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Original Article

Radiological Classification of Adult Skulls Using Alveolar Index among Nigerians Residing Within the South-South Geopolitical Zone

[1]Williams, J., [2]Egbe, N.O., [1]Udo-Affah, G., [1]Eluwa, M.A.

Abstract

BACKGROUND AND AIM: Understanding skeletal patterns is essential for choosing a proper treatment mechanics as well as understanding different populations all over the world. This radiological imaging study was carried out to evaluate, classify and document sex and age differences in terms of alveolar index in South-south geopolitical zone of Nigeria.

METHODOLOGY: A total of 627 (379 males and 248 females) normal lateral skull radiographs images were used, with ages ranging between 18 and 100years, obtained from the archives (2009-2016) of five different hospitals, all within the south-south geopolitical zone of Nigeria. The 627 radiographs were divided into five age groups for both the males and females. To determine the alveolar index, the Basion-prosthion and Basion-nasion distance were measured using a millimeter rule and the ratio between them calculated in percentage. All radiographs were certified normal as contained in the medical report.

RESULTS: The mean basion – prosthion length was 107.64±9.33mm for males and 108.07±7.90 for females, basion-nasion length was 101.85±9.12mm for males, 102.51±7.77mm for females. The mean alveolar index was 105.73±2.54% for males and 105.47±1.74% for females. The findings of this study however, shows that Nigerians are predominantly prognathous with alveolar index value greater than 103. It also shows that Basion-Prosthion length, Basion-nasion length and Alveolar index can be used as age determinant.

CONCLUSION: The data from this study will serve as an important tool in the hands of maxillofacial surgeons, Orthodontists and aesthetic anatomist in facial reconstruction purposes.

Keywords:
Alveolar Index, Prognathious, Mesognathious, Orthognathious

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[1]Department of Anatomy, Faculty of Basic Medical Sciences, University of Calabar, Calabar Nigeria; [2]Department of Radiography and Radiological Sciences, University of Calabar, Calabar Nigeria.

Address for Correspondence:
Williams, J.
Department of Anatomy, Faculty of Basic Medical Sciences, University of Calabar, Calabar Nigeria.
jobswilliams89@yahoo.com

INTRODUCTION

Alveolar index is the anthropometric ratio between the basion-prosthion length and the basion-nasion length (Thomas, 2006; Hanihara, 2000). The basion stated above is the midpoint of the anterior border of the foramen magnum located in the occipital bone through which the spinal cord passes at the base of the skull (Hanihara, 2000)). The nasion, on the other hand is the most anterior point of the fronto-nasal suture, where the frontal and nasal bones meet. While the prosthion is the most anterior point in the midline of the maxilla or the most anterior prominent point in the midline of the maxilla. Alveolar index is determined by finding the percentage of the ratio of basion-prosthion length to basion-nasion length (Hanihara, 2000).

The study of alveolar index gives an indication of the extent of jaw projection in a population (Hanihara 2000). Skulls with alveolar index below 97.9 are termed Orthognathious; those with index between 98 and 102.9 are termed Mesognathious while those with index value above 103 are Prognathious (Hanihara 2000).

Alveolar index varies among populations in the world, a great contrast can be found between the Europeans, Sub-Sharan Africans, Australian aborigines and Melanesians (Groove, 1989; Sarver, 2000). This is as a result of the extent of jaw protrusion among

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these populations (Hanihara, 2000). The Chinese, Japanese and Europeans are said to be less Prognathious, the Australians been more protrusive than others. (Hanihara, 2000). However, the literature on Nigerian values of alveolar index is sparse. There has been limited number of researches carried out so far, to serve as an aid to clinicians, orthodontists as well as forensic anthropologists for age determination, diagnosis, treatment and sex determination purposes, hence the relevance of this study.

MATERIALS AND METHOD

Study Design: This research is an analytic study aimed at evaluating the alveolar index of Nigerians through lateral skull radiographs gotten from the archives of the studied hospitals, adopting a retrospective (non-experimental) survey. A total of 627 (379 males and 248 females) apparently normal lateral skull images of adult Nigerians (between 18years and 100years, were obtained from the radiology archives of the following hospitals; University of Port-Harcourt Teaching Hospital (UPTH), Port-Harcourt. Braithwaite Memorial Specialist Hospital (BMH), Port-Harcourt, University of Uyo Teaching Hospital (UUTH), Uyo, First Rivers Hospital Port-Harcourt, Asi-Ukpo Diagnosis Center, Calabar. All radiographs were certified normal as contained in the medical report.

Ethical Consideration: An approval for the research was sought from the research and ethics committee of the following hospitals; University of Calabar Teaching Hospital (with ethical approval number, NHREC/07/10/2012), University of Uyo Teaching Hospital (with ethical approval number, UUTH/AD/5/96/Vol.XIX/46), University of Port-Harcourt Teaching Hospital (with ethical approval number, UPTH/ADM/90.5.11/VOL.XI/411) and approval was granted. Verbal consent was given by the remaining hospitals.

Study Population: South-south geopolitical zone of Nigeria consists of six (6) states; three (3) states out of the six states were used for the study. The study involved adult subjects who underwent lateral skull x-ray examination; radiographs were gotten from the radiology archives of major hospitals from the three states (Port-Harcourt, Calabar and Uyo). The sample size was calculated using Cochran (1977) formula for estimation of a population proportion;

$$N = \frac{P(1-P)Z^2}{D^2}$$

P = proportion (using 0.5)

d= acceptable error (0.0391)

z =confidence interval (for a 95% confidence interval=1.96). From Z-table

$$N = \frac{0.5(1-0.5) * 1.96^2}{0.0391^2}$$

N=627.71

Sampling Technique: Probability sampling method using simple random sampling (which ensures that all units of the study population have an equal or at least a known chance of being included in the sample) was used for this study, a list of all the six states constituting the south-south was made and each state given a number (1-6), these numbers were written on a small pieces of paper, all the six states were put in a box, after which the box was shaken vigorously to ensure randomization, then three(3) papers were taken out of the box and the numbers were recorded, states belonging to this number constitute the sample. Radiographs of Nigerians residing within the south-south were used.

Inclusion Criteria: Only normal lateral skull radiographs were used for this study. Also skull x-rays of adult subjects (aged 18yrs and above) only were used for this study

Exclusion Criteria: Skull X-rays of subjects with deformities or fracture (in which the landmarks for the study were not clearly visible) were excluded.

Procedure: Lateral skull radiographs (2009-2016 archived) of adult male and female Nigerians were obtained in the various hospitals, values were gotten by locating and tracing anatomical landmarks in the skull x-ray film (as shown in figure 1), from this tracing, the anatomical landmarks were measured. The anatomical landmarks include;

- Nasion: the most anterior part of the frontonasal suture which appear as a radiolucent line between the frontal and nasal bone.
- Basion: The midpoint of the anterior border of the foramen magnum at the base of the skull.
- Prosthion: the most anterior point in the midline on the alveolar process of the maxilla.

Measurements were taken by tracing the nasion to the basion and basion to prosthion in the skull x-ray films placed on a film box (Led medical film viewer made by Shanghai flower medical equipment Co. Ltd, with external size; 838 × 506 × 25mm, visual area; 720 × 425, 60w) using a millimeter rule. All radiographs used were certified normal as contained in the medical report. The following age ranges (18-30, 31-40, 41-50, 51-60, and >61) were used to determine age differences. Alveolar index was calculated using the formula:

$$Alveolar\ index = \frac{Basion-Prosthion\ length}{Basion-Nasion\ Length} \times 100$$

Statistical Analysis: The results obtained were analyzed using IBM SPSS version 23. Tables were used to present results for easy interpretation. The mean, standard deviation, standard errors were also calculated. T-test, Chi-test were used to determine difference in the mean and frequency of distribution of the class of alveolar indexes in males and females respectively, at 0.05 levels of significance. One -way ANOVA with Turkey's HSD post hoc was used to compare variables between age groups.

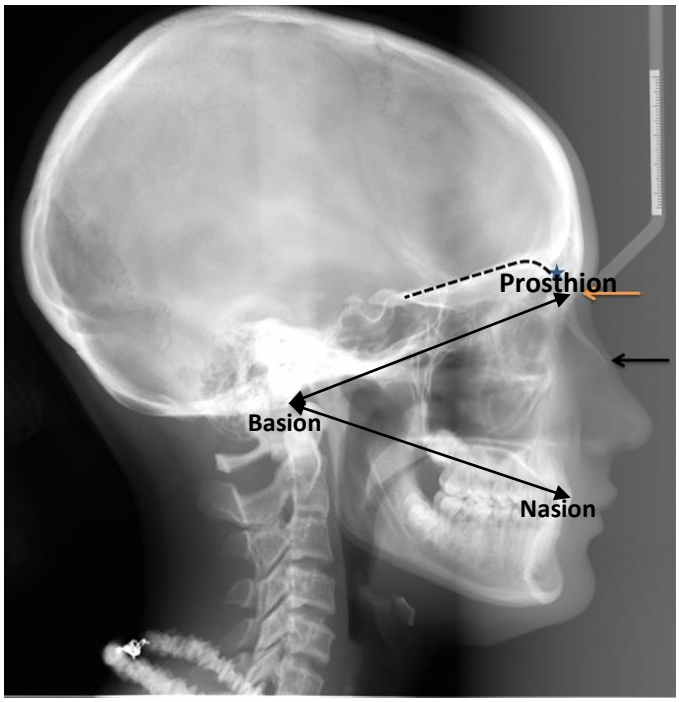

Figure 1: Showing lateral view of a skull indicating the position of the nasion, prosthion and Basion.

RESULTS

The results obtained are presented below in table 1-4. Table 1 is the frequency of distribution of subjects according to age, represented in percentage, with age group 18-30 having 37%, 31-40 having 25%, 41-50 having 16.1%, 51-60 having 7.8% and >60 having 13.6%. The descriptive statistic based on sex is presented in table 2. The mean basion-prosthion length for males was 107.64±9.33mm, that for females was 108.07±7.90mm, the mean basion-nasion length for males was 101.85±9.12mm, that for females was 102.51±7.77mm, the alveolar index was 105.73±2.20% and 105.47±1.74% for males and females respectively. The mean value of the females was slightly higher for the Ba-Pr and Ba-na, but the difference was not statistically significant (P>0.05). The alveolar index was slightly higher in males but the difference was not statistically significant (P>0.05).

Table 3 shows the descriptive statistic according to age irrespective of sex. Significant difference occurred in terms of the basion-prosthion length across the age groups (18-30, 31-40, 41-50, 51-60, >60, no significant difference occurred in the basion-nasion length in age group 18-30 and 31-40. Also, no difference occurred between age group 51-60 and >60. A significant difference occurred between age group 31-40 and 51-60. Difference in terms of alveolar index occurred across the different age groups except for age group 60 and above.

Descriptive statistics of measured parameters based on age group and sex is presented in table 4. A significant difference (P<0.05) occurred in age group 60 and above for the basion-prosthion length and alveolar index and no difference in basion- prosthion length. For age 18-30, 31-40, 41-50, 51-60, no significant difference occurred (P>0.05)

TABLE 1: FREQUENCY OF DISTRIBUTION OF SUBJECTS ACCORDING TO AGE GROUPS AND SEX

	Combined	Males	Females
		Frequency (percentage frequency)	
18-30	234 (37.3)	135 (35.6)	99 (39.9)
31-40	158 (25.2)	98 (25.9)	60 (24.2)
41-50	101 (16.1)	62 (16.4)	39 (15.7)
51-60	49 (7.8)	32 (8.4)	17 (6.9)
>60	85 (13.6)	52 (13.7)	33 (13.3)
Total	627 (100.00)	379 (100.0)	248 (100.0)

TABLE 2: DESCRIPTIVE STATISTICS OF MEASURED PARAMETERS BASED ON SEX

Parameter	Sex	Mean±SD	Range	P value
Age (years)	Combined	39.66±15.19	18.00-80.00	0.241
	M	40.24±15.99	18.00-80.00	
	F	38.78±15.48	18.00-76.00	
B-PR (mm)	Combined	107.81±8.79	90.00-130.00	0.532
	M	107.64±9.33	90.00-130.00	
	F	108.07±7.90	90.00-130.00	
B-NA (mm)	Combined	102.11±8.61	82.00-120.00	0.337
	M	101.85±9.12	82.00-120.00	
	F	102.51±7.77	85.00-120.00	
AI (%)	Combined	105.63±2.03	102.04-113.64	0.094
	M	105.73±2.20	102.04-113.64	
	F	105.47±1.74	102.11-111.76	

B-PR = Basion-Prothion length (mm), B-NA = Basion-Nasion length (mm), AI = Alveolar index in %, SE= standard error, SD= standard deviation, Var= variance, Minv= minimum value, Maxv= maximum value, F= females, M= males

TABLE 3: DESCRIPTIVE STATISTICS OF MEASURED PARAMETERS ACCORDING ON AGE GROUPS IRRESPECTIVE OF SEX

	B-P	B-N	AI
18-30	107.92±8.05^{a,b}	102.37±7.86^{a}	105.46±1.70^{a,b}
31-40	108.74±10.64^{b,c}	102.31±10.31^{a}	106.35±2.60^{c}
41-50	111.90±6.31^{c}	106.77±6.29^{b}	104.83±1.19^{a}
51-60	104.84±8.40^{a,d}	98.94±8.11^{c}	106.00±2.16^{b,c}
>60	102.62±6.52^{d}	97.33±6.46^{c}	105.48±1.97$^{a.b}$

Parameters were compared between age group using one-way ANOVA. *Post hoc* done using Tukey's HSD. Like superscripts means no significant difference between the age groups. Unlike superscripts means significant difference between age groups. B-PR = Basion-Prothion length (mm), B-NA = Basion-Nasion length (mm), AI = Alveolar index in %, SD= standard deviation

TABLE 4: DESCRIPTIVE STATISTICS OF MEASURED PARAMETERS ACCORDING ON AGE GROUPS AND SEX

	B-PR (mean±SD)			B-NA (mean±SD)			AI (mean±SD)		
	M	F	*p*	M	F	*p*	M	F	*p*
18-30	108.25±8.91	107.47±6.73	0.448	102.61±8.77	102.04±6.45	0.564	105.54±1.88	105.34±1.43	0.354
31-40	108.66±11.07	108.87±9.99	0.908	102.13±10.64	102.60±9.85	0.783	106.46±2.75	106.18±2.35	0.520
41-50	111.16±6.91	113.08±5.08	0.113	106.13±6.74	107.79±5.42	0.175	104.76±0.96	104.94±1.50	0.464
51-60	104.75±8.87	105.00±7.71	0.922	98.88±8.65	99.06±7.25	0.941	105.99±2.29	106.01±1.94	0.981
>60	101.69±6.30	104.09±6.67	0.098	96.10±5.96	99.27±6.83	0.032*	105.85±2.39	104.88±0.66	0.008*

* means significant difference between males and females. Parameters were compared between males and females in each age group using independent sample T test. B-PR = Basion-Prosthion length (mm), B-NA = Basion-Nasion length (mm), AI = Alveolar index in %, SD= standard deviation, F= females, M= males

DISCUSSION

Craniofacial sex and age determination are essential in anthropological and forensic investigations (Albert *et al.,* 2007), as well as serving as a vital tool in the hands of maxillofacial surgeons and aesthetic anatomists. The findings of this study show the differences that occurs in male and female craniofacial measurement in terms of alveolar index. The present study uses age as an important tool in skull classification. The primary goal of this analysis is to utilize age to provide base-line data as well as describing how the following anatomic regions of the skull; basion-prosthion, basion -nasion and alveolar index changes with age. Previous studies have focused on sex differences with respect to the basion-Prosthion length, Basion-nasion length, alveolar index, as important landmarks in skull (Hanihara, 2000; Barrett, *et al.,* 1963; Oghenemavwe and Williams, 2014). But this study moves further to state the effect of age with respect to the above-mentioned parameters. The findings of this study show no significant difference (P>0.05) in age group 18-30, 31-40, 41-50, 51-60, >60, in males and females in terms of the basion- prosthion length, basion-nasion length and alveolar index. A significant difference (P<0.05) occurred in the basion-nasion length and alveolar index of individuals in age 60 and above, as shown in table 4. The difference in age group 60 and above could be as a result of decrease craniofacial skeletal size which is more prominent in aged males (Albert, *et al*., 2007; Ross *et al.,* 1998). Ross *et al*.,2007 in their study on American males and female's adult skulls aged 60 and above, stated that males showed a decrease in craniofacial skeleton at the above age range while females showed an increase. The reason for this can be attributed to significant anterior cranial fossa changes that occurs in female when compared to males (Bigler,2007; May, *et al.,* 2010, Urban *et al.,* 2014).

We therefore recommend more study in other population with respect to age, in radiological classification of adult skull using Basion-Prosthion length, Basion-nasion length and alveolar index as parameters. The data from this study is recommended for consideration in age determination during forensic evaluation.

In conclusion, the findings of this study show that Nigerians are Prognathious and that basion-prosthion length, basion-nasion length and alveolar index can be used as parameters for age determination within the studied population.

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