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Anatomical Study of the Pterion in a South African Population of KwaZulu-Natal

Estudio Anatómico del Pterion en una Población Audafricana de KwaZulu-Natal

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SUMMARY: Morphologically the Pterion marks the location of the four cranial bones, viz. frontal bone, sphenoid angle of the parietal bone, squamous part of the temporal bone and the greater wing of the sphenoid bone. Population-specific differences exists in the position and union of the Pterion. The Pterion is also an important neurosurgical landmark for surgical procedures, viz. Pterional/lateral approach, as it provides wide access to the base of the skull. This study aimed to determine the position and incidence of the various sutural patterns of the Pterion in a South African population of KwaZulu-Natal. This retrospective study was conducted bilaterally on 36 dry human skulls (11 females and 25 males) obtained from the Department of Clinical Anatomy at University of KwaZulu-Natal. Ethical clearance obtained from the Biomedical Research Ethics Committee. The morphometric parameters of the Pterion were measured using a digital Vernier caliper, while the morphological characteristics were examined using Murphy's classification scheme to determine (if any) laterality or sex differences exists. The mean distance of the Centre of the pterion from midpoint of zygoma was 44.4+/-4.1 mm in males and 45.1+/-4.6 mm in females. While the distance from frontozygomatic suture was 32.7+/-4.7 mm and 32.6+/-4.8 mm in males and females, respectively. Sphenoparietal type of pterion was most prevalent at 55.6 %, followed by the frontotemporal, stellate and epipteric type with an incidence of 27.8 %; 11.1 % and 5.6 %, respectively. No statistically significant difference for sex or laterality were documented in this study. The present study concluded that the sphenoparietal type of sutural pattern was most prevalent with an incidence of 55.6 %. While the epipteric type was the least prevalent. The comprehensive data about the position of the Pterion is important to neurosurgeons, forensics scientists and anthropologists.

KEY WORDS: Pterion; Pterional/lateral approach; Morphometry; SuturaL morphology.

INTRODUCTION

Knezi *et al*. (2020), defined the Pterion as a topographical antero-lateral point on the skull, located superior to the midpoint of zygomatic arch and posterior to frontozygomatic arch. It is derivative from the Greek term, "Pteron", which means wing. It unites the four cranial bones viz. frontal bone, sphenoid angle of the parietal bone, squamous part of the temporal bone and the greater wing of the sphenoid bone (Standring *et al*., 2016). Furthermore, this forms the floor of the temporal fossa, and is documented to be the weakest part of the skull (Garner *et al*., 2004).

The Pterion corresponds to the antero-lateral fontanelle of neonatal skulls (Williams *et al*., 1995), by the process of membranous ossification; the gap is filled by fibrous tissue, usually three months after birth (Broca, 1875; Rahilly & Müller, 1996; Standring *et al*., 2016). The joints of the calvaria are sutural, which ossify in membranes, the bones grow and leaves the un-ossified sutural membrane to connect to the perichondrium (Rahilly & Müller, 1996). The calvaria is narrow and may fracture easily (Hussain *et al*., 2010).

The Pterion overlies the anterior branch of the middle meningeal artery. This is the most common artery to be damaged. When damaged it produces extradural hematoma, that requires drainage through burr-hole surgery. The Pterion also present variations in the sutural pattern due to the fusion of constituent bones. Broca classified three types of Pterions, viz. sphenoparietal type, fusion of the sphenoid and parietal bone, frontotemporal type- cranial fusion of frontal and temporal bone and stellate type which is the fusion of all

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four cranial bones (Broca, 1875). In 1956, Murphy (1956) expanded the list to include the epipteric/flowers type in which a sutural bone is occasionally present in the centre Pterion (Fig. 1).

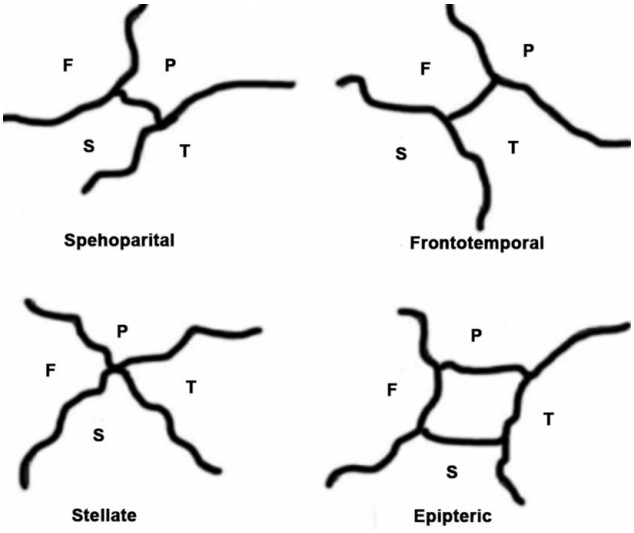

Fig. 1. Different variety types of the pterion according to Murphy (1956).

Several authors have studied the sutural morphology in different population groups (Table I). In accordance with literary reports, Matsumura *et al*. (1991), studied the Pterion formation and variations in 614 Japanese skulls and reported that the incidence of epipteric bones is observed to be more than 10 % in juveniles and adults (Table I). The afore-mentioned authors further recorded that the most common type was sphenoparietal, which was further classified into usual (49.8 %), high (19.4 %), low (3.4 %) and narrow (5.2 %) types. This was followed by the frontotemporal, stellate, and epipteric types, respectively. In addition, the results of their study suggested that the Pterion formation is seen in two phases: with the first phase seen before the occlusion of sphenoidal fontanelle and the second phase is when the fused Pterion and fusing epipteric bones began after 40 years of age (Matsumura *et al*., 1991).

Murphy (1956) reported that variations of the Pterion are presumably an outcome of a combination of environmental and genetic elements. Wang *et al*. (2006) suggested that varieties in the sutural patterns of the Pterion may be a result of genetic variation, subsequently resulting in population-specific differences. The Pterion also shows moderate variation and sexual dimorphism, and literary reports concluded that the location of the Pterion differed among population groups (Mwachaka *et al*., 2008; Iknur *et al*., 2009; Apinhamsit *et al*., 2011; Ukoha *et al*., 2013).

Several surgeons reported that it is essential to be familiar with the sutural morphology of the Pterion prior to surgical procedure (Kamath *et al*., 2015). Therefore, this study aimed to document the position and incidence of various sutural patterns of the Pterion in the South African population in KwaZulu-Natal.

MATERIAL AND METHOD

This retrospective study involved 36 dry human skulls of both sexes (25 males; 11 females) aged between 18-71 years of age, which was obtained from the Department of Clinical Anatomy at University of KwaZulu-Natal (Nelson R Mandela Medical School Campus). Ethical clearance was obtained from the Biomedical Research Ethics Committee (BE:00002996/ 2021). All data was saved onto a hard drive and stored in a locked cupboard within the Department of Clinical Anatomy.

Selection Criteria. Skulls with no bilateral presence of the Pterion due to wreckage or synostosis were excluded from this study. While skulls with a methodical shape and no disfigurement or malformation were included in this study.

Morphometric. During the data collection each skull was oriented to the Frankfurt's plane and all morphometric parameters were measured by the first author, three time to ensure intra-observer reliability and validity. For the morphometric measurements, a small radius circle was drawn to connect the four cranial bones making up the pterion and the centre of the circle (COP) was regarded as the centre of the Pterion. Each morphometric parameter was bilaterally

Table I. Prevalence of the sutural patterns of the pterion (in %).

Authors (year)	Population Group	Sphenoparietal (%)	Frontotemporal (%)	Stellate (%)	Epipteric (%)
Murphy (1956)	Australian	73.2	77	0.7	18.3
Oguz *et al*. (2004)	Turkish	88	10	0	2
Ilknur *et al*. (2009)	Anatolian	89.2	3.6	3.6	3.6
Apinhamsit *et al*. (2011)	Thailand	81.2	1.1	0.4	17.4
Ukoha *et al*. (2013)	Nigerian	75.5	19.6	1.8	3.6
Adejuwon *et al*. (2013)	Nigerian	86.1	8.3	5.6	0

measured using a digital vernier calliper, graduated to the last 0.01mm, between COP and various anatomical bony landmarks (Fig. 2).

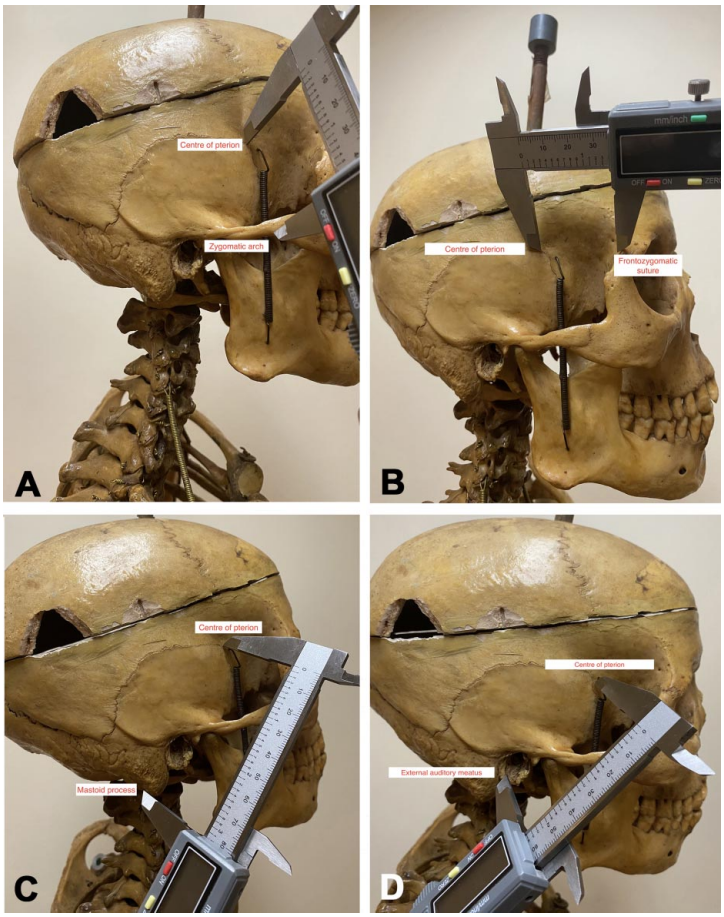

Fig. 2. A) Linear distance from COP to zygomatic arch. B) Linear distance from COP to Frontozygomatic suture. C) Linear distance from COP to mastoid process. D) Linear distance from COP to External acoustic meatus.

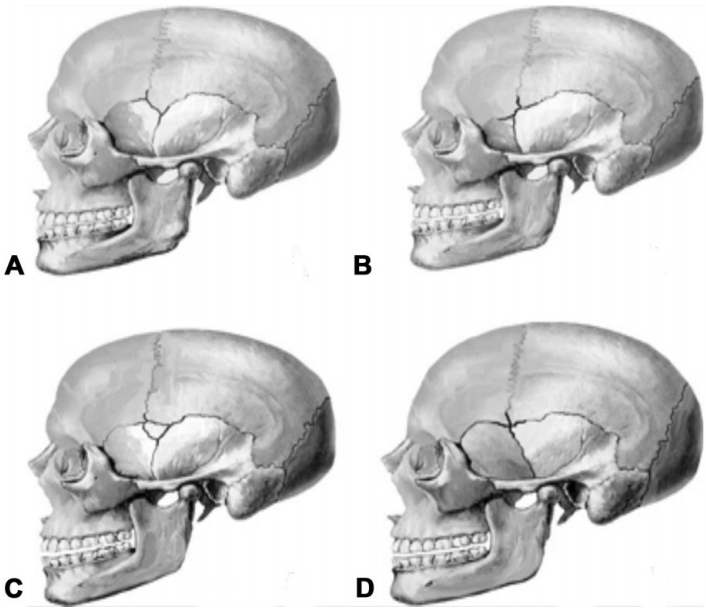

Fig. 3. Classification of the sutural patterns of the Pterion according to Murphy (1956) Key: A - sphenoparietal, B - frontotemporal, C - epipteric, D - stellate.

Morphological. The Pterion was classified in accordance with the Murphy (1956) classification scheme, viz. sphenoparietal, frontotemporal, epipteric, stellate (Fig. 3).

Statistical analysis. Data was analysed using SPSS (Statically Package for Social Sciences, version 20.0, SPSS. Inc, Chicago IL, USA). Descriptive statistics were used for this study, viz. Ranksum test, Braskal-Willis's test, Pearson Chi-squered test and Fisher's Exact test, to determine if a statistically significant relationship between the morphometric and morphological parameters of the Pterion, and sex and age exist. A P-value of <0.05 was considered statistically significant.

RESULTS

Morphometry. The mean distance from the COP to the frontozygomatic suture was 32.6+/-4.68mm, while the distance from the COP to the mastoid process was 82.6+/-5.72mm. The COP to the external acoustic meatus was 65.3+/4.50mm and lastly the COP to the midpoint of the zygomatic arch was 44.6+/-4.20mm (Tables II and III).

Morphology. The results of this investigation showed that all types of the Pterion were detected bilaterally in all 100 % cases. The Sphenoparietal being most prevalent with an incidence of 55.6 % overall (45.5 % females and 52.0 % males, respectively) (Table IV). The epipteric and stellate had a higher presence in males than in females, with an incidence of 8.0 % and 1.0 %, respectively (Table IV). Frontotemporal type was present 27.8 % of the overall sample and was more prevalent in females (54.5 % in females and 16.0 % in males) (Table IV). With regards to laterality, the Pterion sutural make-up was the same in all cases, hence symmetry was observed for all sutural patterns. There was not statistically significance difference between the sutural morphology and laterality (p-value = 1.000) (Table IV).

Validity and Reliability. The Interclass Correlation Coefficient was used to determine the reliability of the results. ICC>0.75 for this study.

Table II. Linear measurements from the COP to the nearest bony landmarks about laterality (in mm).

Sex & laterality	**Female**		**Male**	
	Left	**Right**	**Left**	**Right**
	(N=11)	**(N=11)**	**(N=11)**	**(N=11)**
		MZA		
Mean+ SD	45.3±4.74	44.8±4.63	43.6±3.49	45.3±4.46
Median	44.5	45.2	42.6	45.2
Min-Max	40.8-56.1	37.6-50.6	35.9-50.3	34.0-53.9
		FZS		
Mean+SD	32.35.57	32.9±4.05	31.8±4.88	33.6±4.4
Median	32.0	32.1	31.5	34.0
Min-Max	24.3-42.0	27.6-41.0	22.1-41.6	26.0-45.8
		EAM		
Mean+SD	64.5±3.40	67.0±4.92	63.9±4.55	66.2±4.47
Median	64.6	66.6	63.5	66.3
Min-Max	58.5-71.3	61.2-75.4	54.7-73.2	54.4-74.5
		MP		
Mean+SD	78.7±6.29	84.0±6.59	81.6±5.01	84.8±4.79
Median	81.7	85.6	81.9	85.3
Min-Max	67.6-85.2	70.1-92.8	67.5-92.1	70.5-91.3

Table III. Morphometric measurements of the pterion about sex (in mm).

Mean+/-SD	**Overall**	**Female**	**Male**	**P-value**
		MZA		
Mean	44.6±4.20	45.0±4.58	44.4±4.06	
Median(Q1-Q3)	45.0+/-4.58+/-	44.4+/4.06	44.6±4.20	0.567
Min-Max	34.0-56.1	37.6-56.1	34.0-53.9	
		FZS		
Mean	32.6±4.68	32.6±4.76	32.7±4.69	0.950
Median(Q1-Q3)	32.3	32.1	32.4	
Min-Max	22.1-45.8	24.3-42.0	22.1-45.8	
		EAM		
Mean	65.3±4.50	65.7±4.31	65.1±4.60	0.559
Median(Q1-Q3)	65.0	65.1	65.0	
Min-Max	54.4-75.4	58.5-75.4	54.4-74.5	
		MP		
Mean	82.6±5.72	81.3±6.84	83.2±5.12	0.211
Median(Q1-Q3)	82.5	82.2	82.7	
Min-Max	67.5-92.8	67.6-92.8	67.5-92.1	

Table IV. Sutural morphology of the pterion (in %).

Morphology	**Overall**	**FEMALE (N=22)**		**MALE (N=50)**		**P-value**
		Right	**Left**	**Right**	**Left**	
Frontotemporal	27.8 %	54.5 %	54.5 %	16.0 %	16.0 %	0.368
Sphenoparietal	55.6 %	45.5 %	45.5 %	52.0 %	52.0 %	1.000
Epipteric	5.6 %	0.0 %	0.0 %	16.0 %	16.0 %	0.368
Stellate	11.1 %	0.0 %	0.0 %	16.0 %	16.0 %	0.368

P-value for the sutural morphology and laterality was 1,000.

DISCUSSION

Many neurosurgeons attest that it is important to be familiar with the precise position of the pterion, as the pterion is an H-shape suture on the antero-lateral side of the skull and is often used as a point of surgical entrance during pterional surgeries (William *et al*., 1995). It provides access to the sylvian fissure, which gives access to the cerebral arterial circle (circle of Willis) and the middle meningeal artery. Internally the pterions location is from the optic canal

to the sphenoid ridge, while it is marked externally by a linear distance from the centre of the pterion to the midpoint of the zygomatic arch (Kamath *et al*., 2015).

Sutural morphology of the pterion. In this study, the sphenoparietal type is the most common to occur, with a prevalence of 55.6 % (Table V). This correlated with previous studies, as the sphenoparietal type was most common across different ethnic groups, viz. in Nigerians population - 82.1 %-84.81 % (Saxena *et al*., 1988; Asala & Mbajiourg, 1996); Asiatic Indian population - 95.1 % (Saxena *et al*., 1988); Northern Indians population – 72.0 % (Agarwal *et al*., 1980); Australian population 73.2 % (Murphy, 1956) and Japanese population 90.4 % (Matsumura *et al*., 1991) (Table V). These population-specific differences may be attributed to ethnicity, sex, and age (Kamath *et al*., 2015). Frontotemporal sutural pattern type had the second highest incidence in the present study (27.8 %), which corroborated the findings of previous studies who recorded a prevalence range of 4.35 %-41.1 % (Table V). This was followed by the stellate type with an incidence of 11.1 % in this study, which correlated with the findings of Kameth *et al*. (2016) (Table VI). The epipteric type was least prevalent (5.5 %), which was like the study conducted by Ukoha *et al*. (2013) (Table V).

Morphometry. In the present study, the mean distance for MZA was 45.1+/-4.5 mm and 44.1+/-3.9 mm in right and left side of the skull, respectively, which was higher than previous studies (Table VI). This study reported the mean distance of FZS was 33.4+/-4.3 mm on the right side and 31.9+/-5.0 mm on the left side, which was higher than the Nigerian, Indian, Thailand and Kenyan population (Table VI). However, it was lower in Turkish and Anatolian population (Table VI).

In the current study, the distance between the centre of the midpoint of the pterion to the zygomatic arch was 44.4 mm. These results were similar to a study carried out by Apinhamsit *et al*. (2011), as the authors concluded that the pterion's external location was 38.5 +/-4.38 mm superior to the zygomatic arch. Apinhasmit *et al*. (2011), further reported that pterion's position differs across population groups. Table VII compares this result with previous studies, the afore-mentioned morphometric parameter was recorded to be 40.0 mm in Nigerian and Turkish population groups, and 38.0 mm in the Kenyan, Thai, and Anatolian population groups. However, in the Indian population it was much smaller (36.0 mm). The frontozygomatic suture is approximately 32.6 mm in the current study, which was similar to the previous studies conducted by Ilknur *et al*. (2009) and Oghuz *et al*. (2004) in the Anatolian and Turkish skulls, respectively (Table VII). This study recorded that the location of the pterion was highest in the South African, Turkish and Nigerian population groups. However, it was located more posteriorly in the Thai, Anatolian, and Kenyan population groups.

Table V. The morphology of the Pterion in different ethnic groups.

Authors	Population group	Sphenoparietal (%)	Frontotemporal %)	Stellate (%)	Epipteric (%)
Murphy (1956)	Australian	73.2	7.7	0.7	18.3
Oguz *et al*. (2004)	Turkish	88	10	0	
Iknur *et al*. (2009)	Anatolian	89.2	3.6	3.6	3.6
Apinhamsit *et al*. (2011)	Thailand	81	1.1	0.4	17.4
Ukoha *et al*. (2013)	Nigerian	75	19.6	1.8	6.3
Adejuwon *et al*. (2013)	Nigerian	86	8.3	5.6	0
Kamath *et al*. (2016)	Indian	79.25	10.25	6.3	4.2
Present study	South African	55.55	27.8	11.1	5.55

Table VI. The ethnic variation in the position of the pterion with distance in millimetres (in mm).

Authors	Population Group	Mean distance +/-SD of the centre of the pterion					
		MZA			FZS		
		Right	Left	Overall	Right	Left	Overall
Oghuz *et al*. (2004)	Turkish	40.5±3.9	38.5±2.5	39.5±3.2	33.0±4	34.4± 3.9	33.5±4.0
Mwachaka *et al*. (2008)	Kenyan	38.9±3.5	38.2±3.5	38.55±3.5	30.3±4.3	30.4±3.4	30.4±4.3
Ilknur *et al*. (2009)	Anatolian	38±4	39± 4	38.5±4	35±5	35±5	35.5±5
Apinhamsit *et al*. (2011)	Thailand	38.5±4.4	38.3±3.7	38.4±4.1	31.12±4.89	33.4±3.8	32.3±4.3
Ukoha *et al*. (2013)	Nigerian	40.2±0.5	40.1±0.3	40.4±0.1	27.4±0.7	27.4±0.6	27.4±0.2
Adejuwon *et al*. (2013)	Nigerian	39.1±0.1	38.8±0.6	38.95±0.4	31.5±0.7	30.8±0.8	31.6±1.2
Kamath *et al*. (2016)	Indian	30.8±-0.8	35.5±3.8	33.15±2.3	31.0±4.1	30.92±4.1	30.3±4.1
Present study	South African	45.1±4.5	44.1±3.9	44.6±4.2	33.4±4.3	31.9±5.0	32.7±4.4

Table VII. Location of the Pterion according to previous studies.

Author (Year)	Location of the pterion (cm)
Gray (1918)	3.5 cm behind and 1.2 cm above FZ suture.
Abrahams *et al*. (2005)	3.5 cm behind and 1.5 cm above FZ suture (*4 cm above midpoint of zygomatic arch).
Sinnatamby (2006)	About 3 cm above the zygomatic arch and 3 cm behind the zygomatic process of the frontal bone (above the midpoint.
Lumley (2008)	3.5 cm posterior and 1.5 cm above the FZ suture.
Moore & Dalley (1999)	2 cm above zygomatic arch and 1cm posterior to the frontal process of the zygomatic bone (3–4 cm superior to midpoint of zygomatic arch).
Standring (2016)	2.5 cm above zygomatic arch and 2.5 cm posterior to lateral orbital margin.
Present study (2021)	4.4 cm above Zygomatic arch, and 3.26 cm posterior to frontozygomatic arch

CONCLUSION

In this study, sphenoparietal type was bilaterally the most prevalent sutural pattern of the Pterion. The position of the Pterion in an SA population within KwaZulu-Natal is approximately 4.40 cm above zygomatic arch and 3.26 cm posterior to frontozygomatic arch. The findings of the present study may contribute to the existing knowledge and may assist neurosurgeon with surgical procedures around the pterion region, such a burr-hole procedure. It may also assist forensic scientists in the identification of human remains.

Limitation and Future Recommendations. A limitation of this study was the small sample size; therefore, it is recommended that future studies investigate a larger sample size.

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MAHLALELA, M. G.; ISHWARKUMAR, S. & PILLAY, P. Estudio anatómico del pterion en una población sudafricana de KwaZulu-Natal. *Int. J. Morphol., 42(3)*:859-865, 2024.

RESUMEN: Morfológicamente, el pterion marca la ubicación de los cuatro huesos craneales: hueso frontal, ángulo esfenoidal del hueso parietal, parte escamosa del hueso temporal y el ala mayor del hueso esfenoides. Existen diferencias específicas de la población en la posición y unión del pterion. El pterion es también un hito neuroquirúrgico importante para los procedimientos quirúrgicos en el bordaje pterional/lateral, ya que proporciona un amplio acceso a la base del cráneo. Esta investigación tuvo como objetivo determinar la posición y la incidencia de los diversos patrones suturales del pterion en una población sudafricana de KwaZulu-Natal. Este estudio retrospectivo se realizó bilateralmente en 36 cráneos humanos secos (11 mujeres y 25 hombres) obtenidos del Departamento de Anatomía Clínica de la Universidad de KwaZulu-Natal. ALa autorización ética fue otorgada porel Comité Ético de Investigación Biomédica. Los parámetros morfométricos del pterion se midieron usando un calibrador Vernier digital, mientras que las características morfológicas se examinaron usando el esquema de clasificación de Murphy para determinar, si existe alguna lateralidad o diferencias sexuales. La distancia media del centro del pterion desde el punto medio del cigoma fue de 44,4+/-4,1 mm en hombres y de 45,1+/-4,6 mm en mujeres. Mientras que la distancia desde la sutura frontocigomática fue de 32,7+/-4,7 mm y 32,6+/-4,8 mm en hombres y mujeres, respectivamente. El tipo de pterion esfenoparietal fue el más prevalente con un 55,6 %, seguido del tipo frontotemporal, estrellado y epiptérico con una incidencia del 27,8 %; 11,1 % y 5,6 %, respectivamente. En el estudio no se documentaron diferencias estadísticamente significativas para el sexo o la lateralidad. Concluimos que el tipo de patrón de sutura esfenoparietal fue el más prevalente con una incidencia del 55,6 %. Mientras que el tipo epiptérico fue el menos prevalente. Los datos completos sobre la posición del pterion son importantes para los neurocirujanos, los científicos forenses y los antropólogos.

PALABRAS CLAVE: Pterion; Abordaje pterional/ lateral; Morfometría; Morfología de la sutura.

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