5°	5.46°	111.06°	5.96°	.003
Insisivus mandibular to occlusal plane angle	60.5°	3.13°	59.4°	5.48°	.329
Insisvus mandibular to mandibular plane angle	103.4°	5.08°	106.1°	5.07°	.171
Upper incicivus to A.Pog Plane	9.1 mm	1.6 mm	12.4 mm	2.29 mm	.001 (*)

(*): significant differences

angle ($p<0.05$) and higher upper incisivus to A.Pog Plane ($p<0.05$).

DISCUSSION

Cephalometric studies on non-Caucasians indicated there were measurable skeletal and dental differences when compared to Caucasians. The mean for the measurements of one racial group could not be considered normal for others. Down's normal values should be used only as guideline not as absolute values for every patient. This concept emphasizes a normal range for a particular racial population; an infinite variety of facial patterns exists.

The mean of facial angle, angle of convexity, AB-Plane angle, Y axis angle, occlusal plane angle, interincisal angle, incisivus mandibular to occlusal plane angle, incisivus mandibular to

mandibular plane angle, and linear measurement of upper incisor to A. Pog Plane was significantly different from the Down's established value. The facial angle in Papuan population was higher than the Down's norm. Facial angle is the inside inferior angle formed by the intersection of Nasion-pogonion plane and FHP (Figure 1, point 1). This angle indicates the antero-posterior positioning of the mandible in relation to the upper face. The value increases in cases of mandibular prognathism.[1,2] Papuan population had more mandibular prominence (mean: 91.09°) than Caucasians as indicated in the Down's norm (mean: 87.8°).

Convexity angle is formed by the intersection of a line from nasion to point A and a line from point A to pogonion (Figure 1, point 2). This angle shows the convexity or concavity of the skeletal profile. A positive angle reveals a prominent maxillary denture base relative to mandible and negative angle indicates a prognathic profile.[1,2] Papuan population had more maxillary prominence (mean:12.84°) than Caucasians as indicated in the Down's norm (mean: 0°). A-B Plane angle is formed between a line connecting point A and point B and a line joining nasion to pogonion (Figure 1, point 3). This angle reveals the maxillo-mandibular relationship in relation to the facial plane. The value is usually negative since point B is positioned behind point A. AB Plane angle defines a person profile condition.[1,2] Compared to the Caucasian mean, the Papuan population showed more convex profile. Y-axis angle is obtained by joining the sella-gnathion line with the FHP (Figure 1, point 5). Y axis indicates the growth pattern of mandible. A greater value indicates greater vertical growth of the mandible.[1,2] The mean of the Y-axis angle in the Papuan population (mean:57.9°) was much lower than the Caucasian value (mean: 59.4°) which suggests that the growth of the mandible is favorably horizontal.

Occlusal plane angle is formed between the occlusal plane (by bisecting the occlusion of the 1st permanent molars and the incisal overbite) and FHP (Figure 1, point 6).[1,2] Significant differences were found for occlusal plane angle, indicating class II facial pattern in the Papuan Population. An increase in occlusal plane is associated with a higher mandibular plane angle, which also occurs in cases of decreased occlusal plane and lower mandibular plane angle.[18] The mandibular plane angle in the Papuan population was slightly higher than that in the Caucasians, but statistically it was not significantly different to Caucasians in the Down's norm. Mandibular plane angle is formed by the intersection of the mandibular plane with the FHP.[1,2]

Interincisal angle is formed between the long axis of the upper and lower incisors (Figure 1, point 7). By this angle, dental proclination or retroclination can be determined.[1,2] The Papuan population (mean: 115.3°) showed more proclined relationship than the Caucasians (mean: 135.4°). Incisivus mandibular to occlusal plane angle (Figure 1, point 8) is the inside inferior angle formed by the intersection between the long axis of lower central incisor and the occlusal plane.[1,2] An increase in this angle suggests an increased lower incisor proclination. The Papuan population (mean: 60.0°) showed more proclined lower incisor. Incisor mandibular plane angle (Figure 1, point 9) is formed by the intersection of the long axis of the lower incisor and the mandibular plane angle. Similiar to Incicivus mandibular to occlusal plane angle, an increase in this angle is indicative of lower incisor proclination.[1,2] The Papuan population (mean: 104.81°) showed more proclined lower incisor. Upper incisor to A.Pog plane is a linear measurement between the incisal edge of the maxillary central incisor and the line joining point A to Pogonion (Figure 1, point 10). The measurement is higher in patients with upper incisor prominence.[1,2] The Papuan population (mean: 10.81 mm) showed more upper incisor prominence.

Most of the measurement results indicates that the Papuan population had a convex facial profile (skeletal and dental). According to Jacobson (1975), this finding results from different factors that include cranial base length, the position of the jaws anteroposteriorly and rotation of the occlusal plane.[4] According to the result of the present study, the measurement results between

the Papuan males and females were almost the same, except the interincisal angle and linear measurement for upper incisor to A.Pog Plane. These result suggest that the Papuan females displayed more upper incisor procumbency which affects the interincisal angle.

The results of the current study are in line with the findings of previous studies carried out in the Australo-Melanesian and Deutero-Malay race. The Australo-Melanesian race had more maxillary protrusion to cranial base, more flat mandibular plane, and more proclined upper incisors compared to Deutero-Malay race.[19] Research on Deutero-Malay found that Indonesians had a more convex face and more vertical facial growth patterns than Caucasians.[17] Therefore, future research is needed with a larger number of Papuans participants.

CONCLUSION

Based on the findings of the current study, it is evident that, even in the Papuan population with the so-called well-balanced faces, there are some variations in the craniofacial structure of Papuans when compared with the Down's reference values. This should be established to serve in the Orthodontic diagnosis and treatment of the Papuan patients. The result of the present study also support the view that a single standard of cephalometric norms should not be applied to all racial and ethnic groups. For future research, the use of digital cephalometric analysis is recommended in a larger number of Papuan populations.

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