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Metopism: Its Prevalence and Morphometry in Adult Nigerian Dry Skulls

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Metopic suture also known as the frontal, interfrontal, or median frontal suture is formed in the midline at the meeting of the two halves of the frontal bone. Normally it gets obliterated by early childhood, but in some cases, it persists and is described as metopism. This study is aimed at investigating metopism prevalence in dry Nigerian skull.
Methods: This study was conducted on ninety-six (65 males and 31 females) adult Nigerian dry skulls from 5 selected Universities in the Southern part of Nigeria. Metopic suture (metopism) was considered to be complete when it continued uninterruptedly from the nasion to the bregma and incomplete when it was not present over its entire length. The incomplete metopic sutures were further classified into shapes.
Results: Metopism was observed in 31 skulls (32.3%) of which 22 (21.9%) were males and 9 (9.4%) were females. Complete metopic suture was found in only 1 skull (1.04%) and incomplete metopic suture was seen in 30 skulls (31.25%). Among the incomplete ones, linear shape metopic suture was the most common in 16 skulls (16.67%). 7 (7.29%) were V-shaped metopic suture and

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another 7 (7.29%) were double-type metopic suture. Prevelence of metopic suture was slightly higher in males than in females. However, there was no statistical level of association with respect to sexual dimorphism.

Conclusion: The prevalence and morphometry of metopism in the 96 adult Nigerian skulls studied, revealed complete metopism to be 1.04% with a length of 127.0mm as against incomplete metopism of 31.25% making a total prevalence of 32.29%. The prevalence of metopic suture was slightly higher in males than in females with the linear metopic suture occurring the most. Sexual dimorphism with respect to incomplete metopism types and shapes revealed no association This study is important for radiologists and neurosurgeons in diagnosis of frontal bone fractures and during surgical intervention including frontal craniotomy.

Keywords: Prevalence; metopism; linear shape.

1. INTRODUCTION

"Metopic suture also known as the frontal, interfrontal, or median frontal suture is a vertical fibrous joint that divides the two halves of the frontal bone present in a newborn and a few adults. It is a dentate-type suture extending from the nasion to the bregma, through the midline across the frontal bone and is often be incomplete" [1,2]. "The fusion of the metopic suture normally begins at the nasion proceeding superiorly and terminates at the anterior fontanelle" [3]. The term metopic is from Greek meaning "in the middle of the face" [4].

"The metopic suture separates the two frontal bones at birth and is the first skull suture to close physiologically, starting as early as at 3 months and generally being completely fused at the age of 8 months" [5,6]. "It may fuse as early as 3 months of age and should fuse in nearly all individuals by around 9 months of age" [6-9]. "Also, it usually closes within the first or second year of life, but it has been reported to take up to seven years to fuse" [10]. "Racial variations have been reported in the literature [11], as well as complications related to incomplete development of the frontal sinus". Its Premature fusion is termed metopic synostosis – a type of craniosynostosis which results in a growth restriction of the frontal bones, which leads to a skull malformation known as trigonocephaly. The metopic suture is usually obliterated by about 7or 8 years of age, however, if it persists into adulthood, it is known as "metopism" [2,11]. "According to some authorities, this suture also disappears by the second or third year of life. It is thought to be a normal variant of the cranial sutures" [12]. "It is rare to find this suture in adults and its presence is not considered pathological, but in rare cases, it can persist [6] as an anatomical variant of little clinical significance that it can be mistaken for a frontal bone fracture". "Persistence of the metopic suture may be associated with frontal sinus agenesis or hypoplasia" [13]. "The suture is best identified in an A-P view of the skull. This view can help differentiate it from a vertical skull fracture" [1]. Del Sol [14] suggested that "metopism can be related to abnormal growth of the cranial bones, hydrocephalus, heredity, or atavism". "The genetic factor is the one currently accepted by most scientists" [15].

"Metopism is found in approximately 5% of Asians and 9% of European Caucasians and 1% of Blacks" [12,16]. Bergman [12] reported "the persistence of the metopic suture in approximately 1-12% of skulls". One author, Agarwal [17] reported "the finding of 38.17% in Indian skulls, and Linc [18] observed it in 11% in Czech skulls, and finally Woo [19] reported the finding in 10% in Mongoloid skulls". "The data may suggest that metopism is higher in temperate climates than in warmer climates" [20].

Berry and Berry [21] reported "a 0%-7% incidence associated with ethnicity". "Metopism has been found by several investigators as being more prevalent in males than females" [22,23]. "The persistence of the metopic suture has been reported in frequencies ranging from 1% to 12% of skulls" [24]. "Castillo reported a world index of incidence of 2.75%. It has also been reported to be perhaps associated with frontal sinus abnormalities however, this fact is still in contention" [4]. "Some authors reported various suspected causes of metopism, including active expression of cytokines during cranial fusion and even resorption of the chondroidal tissue" [11]. "The knowledge of the anatomy of the metopic suture is important because its permanence can be mistaken for a cranial fracture in radiological images, or even for the sagittal suture and it is

also important for paleodemography and forensic medicine" [25]. Again, persistence of the suture and its relation to age and to race have excited comments over a long period of time. Hence, this study provides data-base information on the prevalence of metopism in Nigerian skulls

2. MATERIALS AND METHODS

Ninety-six (96) dry skulls were used for this study, selected from anatomy museums in 5 universities in the Southern part of Nigeria (University of Port-Harcourt, Choba, Rivers State, Niger Delta University, Amassoma, Bayelsa State, Imo State University, Owerri, Imo State, Abia State University, Okigwe, Abia State and Madonna University, Elele, Rivers State). The data being a primary data were obtained in accordance with the Anatomy Act, Chapter 17 of the Nigerian Constitution from anatomical museums in the Department of Human Anatomy of Universities listed. This allows any student attending a course of study in a school of anatomy licensed under this act to examine anatomically the body of any person deceased, if permitted or directed so to do by a person who had at the time of giving such permission or direction had power, in pursuance of the provisions of the act to permit or cause the body to be examined.

2.1 Inclusion/Exclusion Criteria

These were put into consideration as selection criteria: teeth type (permanent) as a confirmation for adulthood and the complete state or undamaged state of the dry skull especially intactness of the frontal bone.

Only confirmed and intact adult Nigerian human dry skulls without visible deformities (especially frontal bone deformity) and skulls that show the permanent dentition were selected for the study. Dry skulls with visible deformities (especially frontal bone deformity) such as those that had cranial surgery, bony malformation and trauma were excluded from the study.

The skulls having met the selection criteria were washed with soap, water and soft brush and wiped with a clean dry cloth. The skulls which were already identified or labelled as male and female in the museum were then differentiated into male and female groups while the sexually unidentified were identified and differentiated into male and female based on the criteria of identification of sexual dimorphism. The criteria are as follows:

- Male skulls generally tend to have larger, thicker and heavier skulls
- Pronounced temporal ridge in males than in females.
- Sharper ridge in the lower section of the orbit in females than in males.
- Supraorbital ridge is prominent in males than in females [26].

Thereafter, the skulls were macroscopically inspected at the normafrontalis for the presence of the metopic suture. The inspected skulls were then divided into 3 groups based on sex [27]; skulls with complete metopic suture, skulls with incomplete metopic suture and skulls without metopic suture. Metopic suture is considered complete if it extends from the nasion to the bregma uninterrupted and incomplete if it extends from the nasion or bregma to varied points on the frontal bone or in between [17,28]. Based on the reports of some authorities [15,16,28], the incomplete metopic sutures were further classified with respect to their shapes.

The complete metopic suture was also evaluated in terms of their continuation as the internasal suture anteriorly or the sagittal suture posteriorly. In addition, the length of the complete metopic suture was measured with the help of a thread spread straight from nasion to bregma [4] and later with a millimeter ruler.

The findings or data were then recorded, tabulated and analyzed.

3. RESULTS

Values are presented as frequencies and percentages. Chi-square (X^2) = 0.423; P=0.516. P: statistical level of association was determined using Chi-square test. P<0.05 means there is an association (or relationship) between variables.

From the above it can be seen that P>0.05, therefore there is no association or relationship between the type of metopic suture and sex.

Values are presented as frequencies and percentages. Chi-square (X^2) = 0.748; P=0.688. P: statistical level of association was determined using Chi-square test. P<0.05 means there is an association (or relationship) between variables. From the above it can be seen that P>0.05, therefore there was no association or relationship between shape of incomplete metopic suture and sex.

Table 1. Descriptive statistics of total prevalenc of metopic suture and shapes of incomplete metopic suture

Metopic suture	Frequency (n)	Percent (%)
Complete	1	1.04
Incomplete		
Linear	16	16.67
V-shaped	7	7.29
Double-type	7	7.29
No metopic suture	65	67.71
TOTAL	96	100.0

4. DISCUSSION

From the 96 dry skulls studied in this present research, metopic sutures were found to be present in 31 (32.3%) of the skulls; of this number, 22 were males (22.9%), 9 were females (9.4%). The metopic sutures in this study were classified into two types: complete and incomplete metopic sutures (Table 1). The complete metopic suture also referred to as metopism was found in only one skull (1.04%), a male skull which in turn showed continuity with the internasal suture anteriorly while posteriorly, the upper end of the metopic suture (median frontal suture) failed to meet the anterior end of the median sagittal suture with a deflection of 2mm. This agrees with Jones [30] who stated that the posterior end of the metopic suture does not meet the sagittal suture end-to-end and may miss it by an interval as great as 15mm. The length of the complete metopic suture in this study was 127.0mm which was below that of Yadav et al.,[29] whose mean suture length was computed to be 128.0mm in North Indian skulls, and below 129.2mm in Brazilian skulls, as reported by Castilho et al.[15]. However, it was above those reported by Das et al*.,* for Uttar Pradesh Indian skulls: 121.4mm [31], Skrzat et al*.,* for Polish skulls: 123.1mm [32] and Aksu et al*.,* for Turkish West Anatolian skull: 123.0cm [33].

In the present study, the incomplete metopic sutures were the most common and were found only in the lower part of the frontal bone (close to the nasion) known as nasion-incomplete metopic suture according to Khamanarong et al*.,* [34]. This is not so different from earlier studies were it was subdivided into bregma-incomplete metopic suture (BIMS) and nasion-incomplete metopic suture by Khamanarong et al., and into upper, upper middle, lower middle and lower by Ajmani et al.,[28]. The incomplete metopic suture was found in 30 (31.3%) skulls of which 21skulls (21.9%) were males and 9 (9.4%) were females (Table 2).

Variations in shape of incomplete metopic sutures in the lower part of the frontal bone have been reported and described by several researchers. Ajmani et al., [28] reported the variations out of 206 Nigerian skulls as linear in 50 skulls (24.7%), H-shaped in 8 skulls (3.88%), V-shaped in 2 skulls (0.97%), inverted 'U-shaped' in 1 skull (0.49%) and wide side to side excursion shaped in 1 skull (0.49%).

Agarwal et al.,[17], described the shape variations out of 1,276 Indian skulls studied to be linear (23.12%), H-shaped (1.57%), V-shaped (3.25%), inverted 'U-shaped' (2.43%) and Y-shaped (1.96%). However, in this study out of the 96 skulls studied, the linear shape was observed in 16 skulls (53.34%), V-shaped in 7 skulls (23.34%) and double type in 7 skulls (23.33%) (Table 3). This variations in shape are similar to the shapes observed by Murlimanju et al*.,* of Indian skulls studied [22], Aksu et al*.,* of Turkish West Anatolian skulls studied [33] and Castilho et al*.,* of Brazilian skulls studied [15]. Variations like H-shaped, Y-shaped and inverted 'U-shaped' were not observed in this study. The linear shape was more common with equal prevalence in V-shaped and Double-type shape (Table 3).

Metopic suture was absent in 65 of the skulls studied (67.7%), of which 43 where male skulls (44.8%) and 22 female skulls (22.9%). This is as a result of obliteration of the median frontal suture. Despite having been studied for decades there is no consensus about the correlation between cranial development and suture closure/obliteration. Calvarial suture obliteration is said to be associated with increased osteoblast proliferation and reduced suture cell apoptosis, which is induced by growth factors such as fibroblast growth factor 2 (Fgf2), bone morphogenic protein 4 (Bmp4) and transforming growth factor-beta 2(Tgf-β2) [35]. A study revealed that in vivo transforming growth factor-beta 3 (Tgf-β3), delayed fusion of the posterior inter-frontal suture in Spraque-Dowley rats. Conversely, the cause of metopic suture in humans might stem from Tgf-β3 [36]. The study also suggested that chondroid tissue is responsible for suture closure and maintenance of an open suture occurs by the process of active osteoclastic resorption. Levine et al*.,* from their animal models discussed the role of the dura mater-suture complex in determining metopic suture patency. It was indicated that some

cytokines showed increased expression during active cranial suture fusion [37].

The prevalence of metopic suture is just slightly higher in males than in females especially when analyzed separately, because the metopic suture was found in 9 out of 31 female skulls (29.03%) and 22 out of 65 male skulls (33.85%) analysed. Complete metopism was observed in only 1.54% (1 out of 65) and incomplete metopism 32.31% (21 out of 65) of male skulls. Metopic sutures in female skulls were all incomplete metopic sutures. With respect to shape, male skulls had higher prevalence of linear and V-shaped skulls except in the double type where females had a higher prevalence. However, there was no statistical level of association with respect to sexual dimorphism (Tables 4 & 5)

Table 2. % prevalence of metopism according to sex

Types of metopic suture	Male n (%)	Female n (%)	Total n (%)
Complete	1 (1.0%)	0 (0.0%)	1 (1.0%)
Incomplete	21 (21.9%)	9 (9.4%)	30 (31.3%)
None	43 (44.8%)	22 (22.9%)	65 (67.7%)
Total	65 (67.7%)	31(32.3%)	96 (100%)

Table 3. Prevalence of shape of incomplete metopic suture according to sex

Shapes	Male n (%)	Female n (%)	Total n (%)
Linear	12 (40.0%)	4 (13.33%)	16 (53.33%)
V-shaped	5 (16.67%)	2 (6.67%)	7 (23.34%)
Double	4 (13.33%)	3 (10.0%)	7 (23.33%)
Total	21(70.0%)	9 (30.0%)	30 (100.0%)

Table 4. Sexual dimorphism in types of metopic suture

Types of metopic suture	Male n (%)	Female n (%)	Total n (%)
Complete	1 (1.0%)	0 (0.0%)	1 (1.0%)
Incomplete	21 (21.9%)	9 (9.4%)	30 (31.3%)
None	43 (44.8%)	22 (22.9%)	65 (67.7%)
Total	65 (67.7%)	31(32.3%)	96 (100%)

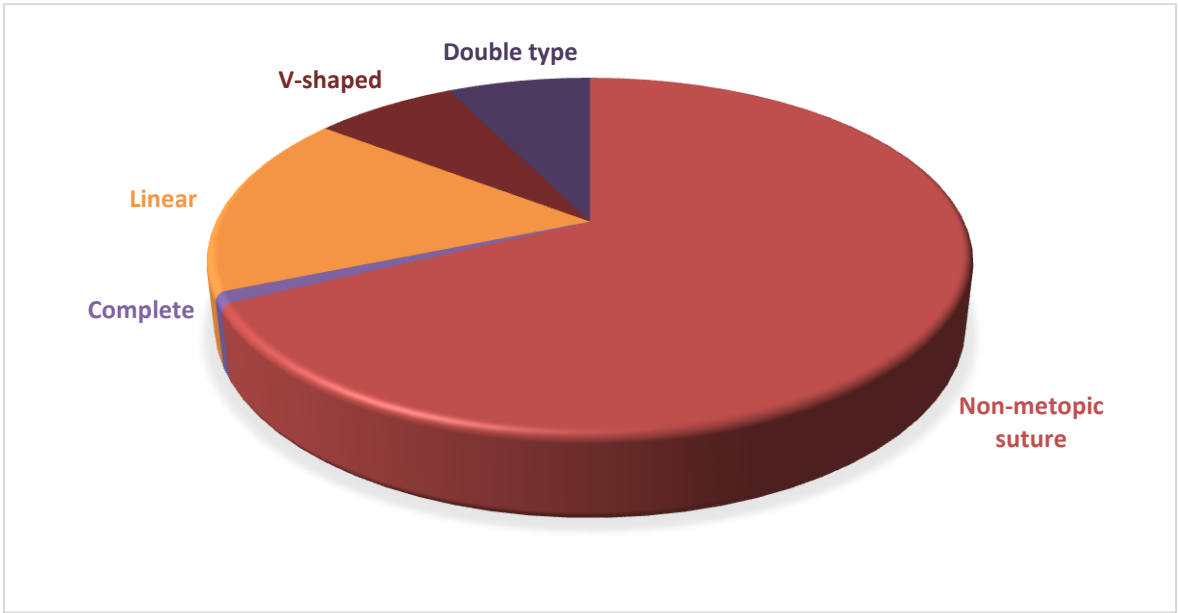

Fig. 1. Pie chart showing prevalence of metopic suture in Nigerian skulls

Comparing the percentage prevalence of complete metopism among races, the prevalence in the present Nigerian study was 1.04% and this was slightly lower than Murlimanju et al., study [22] and Wadekar et al., [38] who worked on 81 Indian skulls (1.2%) and 80 Indian skulls (1.25%) respectively. This agrees with Breathnach who reported metopism to be present in 1% of African skulls [39] and Bryce [40] who stated metopism to be present in 1.2% of Negroes. However, this is lower compared to other races, 7-10% in Europeans, 4-5% in yellow races [39] and 9.5% in Scottish skulls, 8.7% in European crania, 5.1% in Mongolian subjects, 1% in Australian skulls [40]. A summary of the prevalence of metopism, as reported by different research workers in different world population is represented in Table 6.

Table 5. Sexual dimorphism in shapes of incomplete metopic suture

Shapes	Male n (%)	Female n (%)	Total n (%)
Linear	12 (40.0%)	4 (13.33%)	16 (53.33%)
V-shaped	5 (16.67%)	2 (6.67%)	7 (23.34%)
Double	4 (13.33%)	3 (10.0%)	7 (23.33%)
Total	21(70.0%)	9 (30.0%)	30 (100.0%)

Table 6. Prevalence of metopism as reported by various studies

Researcher	Year of study	Skulls studied	No of skulls studied	Percentage of metopism
Bryce et al	1915	European		8.70%
		Scottish		9.50%
		Mongolian		5.10%
		Australian		1%
		Negro		1.2%
Keith et al	1948	Subject to race		3.80%
Inderjit and Shah	1948	Indian (Punjabis)		5%
Woo et al	1949	Mongoloids		10%
		Negroids		2%
Breathnach et al	1958	European		7 to 10%
		Yellow races		4 to 5%
		Africans		1%
Romanes et al	1972	Europeans		8%
Das et al	1973	Indian (U.P)		3.31%
Berry et al	1975	Various ethnic groups		7.4%
Agarwal et al	1979	Indians (Kanpur)	1,276	2.66%
Ajmani et al	1989	Nigerians	206	3.4%
Bilodi et al	2003	Nepalese	51	3.92%
Baaten et al	2003	Lebanese		0.82%
Castilho et al	2006	Brazilian	71	7.04%
Yadav et al	2007	North Indian	1020	3.5%
Murlimanju et al	2010	Indian	81	1.2%
Saheb et al	2010	South Indian	125	3.2%
Chandrasekaran et al	2011	South Indian	160	5%
Chakravarthi et al	2012	South Indian	80	6.25%
Masih et al	2013	Indian (Rajasthani)	200	6.5%
Chanwit et al	2013	Northeastern Thai		10.12%
Ivan do Nascimento et al	2013	Brazilians	134	4.48%
Aksu et al	2013	Turkish West Anatolian	106	7.50%
Saikia	2014	Indian (Assamese)	126	3.17%
Wadekar et al	2014	Indian	80	1.25%
Khamanarong et al	2015	Thai	706	2.83%
Present study	2021	Nigerian	96	1.04%

Table 7. Prevalence of shapes of incomplete metopic suture as reported by different authors

Researchers with year of study	Skulls studied	No of skulls studied	No of skulls with incomplete metopic suture	Shapes of incomplete metopic suture (%)							% Incidence of incomplete metopic suture
				Linear	U-shaped	V-shaped	Double type	Inverted U-shaped	H-shaped	Y shaped	
Inderjit and Shah, (1948)	Indians (Punjabis)							11.25	1.25	1.25	
Das et al., (1973)	Indian (U.P)					1.01		1.93		0.28	17.57
Agarwal et al., (1979)	Indian (Kanpur)	1,276	473	23.12		3.25		2.43	1.57	0.63	35.51
Ajmaniet al., (1983)	Nigerian	206	65	24.27		0.49		0.97	3.88		31.57
Castilho et al., (2006)	Brazilian	71	23	22.53	5.63		4.22				32.38
Chandrasekaranet al., (2010)	South Indian	160	64	17	15	7.5					40
Murlimanjuet al., (2011)	Indian	81	51	22.22	21%		19.7				62.9
Chakravarthiet al., (2012)	South Indian	80	31	18.75	10	10					38.75
Masihet al., (2013)	Indian (Rajasthani)	200	68	40	16	12					34
Aksuet al., (2013)	Turkish West Anatolian	160	108	39.40	23.10		5				67.50
Saikia, (2014)	Indian (Assamese)	126	42	16.66	12.96	3.96					33.33
Wadekaret al (2014)	Indian	80	18	16.25	5			1.25			22.5
Present study (2021)	Nigerian	96	30	16.67	7.29		7.29				31.25

The prevalence of complete metopism in Nigerian skulls in this present study of 1.04% is lower compared to the previous study in same Nigerian skulls by Ajmani et al., [28] whose prevalence was 3.40%. However, the incidence of incomplete metopism in this present study (31.25%) even if lower when compared to that of Ajmaniet al., – 31.57%, both prevalence almost falls within the same range. This shows that incidence of incomplete metopic suture from both studies is similar. The difference in prevalence of metopism may be as a result of differences in height of people in Northern and Southern part of Nigeria, as Bryce stated that metopism is more frequent in the taller individuals [40]. This may also be as a result of time interval both researches were carried out, that is, 1983 and 2021 which is more than 30 years difference. Ajmani et al., from their study observed metopic sutures in the upper, upper-middle and lower-middle parts of the frontal bone and also observed the H-shaped and inverted 'U-shaped' incomplete metopic sutures. However, from this present study there was no metopic suture in those positions and with those shapes.

5. CONCLUSION

The prevalence and morphometry of metopism in the 96 adult Nigerian skulls studied, complete metopism was 1.04% with a length of 127.0mm as against incomplete metopism of 31.25% making a total prevalence of 32.29%. The prevalence of metopic suture was slightly higher in males (33.85%) than in females (29.03%) and the linear, V-shaped and Double-type shapes of incomplete metopic sutures were observed of which the linear-shape metopic suture occurred the most. Sexual dimorphism with respect to incomplete metopism types and shapes revealed no association

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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