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EVALUATION OF BASAL SPHENOID ANGLE AMONG ADULTS OF AFRICAN DESCENT USING TOMOGRAPHIC IMAGING

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ABSTRACT

Background: The Basal Angle (BA) of the sphenoid represents an integral anthropological component of the radiological examination of the cranial floor which allows for the diagnosis of platybasia. As a developmental anomaly of the skull base, occipital bone and upper cervical vertebrae, platybasia is associated with changes in the depth of the posterior cranial fossa and the shape of the spheno-occipital region.

Objective: To determine the average basal sphenoid angle and its relationship with the dimensions of the sphenoid sinus among adults of African origin using computerized tomography (CT).

Method: Computerized tomography (CT) images of three hundred and twenty-three adult sphenoid sinuses of individuals with age ranging from 18 to 80 years, over a 5-year period were retrospectively studied at the Radiology Department of the University Teaching Hospital following institutional ethical approval. On a sagittal CT slide, the sphenoid BA was measured as the angle subtended between two lines on the cranial floor. Platybsia was defined as; BA greater than 143°. The anteroposterior, craniocaudal, and transverse diameters of the sphenoid sinus were measured, the extent of pneumatisation was noted, while sinus volume was calculated.

Results: The BA of the sphenoid ranged from 88° to 157.9°with a mean BA of 124.70° ± 11.4. There was a statistically significant relationship between the BA and the craniocaudal diameter of the sphenoid sinus.

Conclusions: Computerized tomography assessment of the sphenoid basal angle among Africans is lower than currently known. These values are also lower compared to results obtained using X-rays and among Caucasians. This emphasises the need for more studies on CT assessment of the skull base for the determination of an applicable African average for the sphenoid BA. This is relevant in the radiological identification of skull base malformations.

Keywords: Imaging; Skull; Sphenoid; Angle; African

Introduction

The basal sphenoid angle (BA) represents an anthropological angle of the base of the skull, that allows for the radiologic evaluation of developmental and pathologic anomalies involving the cranial base.[1,2] This anthropological angle, corresponds to two precise segments of the cranial floor on a lateral radiograph. The first subdivision of this segment is a line extending horizontally backwards across the anterior cranial fossa to the tip of the dorsum sellae, while the second subdivision is indicated by a line from the top of the dorsum sellae, downward and backward, along the posterior margin of the clivus to the anterior margin of the Foramen magnum.[3] The angle subtended inferior to these two lines is the basal sphenoid angle.[3,4]

Several congenital and pathologic conditions like the platybasia, basilar kyphosis, syringomyelia, multiple sclerosis, osteogenesis imperfecta, Arnold-Chiari malformation, Paget disease, osteomalacia and rickets are characterised by changes in the shape of the spheno-occipital and posterior cranial fossa orientation with a resultant distortion of the BA.[4,5,6]. Although the degree of these malformations varies widely, they are known to present with an upward displacement of the upper cervical vertebrae and the foramen magnum into the posterior cranial cavity, elevation of the clivus, with resultant abnormal obtuseness or flattening of the skull base. This allows the odontoid process to impinge on the medulla, while the clivus could compress the brainstem and cerebellum against the tentorium cerebelli.[3,4,5,6] The posterior cranial fossa shrinks with alteration in the relative position, size and shape of the foramen magnum and upper cervical segment, and the patients typically exhibit a short squat neck with backward tilting of the head. Despite these skeletal deformities, studies have shown that a few patients remain asymptomatic throughout life, however, neurologic manifestations usually result from pressure effects on the brainstem and cerebellum, around the third to fifth decade of life, and sometimes with progressive deterioration and death.[2]

Normal ranges of adult BA obtained from studies on lateral roentgenogram on the basis of standard landmarks fall between ranges from 125° to 143°.[7,8,9] Consequently, BA greater than 143º are classified as skulls with abnormal shapes of cranial floor. However, BA of less than 125°, is characterised by extensive flexion, with an abnormally deep posterior cranial fossa. This is known as basilar kyphosis.[7,8]

According to Adam[4], the BA among adult Kenyans was 113° ± 7 in a study of 320 subjects. Koenigsberg *et al.*,[8] reported a BA of 129° ± 6 in Philadelphia, while, Netto *et al.*,[9], found a BA of 115.41° ± 8.45, (males = 115.28° ± 8.17, and females = 115.56° ± 8.83). Following a robust literature search effort, we were able to conclude that there is an obvious paucity of data on the assessment of BA among subjects of African descent using computerised tomography. The study among Kenyans in Nairobi was conducted using X-rays[4], and this could differ from the outcome of this study. In addition, the use of computerized tomography (CT) as an investigative tool has improved the quality and quantity of available information, derivable from the assessment of bony components, which are not obtainable from other radiologic procedures like the X-ray.[10,11] As such, the aim of this study was to determine the average basal sphenoid angle and its relationship with the dimensions of the sphenoid sinus by means of CT among a selected population of Africans. Clinically, these measurements represent minute changes in the dimensions and shape of the skull base which could be indicators of rare bone diseases. Moving forward, the availability of these baseline values for Africans will facilitate and afford neuroradiologists the opportunity to correlate and differentiate radiologic findings among individuals in order to avoid delayed or missed diagnosis of rare bone diseases

Methods:

Computerized tomography images of three hundred and twenty-three adult sphenoid sinuses of subjects aged between 18 and 80 years, were retrospectively studied at the Anatomy and Radiology Departments following institutional ethical approval. CT images of patients who had a history of surgery, or tumours distorting the normal anatomy of the skull base and the sphenoid sinus region were excluded. All images were taken with a GE Bright Speed Multidetector Helical CT scanner, between November 2018 and March 2023, and viewed on the computer, using the Digital Imaging and Communication in Medicine (DICOM) viewer, powered by the RadiAnt Version 4.2 software. The basal sphenoid angle was measured as the angle subtended between two lines on the cranial floor in a sagittal CT slide. The first line, XY (figs 1, 2), extends horizontally backwards, through the floor of the anterior cranial fossa to the tip of the dorsum sellae, while, the second line, YZ, extends from the tip of the dorsum sellae, downward and backwards along the posterior margin of the clivus to the anterior border of the Foramen magnum. The angle measuring tool provided by the software was used to measure this angle on the cranial floor on a sagittal slide of sphenoid sinus CT (3,4). The anteroposterior (AP), craniocaudal (CC), and transverse (TR), diameters of the sphenoid sinus were measured on sagittal reformatted, axial and coronal reconstructed CT images (Fig 3), and the extent of sinus pneumatisation was noted for each subject. The volume of the sphenoid sinus was calculated, using the ellipsoid formula; Sinus Volume = 1/2 x A x B x C [12], where, A, B, and C are the ellipsoid diameters corresponding to AP, CC, and TR diameters respectively.

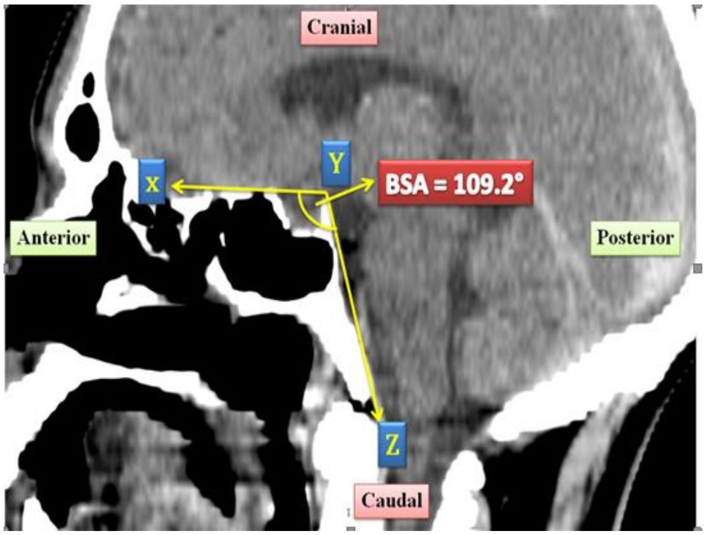

Figure 1: Sagittal slide of sphenoid sinus CT of a 51-year-old female showing sphenoid flexion and landmarks of measurements of the basal sphenoid angle, between lines XY, and YZ.

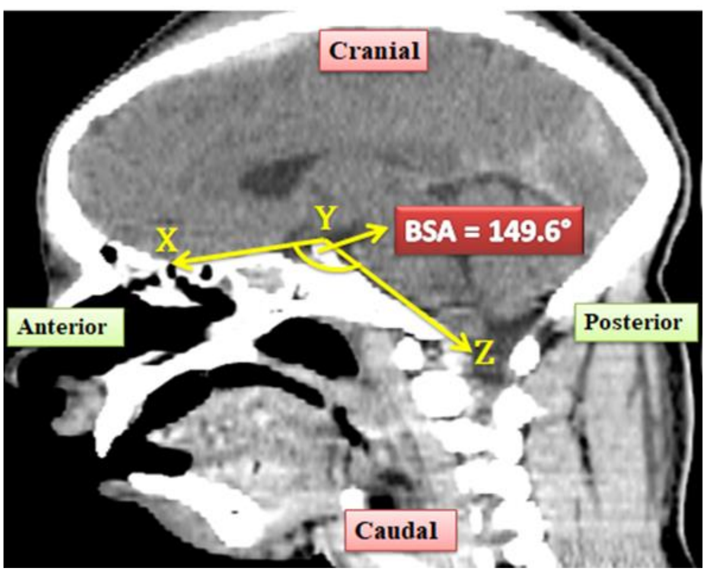

Figure 2: Sagittal Slide of sphenoid sinus CT of a 65-year-old male showing partial flattening of the skull base and landmarks of measurements of the basal sphenoid angle.

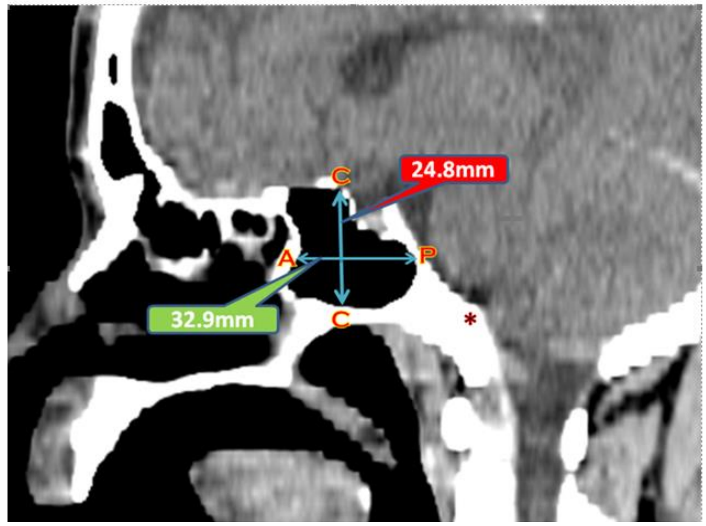

Figure 3: Sagittal slide of sphenoid sinus CT of a 72-year-old male showing landmarks of measurements. AP = Anteroposterior diameter, CC = Craniocaudal diameter. Clivus bulge (elevation) is marked*, found in 5% of normal individuals. [2,5]

Data Analysis:

Data was sorted out manually, tabulated and then entered into a Microsoft Excel spreadsheet. SPSS Version 22 was used for data analysis. The means (± SD) of the craniocaudal, transverse, anteroposterior diameters, basal sphenoid angle and the calculated volumes of the sphenoid sinus were determined. Comparison of mean values in relation to sex and age distribution of the subjects was carried out using one-way ANOVA, while proportions were compared using the chi-square test.

Results:

Average values for BA and its relationship with age and sex

The basal sphenoid angle from this study ranged from 88° to 157.9°. the mean BA was 124.70° ± 11.4. There were no statistically significant differences in the studied population between BA and sex or age groups of the subjects.

Logistic regression: Test of association between BA and dimensions of the sphenoid sinus

Table 3, shows that there was a statistically significant association between the BA and the craniocaudal diameter of the sphenoid sinus.

Table 1 Mean ± SD for basal sphenoid angle for different age groups of subjects

Age Groups (Years)	BA (Degrees)
18 – 26	124.70 ± 10.41
27 – 35	123.90 ± 11.02
36 – 44	124.60 ± 10.99
45 – 53	123.50 ± 12.98
54 – 62	124.10 ± 10.64
63 – 71	128.00 ± 12.72
72 – 80	126.80 ± 8.17
p – value	0.6323

One-way ANOVA. No statistically significant relationship between the age group and BA. $p > 0.05$. BA = Basal Sphenoid Angle

Table 2 Mean ± SD for Basal Sphenoid Angle between male and female subjects

Sex	BA (Degrees)
Males	124.40 ± 11.11
Females	124.40 ± 11.21
p - Value	0.482

One-way ANOVA. No statistically significant relationship between sex and BA. $p > 0.05$. BA = Basal Sphenoid Angle

Table 3 Test of association between the Basal Sphenoid Angle and measurements of the sphenoid sinus

Sphenoid Sinus Features	Mean ± SD	*p* value
AP (mm)	26.90 ± 6.431	0.114
CC (mm)	24.62 ± 4.304	0.001*
TR (mm)	34.03 ± 5.947	0.203
VOL (cm^{3})	11.94 ± 5.491	0.929
Extent of pneumatisation	124.74 ± 11.109	0.391

Logistic regression:* Statistically significant association at $p < 0.05$. AP = Anteroposterior, CC = Craniocaudal, TR = Transverse, VOL = Volume.

Discussion:

Due to the inherent drawbacks of x-ray films usually from poor image quality and positioning, the identification of patients with asymptomatic features of congenital or acquired cranial floor abnormalities may be elusive. This would underscore the benefits of deploying CT scans for the evaluation of the skull base to forestall delayed, missed or mistaken diagnosis.[4,7]

This study found a mean basal sphenoid angle of 124.70 º ± 11.4, this value is lower than the inferior limit of the normal ranges in comparison with the report of Ramsey.[7] Another study among Africans reported a mean BA of 113° ± 70.[4] By implication, currently known normal adult ranges of BA (125° to 143°), according to Ramsey [7], may not be applicable to Africans, although, more studies are required to support this claim. Moreso, the higher the lower limit of the applicable BA ranges, the more chances it is for more normal subjects to be diagnosed with basilar kyphosis. This is also applicable to a lower higher limit of normal ranges for basal sphenoid angles. With this concern, there is a need for more reports among different ethnic and racial African populations that could form the basis of a review of applicable reference ranges for BA.

Furthermore, a significant percentage of 53.87% among the studied population had a basal sphenoid angle of ≤ 125°, which defines basilar kyphosis according to Ramsey.[7] Although, these patients were not identified for further investigation, however, it is noteworthy that several studies have found lower normal basal sphenoid angle values, ranging from 113.7° to 121.65°.[13-18]

In agreement with the report from a study at the Universiade Federal de São Paulo, Brazil, Netto *et al.*, [9], reported that there was no statistical relationship between the mean BA and sex or ages of the subjects, however, our average BA was higher than the 115.41° ± 8.45, (males = 115.28° ± 8.17, and females =

115.56° ± 8.83) according to Netto *et al*.[9].Our study also reported a higher mean BA than the outcome of the study in Nairobi, involving adult Kenyans (113° ± 7).[4] Our findings for average BA were lower than the result among adult Americans in Philadelphia (129° ± 6) (8). The differences in these reports could have emanated from the varied methods employed in these studies. Some of these studies carried out direct cadaveric measurements on dry skulls [9], while others used lateral radiographs [4], MRI [8,16], and CT.[14,18] These variant approaches may have accounted for the differences in the reported values of the BA. However, environmental, racial or genetic factors could have contributed.

Conclusion:

Computerized tomography assessment of the basal sphenoid angle among Africans could be lower than currently known ranges and different from results obtainable among Caucasians and from the use of X-rays. Emphasis is on the need to conduct more studies on CT assessment of the skull base for the determination of an applicable African average for the basal sphenoid angle. This has become increasingly relevant in the radiological identification of skull base malformations. In clinical practice, these measurements represent changes in the dimensions and shape of the skull base as pointers or indicators of rare bone diseases. Moving forward, the availability of baseline values for Africans will facilitate and afford neuroradiologists the opportunity to correlate and differentiate radiologic findings between individuals in order to avoid delayed or missed diagnosis of rare cranial floor bone diseases.

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