Metric Assessment of Palatal Index and Gnathic Index in Nigerian Population

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ABSTRACT

Background

Understanding the variations of the hard palate is crucial in surgical procedures relating to oral cavity and in individual identification. Similarly, gnathic index assesses the projection of the lower face relative to the upper face. The aim of this study was to analyse the normative data of the palate and gnathic indices in Southern part of Nigeria.

Materials and method

The cross sectional study analysed 150 dry adult male skulls. Venier caliper and spreading caliper were used to measure palate length and palate breadth as well as basion-nasion length and basion prosthion length. From these measurements, palatal index and gnathic index were calculated.

Results

For the southeast group, the values of palate breadth, palate length, (mm), palate index (%) and basion-prosthion length, basion nasion length (mm), gnathic index (%) were 38.0 (±3.7), 43.0 (±10.3), 94.1 (±29.7) and 102.2 (±5.5), 103.1 (±5.5), 99.1 (±5.5). For the south south group, the values of palate breadth, palate length (mm), palate index (%) and basion-prosthion length, basion-nasion length (mm), gnathic index (%) were 43.2 (±5.3), 51.2 (±5.9), 84.8 (±11.1) and 103.7 (±8.0), 103.1 (±4.7), 100.5 (±5.4). There was a significant difference in the values of palate breadth and palate length in southeast and southsouth groups, but no significant difference in the palate index. There was no significant difference in the gnathic variables in both groups.

Conclusions

The category of palate index in Southeast and south south Nigerai is brachystaphyline and mesostaphyline respectively while the category of gnathic index in both regions is mesognathous

Key words: Palate index, gnathic index, Nigeria

INTRODUCTION

The hard palate and the soft palate together form the roof of the mouth and the floor of the nasal cavity. The hard palate is formed by the palatine process of the maxilla in front and the horizontal plates of the palatine bones posteriorly (Standring, 2005; Wahane et al, 2019). The two parts are united by cruciform sutures, which consists of intermaxillary, interpalatine and palatomaxillary sutures (Jacob et al, 2016).

The hard palate is an important structure because of its forensic and clinical applications. It is involved in the passive articulation of speech (Varalakshmi et al, 2015), and in the pathology of obstructive sleep apnoea and cleft palate (Wahane et al, 2019). Clinically, the knowledge of morphometry of hard palate is applied in

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procedures such as nasopharyngoscopy and nasogastric intubation. It is therefore relevant in orthodontic surgeries, palatal implants, repair of cleft palate (Badshah et al, 2018), and treatment of obstructive sleep apnoea syndrome (Varalakshmi et al, 2015; Wahane et al, 2019).

Palatal index is the ratios of the palate breadth to palate length expressed in percentage. It is classified as Leptostaphyline < 80%, mesostaphyline 80-85%, and brachystaphyline > 85% (Gujar et al, 2018).

Morphometric study of hard palate is also relevant in forensic anthropology and forensic odontology, because it is valuable in identification of humans in cases of mass disaster (Kumar et al, 2023). The hard palate is better preserved during decomposition because its location within the oral cavity gives it some protection from post-mortem decomposition (Mustafa et al, 2019; Sinha et al, 2021). The shape of hard palate can be used for sex determination (Mustafa et al, 2019). The hard palate has several anatomic landmarks which makes measurements easy. Thus it renders itself useful for forensic investigation. Thus, differences in the morphometry of the hard palate among races can be useful for identification (Sarilita et al, 2015).

The gnathic index (also known as alveolar index) is the ratio of basion-prosthion distance to the basion-nasion distance multiplied by 100 (Oghenemavwe et al, 2015). Gnathic index expresses the extent of prognathism in a population (Oghenemavwe et al, 2015). The gnathic index is a useful tool in classifying the skull in different races (Lesciotto et al, 2016).

Prognathism is defined as the anterior projection of the lower face relative to the upper face (Lesciotto et al, 2016). It is frequently used to characterize and distinguish hominin taxa and human populations in the fields of paleontology, bioarchaeology and forensic anthropology (Lesciotto et al, 2016). Varying degrees of prognathism has been observed between geographically distinct populations as an evidence of population diversity. Consequently, Africans have been described as having a high-degree of prognathism in contrast with European, Asian, and Native Americans, who are generally described as having little or no prognathism (Lesciotto et al, 2016). The skulls are classified as orthognathous when GI ≤ 98%, between 99 – 103% as mesognathous and > 103% as prognathous (Padala et al, 2017).

Furthermore, gnathic index has clinical application as it shows the relationship of the mandible and maxilla to the rest of the face. This relationship is sought for in oral and maxillofacial surgeries and orthodontics.

On the backdrop of paucity of research data on this subject, this study was aimed at characterizing the palatal index and gnathic index in the study population in order to provide a norm for possible use in the relevant fields of bioarcheology, forensic anthropology and paleontology, and also to add to the body of knowledge.

MATERIALS AND METHODS

The study was a cross sectional study and for which 150 dry adult male crania were studied in the southeast and southsouth part of Nigeria. This geographical area is mainly occupied by Igbo and Ijaw tribes respectively (Demographics of Nigeria, 2023). The crania belong to the Departments of Anatomy of medical schools within the study area.

Ethical approval was obtained from the ethics committee of the Faculty of Basic Medical Sciences of our Institution. Crania whose landmarks were intact were included in this study, while crania whose landmarks were not intact were excluded. Measurements were taken with spreading caliper (FERVI C028/150 - C028) and Vernier caliper (Gilson tools Japan, 0-150mm X 0.05/6" X 1/128), with precision of 0.05mm). Two measurements were made and the mean was recorded.

The landmarks that were used for measurements are as follows:

Staphyli on (st): is the point on the median palatine (intermaxillary) suture where a line drawn between the deepest parts of the notches (free edges) at the rear of the palate crosses the midline.

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Olare (ol): Orale is the midline point on the hard palate where a line drawn tangent to the posterior margins of the central incisor alveoli crosses the midline

Prosthion (pr): is the midline point at the most anterior point on the alveolar process of the maxillae

Endomolare (enm) is the most medial point on the inner surface of the alveolar margin opposite the center of the M2 crown

Basion (ba): Basion is the midline point on the anterior margin of the foramen magnum

Nasion (n): Nasion is the midline point where the two nasal bones and the frontal intersect

Based on these landmarks, the following measurements were taken:

Palatal length (PL): The distance from olare to staphylion

Palatal breadth (PB): endomolare to endomolare

Basion –nasion Length (BNL): The distance from nasion to basion

Basion-Prosthion Length (BPL): The distance from basion to prosthion.

Palatal index is calculated as PB/PL X 100. It is categorize as Leptostaphyline (< 80%), mesostaphyline (80-85%), and brachystaphyline (> 85%).

Gnathic index is calculated as BPL/BNL X 100. It is categorized as orthognathous (≤ 98%), mesognathous (99 – 103%) and prognathous (> 103%)

Data was analysed with Statistical Package for Social Science (SPSS version 25). The variables were divided into two groups based on location: southeast and southsouth groups. The means and standard deviations of the various cranial variables were calculated, while test of significant difference between the two groups was computed. A variable is said to exhibit significant difference when p value is less 0.05. When there is significant difference, effect size is calculated with Cohen's d test.

RESULTS

The values of palatal breadth, palatal length and palatal index in the present study are shown in table 1. There is a significant difference in the values of palatal breadth and palatal length in southeast and southsouth groups with Cohen's d of - 1.11 (palatal breadth) and - 0.82 (palatal length). There was no significant difference in the mean of palatal index in the two study population. The mean of palate index in the southeast was 94.1% (brachystaphyline) while the mean of palate index in the southsouth was 84.8% (mesostaphyline).

Table 1: Means of palatal and gnathic indices and variables

	Southeast	Southsouth			combined
	Mean	Mean	t	P value	Mean
Palatal breadth (mm) (±SD)	38.0 (±3.7)	43.2 (±5.3)	-6.853	**.000**	39.3 (±4.8)
Palatal length (mm) (±SD)	43.0 (±10.3)	51.2 (±5.9)	-4.609	**.000**	45.2 (±9.9)
Palatal index (%)	94.1 (±29.7)	84.8(±11.1)	1.772	.079	91.2 (±26.0)
Basion - Prosthion Length (mm) (±SD)	102.2 (±5.5)	103.7 (±8.0)	-1.299	.196	102.5 (±6.2)

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Basion – nasion Length (mm) (±SD)	103.1 (±5.5)	103.1 (±4.7)	.007	.994	103.1 (±5.2)
Gnathic index (%)	99.1 (±5.5)	100.5 (±5.4)	-1.403	.163	99.5 (± 5.4)

When considering the categories of palatal index in the study population, brachystaphyline has the greatest prevalence while Mesostaphyline has the least prevalence in both groups (table 2).

Table 2: Categories of palate and gnathic indices

		Southeast	Southsouth
Palate index	Leptostaphyline (%)	28.8	33.3
	Mesostaphyline (%)	19.8	25.6
	Brachystaphyline (%)	37.8	35.9
Gnathic index	Orthognathous (%)	43.2	28.2
	Mesognathous (%)	30.6	51.3
	Prognathous (%)	21.6	20.5

The values of Basion - Prosthion length, Basion – nasion length and gnathic index in the present study are shown in table 1. There was no significant difference in the values of Basion - Prosthion length and Basion – nasion length among the two study groups. The mean gnathic index for the southeast and southsouth groups fall in the mesognathous category.

The pattern of distribution of various categories of gnathic index is different in both study groups. The most occurring category of gnathic index was orthognathous and mesognathous in southeast and southsouth respectively (table 2).

DISCUSSION

The hard palate plays a vital role in articulation of speech and respiration. It is therefore clinically significant, spanning several areas like sleep apnoea, cleft palate, pharyngoscopy, orthodontic surgeries and even nasogastric intubation. Apart from its clinical relevance, the hard palate renders itself useful in forensic science as it can aid in identification process.

In the present study, there was significant difference in the magnitude of palatal breadth and length between the southeast group and southsouth group (table 1). However, there was no significant difference in their palatal index. This difference could be due to ethnic difference. The southeast is mainly dominated by Igbos while the southsouth is dominated by the Ijaws (Demographics of Nigeria, 2023).

Palatal index is calculated as the ratio of palate width to palate length multiplied by 100. There are three classifications of palatal index: leptostaphyline (narrow palate), mesostaphyline (medium palate) and brachystaphyline (wide palate). The value of palatal index in our study was higher than the values reported by Badshah et al (2018) and Ortug et al (2019) which was conducted in Pakistan and Turkey respectively. Table 3 shows the comparism of palatal index in several works.

Table 3: comparison of palatal index in different populations

Study	Population	Palate length	Palate width	Palatal index
Present study	Southeast Nigeria	43.0	38.0	L-28.8%

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				M-19.8% B-37%
	Southsouth Nigeria	51.2	43.2	L-33.3% M-25.6% B-35.9%
Jotania et al, 2013	India	49.74	37.75	L-70% M-15% B-15%
Sarilita et al, 2015	Dundee	52	38	L-84% M-8% B-8%
Varalakshmi et al, 2015	Karnataka	48.47	36	L-66% M-18.5% B-15.5%
Kumar et al, 2016	India	52.5	36.51	L-58% M-27% B-15%
Kulkarni et al, 2017	India	40.2	44.15	L-68% M-1.4% B-11.6%
Badshah et al, 2018	Pakistan	51.89	38.04	73.43%
Gujar et al, 2018	Gujarat	47.10	36.26	L-68% M-20% B-12%
Ortug et al, 2019	Turkey			86.28 %
Sinha et al, 2021	India	42.68	33.86	L – 40% M-14% B-23%
Kumar et al, 2023	India	38.84	31.36	L-47% M-22% B-31%

The hard palate has potentials for its use in forensic anthropology. First, it is better preserved during decomposition because its location within the oral cavity gives it some protection from post-mortem

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decomposition (Mustafa et al, 2019; Sinha et al, 2021). Secondly, it has several anatomic landmarks which makes measurements easy. Therefore, it has been shown that the shape of hard palate can be used for sex determination (Mustafa et al, 2019) and differences in the morphometry of the hard palate among races can be useful for identification (Sarilita et al, 2015).

The hard palate is made of the palatine processes of the maxilla anteriorly and the horizontal plates of the palatine bones posteriorly. These bones meet at a cruciform system of sutures, which includes the median and transverse palatine sutures. Clinically, the knowledge of morphological variations of the hard palate is necessary for some dental and maxillofacial surgical procedures. This includes, but not limited to its application in anaesthetizing the maxillary teeth and in repair of cleft palate (Badshah et al, 2018). Palatal index is used to classify cleft palate deformity and select a proper surgical technique based on the severity of the cleft palate and tissue deficiency (Rossell-Perry et al, 2014). Sleep apnoea may be associated with alteration of hard palate as well as soft palate (Sinha et al, 2021). Knowledge of morphometric variation of hard palate is equally important for transnasal and transoral approaches for endoscopic anterior skull base surgeries (Jacob et al, 2016).

The greater palatine foramen is located close to the lateral border of hard palate medial to the third molar tooth. This foramen transmits the greater palatine nerves and vessels. The lesser palatine foramina (about two) lies just behind the greater palatine foramen. It transmits the lesser palatine nerves and vessels and incisive foramen transmits the nasopalatine nerve (Jacob et al, 2016, Gujar et al, 2018). Correct knowledge of the greater and lesser palatine foramen is necessary in order to avoid damage to neurovascular structures during anaesthesia. High and narrow palate is associated with certain syndromes which include Apert syndrome, Turners syndrome, Franceschetti-Teacher Collins syndrome and Trisomy 21 syndrome (Jacob et al, 2016).

The findings of the present study showed that there was no significant difference between the values of basion-prosthion length and basion-nasion length in the southeast and southsouth groups. In both, mesognathism was more prevalent. This was followed orthognathism and then prognathism (Table 2). This pattern was similar with the findings of Orish et al (2016) in Nigeria who reported that mesognathism was most prevalent (42.30%) as orthognathism followed (30.77%), and prognathis was the least prevalent (26.92%). Our finding was different from the works of Khandelwal et al 2023 and Howale et al, 2012 who in their separate works reported that orthognathism was the most prevalent type of gnathic index in India population (84% and 94% respectively) while prognathism was least prevalent (00% and 1.33% respectively). In 2015, Oghenemavwe et al did a radiographical study in Nigeria and reported that the most prevalent type gnathic index was prognathism (93.18%) (Table 4).

Table 4: Comparison of gnathic index in different populations

Study	Population	Basion-prosthion length (mm)	Basion-nasion length (mm)	Gnathic index (%)	Gnathic index category (%)
Present study	Southeast Nigeria	102.2	103.1	99.1%	O-43.2% M-30.6% P-21.6%
	Southsouth Nigeria	103.7	103.1	100.5%	O-28.2% M-51.3% P-20.5%
Khandelwal et al, 2023	India				O-84% M-16% P-00%

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Oghenemavwe et al, 2015 (radiographical study)	Nigeria	88.67	83.23	106.69	O-00 M-6.82% P-93.18%
Howale et al, 2012	India			92.67	O-94.66 M-4.0 P-1.33
Padala et al, 2017	India	95	102	93.61	O-92 M-08 P-00
Orish et al, 2016	Nigeria	100.5	101	99.50	O- 30.77% M- 42.30% P-26.92%

This was different from our study. However, it could give us insight on the impact of methodology in research. Our research work employed direct measurement on the skeleton, while theirs employed imaging.

Gnathic index can be used for assessing sexaual dimorphism of the skull (Padala et al, 2017). It is a characteristic that differentiate humans from other primates and it is also used to classify races.

At the beginning of anthropology, prognathim was described with such non quantifiable expressions as 'high, moderate, low or lacking'. In order to reduce bias, attempts were made to quantitate the expressions. . Huxley in 1863 (cited by Lesciotto et al, 2016) suggested using the craniofacial, or sphenomaxillary, angle as a measure of prognathism. This angle was calculated from lines connecting *prosthion* (the most anterior point on the maxilla), *sellion* (the most anterior point on the sphenoid), and *basion* (the most anterior point on the foramen magnum). The challenge then was that in order to locate sellion, the cranial cavity must be entered. This made it difficult to measure intact cranium (Lesciotto et al, 2016). Therefore, gnathic index was proposed, which can assess the following ectocranial landmarks: basion, nasion and prosthion.

CONCLUSION

The category of palate index in Southeast and southsouth Nigeria is brachystaphyline and mesostaphyline respectively while the category of gnathic index in both regions is mesognathous.

Conflict of interest:

Nil

Ethical approval:

Ethical approval was obtained from Nnamdi Azikiwe University Teaching Hospital (NAUTH/CS/66/VOL.16/VER.3/97/2024/039). Permissions were obtained from various institutions where data were collected

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