

Evaluation of Tweed's Facial Triangle among Students in Lagos, Nigeria

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ABSTRACT

Introduction: The advent of cephalometric analysis has aided orthodontic diagnostic procedures, while the Tweed's facial triangle which is a type of cephalometric analysis has complemented routine orthodontic treatment planning. This aim of this study was to evaluate Tweed's facial triangle among a selected Nigerian population with normal occlusion.

Materials & Method: A sample of 100 subjects, selected by multistage sampling from three schools in Ikeja local government, Lagos State had lateral cephalometric radiographs taken. The final sample analysis of the radiographs was 84. The error of the cephalometric method was assessed using the intra-class correlation co-efficient. The Tweed's facial triangle was analyzed on the cephalometric radiographs and comparison between this Nigerian population and Tweed's Caucasian cohort was carried out.

Result: Out of the 84 subjects, 41 (48.8%) were males and 43 (51.2%) females. This study reported mean values of $23.26^\circ \pm 4.78^\circ$ for FMA, $54.08^\circ \pm 5.11^\circ$ for FMIA and $103.47^\circ \pm 6.26^\circ$ for IMPA. Females had higher FMIA and IMPA values compared to males which was statistically significant for FMIA. The FMA was higher in males with a statistically significant difference between genders. The results suggest increased proclination of lower incisors in this Nigerian population compared to Tweed's Caucasian population.

Conclusion: The mean values for Tweed's facial triangle in this Nigerian population were significantly different from that obtained by Tweed. Orthodontists should aim at achieving these values when analyzing cephalometric radiographs using Tweed's facial triangle in Nigerians. This will further aid proper diagnosis, treatment planning with or without extractions and planning of retention after orthodontic treatment.

Keywords: Cephalometric analysis, Facial patterns, Tweed's facial triangle.

INTRODUCTION

Since its introduction in 1931 by Broadbent¹ and Hofrath,² cephalometric analysis has been used in diagnosis, treatment planning and evaluation of orthodontic cases. Lateral cephalographs are routine components of the diagnostic records taken in orthodontics.³ They are frequently used as a research tool in evaluating the effects of orthodontic treatment and describing facial growth.⁴ Other uses include orthodontic treatment planning, monitoring the progress of treatment and soft tissue analysis. Different types of cephalometric analysis have been described and used overtime. These include Steiner's,⁵ Downs,⁶ Jarabak's,⁷ Rickett's⁸ and McNamara's.⁹ The most common include Steiner's, Downs' and Tweeds facial triangle.¹⁰

The Tweed's analysis is easy and simple to carry out and can be done in addition to other analyses commonly used. Tweed¹¹ believed that upright mandibular incisors were related to post treatment facial balance and successful treatment. He made use of three planes that form a diagnostic triangle. The planes used were the Frankfort horizontal plane, the mandibular plane and the long axis of lower incisor.^{11,12} The three planes meet to form a triangle: Tweed's facial triangle. The first angle is the Frankfort mandibular plane angle (FMA) which has a normal range of 22° - 28° (average of 250) in Caucasians,^{11,13} $21.5^\circ \pm 5^\circ$ in Pakistanis,¹⁴ $34.0^\circ \pm 5.1^\circ$ in Kenyans¹⁵ and 20.8° - 26.1° in Nigerians.¹⁶ The Frankfort plane has been linked to the slope of the mandibular incisor as an important angle in the Tweed's triangle.^{10,17} An increased FMA value indicates excessive vertical growth while a reduced value indicates a reduced vertical growth pattern. The second angle is the

Frankfort mandibular incisor angle (FMIA). The FMIA has a value of 65° in Caucasians,¹⁰ 50.9° in Brazilians¹⁸ and 57° in the Nepalese.¹² This angle tends to increase with increasing age to balance the corresponding decrease in the FMA.¹⁹ It has a value of 68° when the FMA is between 22°-28° and 65° when FMA is 30° and above.¹¹ The third angle is the incisor mandibular plane angle (IMPA) which is usually 88° in Caucasians for the upright lower incisors.¹⁰ If the lower facial profile is flat the lower incisors may be corrected into a labial position then the IMPA will be 94°. It is 96.2± 5.0° in Kenyans¹⁵, 99.87° in Brazilians,¹⁸ 96° in the Nepalese¹² and 96-104°²⁰ in Nigerians. Nigerian children have been noted to exhibit prominent bimaxillary proclination with protrusive maxillary and mandibular incisors and a steep Frankfort mandibular plane angle (FMA).^{16,20}

The post treatment stability of orthodontic treatment and prevention of relapse after treatment is of great concern to many clinicians.²¹ Relapse of orthodontically treated dentition may be influenced by apical base differences, the subject's age, the duration of retention, post-treatment growth, third molar development, habits, occlusal functioning, Bolton's discrepancies, continued decrease in arch length and incisor positions relative to basal bone.²¹ To prevent relapse therefore, Tweed¹⁰ proposed post-treatment stability in relation to the position of the lower incisors to basal bone in order to achieve a balanced and pleasing occlusion. The lower incisor position, facial profile, in combination with a tooth arch size analysis, provides clues that can aid in making a decision whether an extraction or non-extraction treatment protocol must be followed to achieve stability.²¹

Few studies to find out the cephalometric norms using the Tweed's analysis have been reported (among the Caucasians,^{10,17} Nepalese¹² and the Brazilians¹⁸) but none has been carried out in Nigerians. The aim of this study was to evaluate the Tweed's facial triangle and to establish baseline norms in a population of 12-16 year old Nigerian students situated in Ikeja, Lagos State.

MATERIALS AND METHOD

Study Design and Setting

This was a cross sectional descriptive and quantitative study carried out over 12 months in three secondary schools and at the Lagos State University Teaching Hospital (LASUTH) which are situated in Ikeja local government area (LGA) of Lagos state. Lagos state has a population of about 22million people who are majorly of the Yoruba tribe. The state is divided into five main

regions namely Ikeja, Badagry, Ikorodu, Lagos Island and Epe. It has been and remains a commercialized and industrial state up to date.

Sample Size Determination

The Fisher's formula²² used for determining the study sample size was : $n = Z^2 pq/d^2$.

Using a prevalence value of 24.7% based on a study describing prevalence of normal occlusion in Nigeria²³ and making provision for 30% attrition, a sample size of 100 was determined.

Inclusion Criteria

Subjects of Nigerian origin aged 12-16 years, with full complement of permanent dentition excluding the third molars, having normal occlusion and with no history of previous orthodontic treatment who gave their assent and obtained parental consent.

Exclusion Criteria

Non-Nigerian origin or of mixed race subjects with history of previous extractions of permanent teeth or previous orthodontic treatment; Overjet less than 2mm or greater than 4mm; Overbite less than one-third or greater than half of lower incisors and Subjects not willing to participate in the study were excluded.

Diagnostic Criteria for normal occlusion²⁴

Subjects with skeletal pattern 1; Anteroposterior relationship of Class I; Normal overjet of 2-4mm; Normal inclination and angulation of teeth; Normal overbite of one-third to half vertical overlap of lower incisors; Absence of rotations, cross bites and arch length discrepancy (no spacing or crowding).

Sample Selection

A multistage sampling method was adopted to select the subjects. The first stage made use of simple random sampling (balloting) to select 3 schools in Ikeja local government area (LGA) using the list of schools in the LGA obtained from the Lagos State Ministry of Education as the sampling frame. The 100 subjects were distributed among the three public schools by stratified random sampling. The second stage involved simple random sampling (balloting) for one class in each arm with most children aged between 12-16 years (JSS 2, JSS 3 and SS1). At this stage questionnaires were administered by the researcher to all the students of the classes and oral examination was carried out to determine those who met the inclusion criteria. Subjects that fell within 12-16 years of age and that met the

other inclusion criteria outlined below were enrolled into the study and allowed to proceed to the third stage. The third stage involved balloting to select the number of subjects in each gender required per class to make up the sample size. Prior to balloting, eligible students were grouped by their sex in each arm.

Ethical Considerations

Approval for the study was obtained from the Health Research and Ethics Committee of the Lagos State University Teaching Hospital and from the Lagos State Education Review Board of the Ministry of Education. Informed consent and assent were obtained from the parents of the subjects and the subjects consecutively before proceeding with the study.

Data Collection

Demographics

The subjects' demographic data was obtained in the first section of the questionnaire. This consisted of age, gender, tribe, nationality and student's class. The dental and orthodontic histories were obtained from the second section of the questionnaire. These included the history of previous extractions and orthodontic treatment

Clinical examination

Clinical examination was performed by the principal investigator (A.O) under natural light. Values for normal overjet ranged between 2-4mm and any subject with value less or greater than this was excluded. The anteroposterior molar and canine relationships were determined by the Angle's classification as Class I, II or III. The subjects that had Class I molar relationships were included while those with Class II or III relationships were excluded. The midline was assessed using the tip of the nose and philtrum as a guide comparing the midline between the upper and lower central incisors. Any crossbite seen was documented as anterior or posterior crossbite. Tooth bone ratio was recorded as crowding or spacing; mild (0-3mm), moderate (4-7mm) and severe (>8mm), while lip competence was assessed and recorded as competent or incompetent using the Jackson's lip classification. Strict infection control procedures were adhered to during the examinations.

Cephalometric Radiographs

Appointments were given to subjects who met the inclusion criteria and they were conveyed to the Cephalometry Radiology Unit of the Lagos State University College of Medicine, to take the

lateral cephalometric radiographs with a digital orthopantomograph /cephalostat, (Vatech PaX-400C IEC60601-2-7 by Vatech Ltd Gyeonggi, Korea). The subject's head was placed in the natural head position and with the teeth in maximum intercuspation (as shown in figure 1). Prior to taking the radiograph, each subject was provided with a lead apron to protect vital organs and the number of images taken were limited to the minimum (1 or 2 exposures) to minimize the risks associated with radiation exposure. Each subject was positioned at 150cm from the source of radiation and 15cm from the film²⁵ and exposed to the radiation for 5 seconds at a setting of 70 kilovoltage and 4 milliamperes. The above precautions were taken to achieve the ALARA principle.²⁶ Each lateral cephalogram was traced by the investigator (A.O) with a lead pencil on a 0.003mm matte finish acetate tracing paper on a light viewing box in a dark room. The cephalometric ear rods, forehead supporter and nasion pointers were wiped after each patient with iodine disinfectant solution. The following landmarks and planes were identified and used in the analysis²⁷ (figure 2 & 3).

Landmarks: Sella (S), Nasion (N), Anterior nasal spine (ANS), Posterior nasal spine (PNS), A point (Subspinale), B point (Supramentale), Orbitale (Or), Porion (Po), Gonion (Go), Gnathion (Gn) and Pogonion (Pg).

Planes: Frankfort Horizontal plane (Po-Or), Mandibular plane (Go-Me), Sella –Nasion(S-N) plane, Long axis of the mandibular incisor, Basion- Nasion plane, Frankfort Mandibular plane angle (FMA), Frankfort Mandibular Incisor angle (FMIA), Incisor Mandibular Plane angle (IMPA), Facial axis angle (Ptm-Gn/ Ba-N), Sella- Nasion- A point angle (SNA), Sella-Nasion- B point angle (SNB), A point –Nasion –B point angle (ANB) and SN-Go.Gn angle.



Figure 1: Subject in cephalostat prior to taking lateral cephalometric radiograph

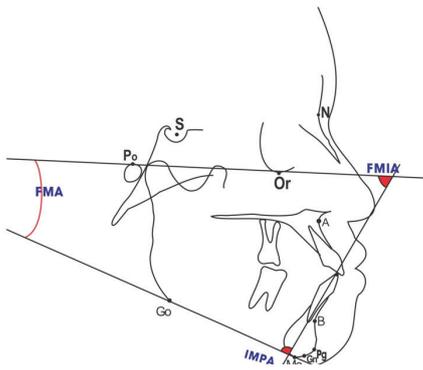
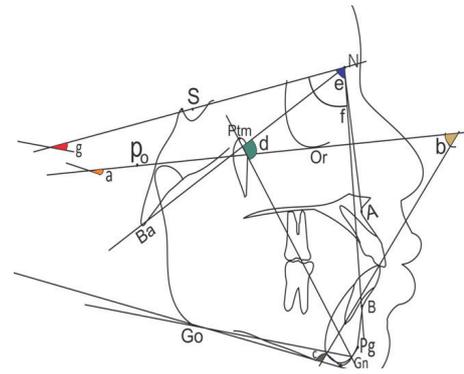


Figure 2: Tweed's facial triangle showing the angles Frankfort mandibular plane (FMA), Frankfort mandibular incisor plane angle (FMIA) and the Incisor mandibular plane angle (IMPA)



a -FMA, b-FMIA, c- IMPA, d- Facial axis angle, e- SNA, f- SNB, g- SN.Go-Gn

Figure 3: Angular measurements in this study

Assessment of Tracing Error

Twenty (20) cephalometric radiographs were retraced by the principal investigator (A.O) four weeks after the first set of tracing was done. Intra-class co-efficient was done to assess the intra-examiner error.

Data Analysis

The data collected was entered into Microsoft excel and stored in a personal computer. Descriptive statistics for continuous variables was carried out using mean, standard deviation, minimum and maximum value while categorical variables were represented using frequencies and percentages. Test of association between categorical variables were carried by Pearson Chi square test. Test of normality were performed for continuous variables using Kolmogorov Smirnov test. Parametric test (Independent student t-test) was used to compare means for cephalometric values. Pearson's correlation was used to test for agreement between continuous variables. The p-value (level of significance) was set at p<0.05. The data was analysed using the Statistical Package for Social Sciences (SPSS) version 20.

RESULT

The assessment of intra-examiner error in tracing the cephalometric radiographs revealed a high degree

of reliability of the angles measured (Table 1). The sociodemographic characteristics of the participants in this study revealed that out of the 100 subjects, 16 did not meet up with the required criteria so the final sample was 84. Out of the 84 subjects, 41 (48.8%) were males and 43 (51.2%) were females. The subjects were aged between 12 to 16 years with a mean age of 14.1 ± 1.3 years. Majority of the subjects were from the Yoruba tribe 44 (52.4%) while those from the Hausa tribe consisted of the least group 8 (9.5%). There was no statistically significant difference among the age group, ethnic group or secondary school class (Table 2).

The mean values of the components of the Tweed's facial triangle were as follows; FMA was 23.26° ± 4.78°, FMIA was 54.08° ± 5.11° and IMPA was 103.47° ± 6.26° (Table 3). The comparison between genders in the Tweed's facial triangle was also shown in Table 3. The mean value of the FMA was 23.26° ± 4.78°. The difference between males and females was statistically significant with a p-value of 0.026, with males having a higher FMA value. (p-value ≤0.05). The average mean value for FMIA was 54.08° ± 5.11°. There was a higher mean value in females when compared to males and this was statistically significant (p-value=0.008) signifying more proclined mandibular incisors on basal bone in males. The mean value for IMPA was 103.47° ±

Table 1: Assessment of error method-Co-efficient of Reliability

Angular measurements	Reliability values
FMIA	0.903
IMPA	0.903
FMA	0.879

Table 2: Socio-demographic characteristics of participants

	n=84	Gender		Total n=84 n(%)	p-value
		Male n=41 n(%)	Female n=43 n(%)		
Age (years)	12	5(6.0)	7(8.3)	12(14.3)	0.253
	13	9(10.7)	7(8.3)	16(19.0)	
	14	8(9.5)	14(16.7)	22(26.2)	
	15	13(15.5)	6(7.1)	19(22.6)	
	16	6(7.2)	9(10.7)	15(17.9)	
Ethnic group	Yoruba	20(23.8)	24(28.6)	44(52.4)	0.265
	Igbo	14(16.7)	7(8.3)	21(25.0)	
	Hausa	3(3.5)	5(6.0)	8(9.5)	
	Others	4(4.8)	7(8.3)	11(13.1)	
Secondary school Class	JSS2	13(15.5)	13(15.5)	26(31.0)	0.958
	JSS3	14(16.7)	16(19.0)	30(35.7)	
	SSS1	14(16.7)	14(16.7)	28(33.3)	

*Significant at p-value ≤ 0.05

Table 3: Descriptive statistics of Tweed's facial triangle in this Nigerian population and comparison by gender

	Overall (Mean ± SD) (deg)	Male (Mean ± SD) (deg)	Female (Mean ± SD) (deg)	t-value	p-value
FMA	23.26 ± 4.78	24.45 ± 4.83	22.20 ± 4.51	2.30	0.026*
FMIA	54.08 ± 5.11	52.59 ± 3.98	55.37 ± 5.68	-3.718	0.008*
IMPA	103.47 ± 6.26	103.05 ± 6.29	103.95 ± 6.29	-0.851	0.552

*Significant

Mean ± SD: Mean ± Standard deviation

FMIA: Frankfort mandibular incisor angle

FMA: Frankfort mandibular plane angle

IMPA: Incisor mandibular plane angle

Table 4: Comparison of FMA, FMIA and IMPA in this Nigerian population with Caucasian population (Tweed)

	This study (Mean ± SD) (deg)	Tweed (Mean ± SD) (deg)	t-value	p-value
FMA	23.26 ± 4.78	25.00 ± 5.00	-2.973	0.001*
FMIA	54.08 ± 5.11	65.00 ± 5.00	-5.431	<0.001*
IMPA	103.47 ± 6.26	90.00 ± 5.75	6.312	<0.001*

*Significant

Mean ± SD: Mean ± Standard deviation

FMIA: Frankfort mandibular incisor angle

FMA: Frankfort mandibular plane angle

IMPA: Incisor mandibular plane angle

Table 5: Comparison of SNA, SNB, and ANB in the Nigerian population by gender

	Male (deg)	Female (deg)	Overall (deg)	t-value	p-value
SNA	84.04 ± 3.80	86.37 ± 3.31	85.73 ± 3.59	-1.021	0.096
SNB	82.02 ± 3.47	83.09 ± 3.38	82.57 ± 3.46	-0.911	0.173
ANB	3.02 ± 0.89	3.30 ± 0.84	3.17 ± 0.87	-0.311	0.151

*Significant

Mean ± SD= Mean ± Standard deviation

SNB: Sella Nasion B-point angle

SNA: Sella Nasion A-point angle

SNB: Sella Nasion B-point angle

6.26° with a slightly higher value in females which was not statistically significant (Table 3).

The comparison between the components of this Nigerian sample and the Tweed population is shown in Table 4. The Frankfort mandibular plane angle (FMA)

was higher in Tweed Caucasians than in the Nigerian sample. This difference was statistically significant, p-value=0.001 (p<0.05). The FMIA had a higher value in the Caucasians (65° ± 5°) than in the Nigerian sample (54.08° ± 5.11°). This difference was statistically significant (p value=0.000). The mean value for Incisor

mandibular plane angle (IMPA) was higher in Nigerians than in Caucasians in this sample. The difference was significant statistically (p value=0.000).

Table 5 shows the comparison of mean values between SNA, SNB, ANB and gender. The average mean for SNA is $85.73^\circ \pm 3.59^\circ$. The females had a higher value than males. There was no statistically significant difference in SNA between males and females (p -value=0.096). The average mean for SNB is $82.57^\circ \pm 3.46^\circ$. Males have a higher value of SNB compared to females. There is no statistically significant difference in SNB between males and females (p -value=0.173). The average mean value for ANB is $3.17^\circ \pm 0.87^\circ$ with a range of 2° - 4° . Females had a higher mean value than males. There was no statistically significant difference in ANB between males and females.

DISCUSSION

The use of Tweed values in orthodontic treatment evaluation and planning became popular with the advent of extractions to create a balanced profile.¹⁰ In the present study, all participants were from secondary schools in Lagos state and they were aged between 12 to 16 years. The age range was representative of that at which majority of adolescent patients present to the orthodontic clinic. Some studies are in agreement with this age group^{28,29} while others are in support of an older age group.^{30,31} The patients tend to present for orthodontic treatment at this adolescent stage when the facial pattern can be assessed.

Majority of the respondents were from the Yoruba tribe and this can be ascribed to the fact that the location of the study (Lagos) is primarily populated by the Yoruba people. The Hausa tribe constituted the least number of subjects that participated in the study. This ethnicity had no bearing on the Tweed evaluation or analysis of facial pattern because there was no significant finding in the relationship. The results of this study show that there is a higher value of FMA in males ($24.45^\circ \pm 4.83^\circ$) than females ($22.20^\circ \pm 4.51^\circ$). Studies carried out by Nadidh et al³² in Iraqis, Rajbhandari³⁰ in Nepalese and Atit et al³¹ in Indians also found a higher value of FMA in males than females. This was in contrast to the study carried out by Kuramae et al¹⁸ in Brazilians which had a higher FMA in females (30.87°). The combined value of FMA among this study sample ($23.26^\circ \pm 4.78^\circ$) is slightly lower than the value obtained by Tweed (25°)¹⁰ and

slightly higher than the value obtained from the study by Ajayi¹⁶ also carried out among Nigerians. It is however similar to values obtained by Rajbhandari³⁰ ($23.2^\circ \pm 4.2^\circ$) and Atit et al³¹ ($23.9^\circ \pm 4.3^\circ$ in females, $20.8^\circ \pm 6.2^\circ$ in males). The FMA which describes the direction of the lower facial growth both horizontally and vertically is therefore favourable in this study sample among Nigerians and within the range described by Tweed (22° - 28°). However studies by Kuramae et al¹⁸ carried out among Brazilians and Bhattarai et al¹² in Nepalese show higher values of FMA and postulate a higher vertical and horizontal lower facial growth compared to this sample of Nigerians.

The mean value for Frankfort mandibular plane incisor angle (FMIA) was $54.08^\circ \pm 5.11^\circ$ among the sample studied, and this was lower than the value obtained by Tweed (65°).¹¹ This difference was statistically significant and can be attributed to a more proclined position of lower incisors in Nigerians who have been reported to have a bimaxillary profile.^{16,20} The FMIA as described by Tweed¹¹ was an angle that defined the position of the mandibular incisors on the basal bone. Tweed's average angle of 65° was for upright incisors on the basal bone which gave post treatment stability.^{10,11} However this value cannot be generalized for all racial groups as seen in this study among Nigerians. The lower values of FMIA obtained in this sample population indicates more proclined mandibular incisors on basal bone when compared to Caucasians studied by Tweed.^{10,11} These lower values obtained suggest the need to develop norms for the Nigerian population by which subsequent cephalometric analysis can be carried out. When the FMIA value falls below 45° (lower limit of FMIA in the present study), then retraction of the lower incisors to achieve a stable result should be considered. The retraction of the mandibular incisors may follow interproximal stripping and extractions depending on the case selection. Females had a higher value of FMIA ($55.37^\circ \pm 5.68^\circ$) than males with $52.59^\circ \pm 3.98^\circ$. The difference in values in this study sample was also statistically significant, signifying that males have more proclined lower incisors than females.

The Incisor mandibular plane angle (IMPA) in this study had a higher value in the sample studied than in the Caucasians researched by Tweed¹⁰. The mean value of IMPA was $103.47^\circ \pm 6.26^\circ$ with a mean value of $103.95^\circ \pm 6.29^\circ$ in females and $103.05^\circ \pm 6.29^\circ$ in males. The value for IMPA as postulated by Tweed¹⁰ was 90°

$\pm 5.75^\circ$ which implies a more vertical position of the mandibular incisors on the basal bone in Caucasians than in this sample, this difference was however statistically significant ($p=0.000$). This suggests that mandibular incisors in Nigerian are generally stable in a proclined position within the range of values obtained. Nigerians have been reported to have a bimaxillary profile^{16,20} with proclination of both upper and lower teeth, this corroborates the higher value of IMPA obtained in the Nigerian sample. The females in this sample had slightly higher values of IMPA than the males which were not statistically significant. A study by Nahidh et al³² also showed a higher value of IMPA in females than males, however, studies by Kuramae et al¹⁸ and Bhattarai et al¹² reported higher values of IMPA in males.

The results of this study suggests lower incisors with normal occlusion are more proclined on basal bone when compared to Tweed's¹⁰ standards which have more upright mandibular incisors and therefore stable with this outcome. This knowledge also guides the orthodontist on effective retention following treatment. The Caucasian results therefore cannot be generalized for different ethnic or racial groups. The SNA and SNB values are similar to values already established in the Nigerian population.²⁰ SNA value was $85.73^\circ \pm 3.59^\circ$ and

SNB was $82.57^\circ \pm 3.46^\circ$ which are similar to the norms of $85.5^\circ \pm 3.5^\circ$ and $82.7^\circ \pm 3.0^\circ$ respectively. The ANB value also ranged between 2° - 4° with a mean value of $3.17^\circ \pm 0.87^\circ$. These values are in accordance with the known Nigerian values²⁰ which are being used in the Nigerian population today in the analysis of the skeletal pattern using the routinely taken cephalometric radiographs for orthodontic patients.

CONCLUSION

The FMA values among 12-16 year old Nigerian students were lower than those obtained by Tweed. There were lower values of FMIA and increased values of IMPA in the present study compared to those obtained by Tweed; they signified more proclined lower incisors than in the Caucasians studied by Tweed. The Tweed's analysis based on Nigerian norms should be added to the routine analyses currently carried out to further aid in proper diagnosis, treatment planning and planning of retention after orthodontic treatment.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this paper.



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