The Localization and Morphology of Pterion in Adult West Anatolian Skulls

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Abstract: The pterion is an important skull landmark because it is located where the frontal, the great wing of sphenoid, parietal, and squamous parts of the temporal bone junction. The objectives of this study were to determine the localization and the shape of pterion on skulls and to find out the distances between the pterion and some certain anatomic landmarks on neighboring structures. The study was performed on the skulls of 128 (256 sides) adult West Anatolian people. All of the morphometric measurements of the distances between the pterion and the anatomic landmarks were performed using a Vernier caliper with an accuracy of 0.1 mm. The pterion was classified into 4 types: the sphenoparietal, frontotemporal, stellate, or epipteric types. The incidences of types of pterion in the skulls were also found as the sphenoparietal type (85.2%), the epipteric type (8.2%), the stellate type (5.5%), and the frontotemporal type (1.1%). The mean (SD) distances from the center of the pterion to the zygomatic arch were measured as 40.02 (4.06) mm and 39.88 (4.01) mm; to the frontozygomatic suture, 31.80 (4.51) mm and 31.44 (4.73) mm; to the zygomatic angle, 41.54 (4.95) mm and 41.35 (5.14) mm; to the mastoid process, 82.48 (5.45) mm and 81.81 (5.50) mm; and to the external acoustic meatus, 53.29 (4.55) mm and 56.22 (4.60) mm, on the right and left sides, respectively. The mean (SD) distances between the foremost point of pterion and the anterior edge of the lateral wall of the orbit were 31.02 (5.78) mm and 32.31 (5.79) mm on the right and left sides, respectively. The localization and the shape of pterion are of importance because it is an anatomic landmark and should be of use in surgical approaches and interventions via the pterion.

Key Words: Pterion, morphometry, morphology, pterional approach

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Pterion is defined as an H-shaped small area formed by the junction of frontal, parietal, temporal, and sphenoid bones on the lateral aspect of the skull.[1–4] It is approximately 4.0 cm above the zygomatic arch and 3.5 cm behind the frontozygomatic arch.[2,4] This craniometric point is related to some structures such as the anterior branch of middle meningeal artery, Broca's motor speech area to the left, insula, the lateral (Sylvian) cerebral fissure, and so on in the cranial cavity.[5–7] Therefore, pterional fractures may tear the frontal branch of the middle meningeal artery, leading to extradural hematoma.[8,9]

Murphy,[10] in 1956, had described 4 types of pterion. The first type was named as the *sphenoparietal type* defined as a sutural pattern in which the sphenoid and parietal bones directly came together. The second type was named as the *frontotemporal type* in which there was a sutural pattern in which the frontal and temporal bones were in direct contact. The third one was named as the *stellate type*, which was formed as a point at the junction of 4 bones such as frontal, parietal, temporal and sphenoid bones. The fourth type was named as the *epipteric type* in which was there was a small sutural bone between the parietal bone and the greater wing of the sphenoid bone.

Pterion is a crucial intraoperative landmark for surgical approaches.[5,6,11,12] In neurosurgery, the pterional approach, which is characterized by making craniotomy from the pterion, is used in the treatment of various diseases such as removing complicated tumors as well as interventions on the middle cerebral artery and internal carotid artery and traumatic optic neuropathy.[5,13–17] Pterion keyhole approach may achieve the best operative effect for the treatment of intracranial anterior circulation aneurysms in a selective group of patients with several advantages over traditional craniotomy including minor tissue damage, less brain retraction, a superior cosmetic result, and a shorter duration of surgery.[5,11,14,16] Nowadays, the technique, which is characterized by opening a hole that is less than 1.5 cm at the pterion, provides minimal bleeding in patients with coronal craniosynostosis, less operation time, the minimization of the bony defects, and protection of the dural structures.[18]

The pterional approach may also be used in operations on the Broca's motor speech area.[19] The pterion is used as a surface landmark for the anterior branch of the middle meningeal artery.[9] However, there is racial variation in the location of the pterion.[6,12,20] In terms of symmetric and asymmetric mapping, symmetric and asymmetric pairing of pterion types of surgery is important.[3] The difference between the right and left sides is unclear; nevertheless, it is suggested that this should be borne in mind when operating on the left side of the skull because the relationship between the surface anatomic marking and the underlying soft tissues may vary.[21] The variations of the pterion (parietal, sphenoid, temporal) may cause surgical complications, and a minimally invasive technique should be used, performing the surgical procedure at the most appropriate area.[1]

The purpose of this study was not only to determine the incidences of the types of pterion but also to describe the localization of it, determining the distances from the pterion to crucial anatomic landmarks that may be significant for surgical procedure.

MATERIALS AND METHODS

One hundred twenty-eight craniums (256 sides) of West Anatolian people of unknown sex belonging to the Anatomy

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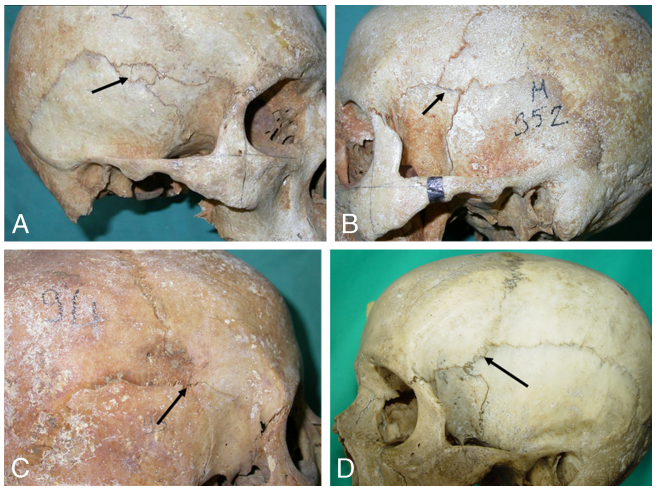


FIGURE 1. Types of pterion: epipteric type (A), sphenoparietal type (B), stellate type (C), and frontotemporal type (D).

Department Laboratory of Dokuz Eylul University Medical School were examined.

Morphologic Parameters

The types of the pterion of both sides of the craniums were determined according to Murphy's classification in all specimens.[10] These types were as follows: sphenoparietal type (S), frontotemporal type (S), epipteric type (E), and stellate type (S) (Fig. 1). Afterward, the incidences of the types were calculated.

Morphometric Parameters

Certain anatomic landmarks next to the pterion, which are of importance from the surgical point of view, were determined. They were the zygomatic arch, the frontozygomatic suture, the zygomatic angle, the mastoid process, and the external acoustic meatus. The distances between the center of the pterion and these landmarks were measured using a Vernier caliper with an accuracy of 0.1 mm. At the end of all measurements, the mean distances between the related structures were calculated. The identified distances between the structures, their abbreviations, and the number of the figure are as follows:

1. The vertical distance between the center of the pterion and the superior border of the zygomatic arch (*PZA*) (Fig. 2).



FIGURE 2. Morphometric parameters: (1) the vertical distance between the center of the pterion and the superior border of the zygomatic arch (*PZA*), (2) the distance between the center of the pterion and the posterolateral point of the frontozygomatic suture (*PFZS*), (3) the distance between the center of the pterion and the anterosuperior corner of the zygomatic arch (zygomatic angle) (*PZAN*), (4) the distance between the center of the pterion and the mastoid process (*PMP*), and (5) the distance between the center of the pterion and the external acoustic meatus (*PEMA*).

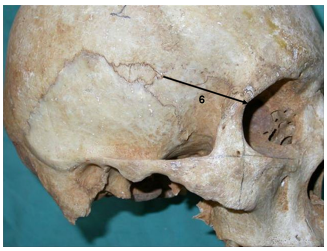


FIGURE 3. Only in the epipteric type of pterion (6), the mean distance between the most anterior point of pterion and the anterior edge of the lateral wall of the orbit (*EO*).

2. The distance between the center of the pterion and the posterolateral point of the frontozygomatic suture (*PFZS*) (Fig. 2).
3. The distance between the center of the pterion and the anterosuperior corner of the zygomatic arch (zygomatic angle) (*PZAN*) (Fig. 2).
4. The distance between the center of the pterion and the mastoid process (*PMP*) (Fig. 2).
5. The distance between the center of the pterion and the external acoustic meatus (*PEMA*) (Fig. 2).
6. Only in the epipteric type of pterion, the mean distance between the most anterior point of pterion and the anterior edge of the lateral wall of the orbit (*EO*) (Fig. 3) was measured.

RESULTS

When the morphologic features of pterion were taken into consideration, we have observed that 218 pterions (85.2%) were sphenoparietal type, 21 (8.2%) were epipteric type, 14 (5.5%) were stellate type, and 3 (1.1%) were frontotemporal type, in all sides (Table 1). There are no statistically significant differences between the types of the pterion.

The mean (SD) distances from the center of the pterion as the right and left sides to the zygomatic arch were 40.02 (4.06) mm and 39.88 (4.01) mm; to the frontozygomatic suture, 31.80 (4.51) mm and 31.44 (4.73) mm; to the zygomatic angle, 41.54 (4.95) mm and 41.35 (5.14) mm; to the mastoid process, 82.48 (5.45) mm and 81.81 (5.50) mm; to the upper border of meatus acousticus externus, 53.29 (4.55) mm and 56.22 (4.60) mm, respectively (Table 2). In skulls with an epipteric bone variation, the mean (SD) distance between the most anterior junction of pterion and the nearest lateral border of the orbit was 31.02 (5.78) mm and 32.31 (5.79) mm as the right and left sides, respectively (Table 2). Statistically, the distance between the center of the pterion and the external acoustic meatus was greater on the left side.

DISCUSSION

Types of Pterion

According to previous studies, the sphenoparietal type of pterion is the dominant form in humans.[6,7,9,12,20–23] In primate evolution, the

TABLE 1. The Comparison of the Incidences of the Types of Pterion According to Sides (n = 256)

		Side	
Pterion Types	**Total**	**Right**	**Left**
Sphenoparietal	85.2%	42.2%	43.0%
Epipteric	8.2%	3.9%	4.3%
Stellate	5.5%	3.2%	2.3%
Frontotemporal	1.1%	0.8%	0.3%

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TABLE 2. Mean and Associated Standard Deviations of the Linear Distance (in millimeters) Between Pterion and Specific Identifiable Bony Landmarks According to Sides

	Mean Value (SD), mm	
	Right	**Left**
PZA	40.02 (4.06)	39.88 (4.01)
PFZS	31.80 (4.51)	31.44 (4.73)
PZAN	41.54 (4.95)	41.35 (5.14)
PMP	82.48 (5.45)	81.81 (5.50)
PEMA	53.29 (4.55)	56.22 (4.60)
EO	31.02 (5.78)	32.31 (5.79)

The abbreviations used are explained in Figure 2.

anterosuperior segment of the squamous part of the temporal bone of lower primates became detached from its parent and incorporated into the posterosuperior angle of the greater wing of the sphenoid bone of humans, thereby changing the pterion pattern from the frontotemporal type of nonhuman primates to the sphenoparietal type of humans.[7] The current study also confirms that the sphenoparietal type is the most predominant type of the pterion (85.2%) (Table 1).

Oguz et al,[21] in 2004, had investigated the localization of the pterion and its relationship with the meningeal artery. They found that the sphenoparietal type of pterion was the most common (96% right side, 79% left side) type, followed by the frontotemporal type (4% right side, 17% left side), and, finally, the epipteric type (4% left side only). They had not found any stellate type in their study. We defined average ratios of these different types as the epipteric type (8.2%), the stellate type (5.5%), and the frontotemporal type (1.1%), respectively. The diversity among the types may result from the different sources of the craniums. In the current study, the examined skulls belonged to the West Anatolian people. Different from our study, Oguz et al[21] had studied only male skulls. This fact might lead to the differences between their results and ours.

Lee et al,[23] in 2004, reported that the incidence of the epipteric bone was 40.3%, and they did not mention the stellate type of pterion in their study. They reported that the difference might become a useful physical and anthropological approach for identification of the Korean skulls. The incidences of types of pterion have been shown comparatively in Table 3.

Pterion and Zygomatic Arch

The pterion was reported to lie 40.0 mm above the zygomatic arch.[2,4] We also found the mean (SD) distance between the center of the pterion and zygomatic arch to be 40.02 (4.06) mm and 39.88 (4.01) mm on the right and left sides, respectively. Ma et al[9] reported that the pterion was located 39 mm superior to the zygomatic arch in their study. Similarly, Oguz et al,[21] in 2004, found the mean (SD) distance between the center of the pterion and the zygomatic arch to be 40.5 (3.9) mm and 38.5 (2.5) mm on the right and left sides. Similarly, Apinhasmit et al[12] reported that the pterion was typically located 39 mm superior to the zygomatic arch in their study. Saxena et al,[20] in 1988, conducted a comparative study of pterion formation and its variations in the skulls of Nigerians and Indians, and they found the mean distance between the center of the pterion and the zygomatic arch to be 39.6 mm and 38.6 mm in Nigerians as well as 37.8 mm and 36.1 mm in Indians, on the right and the left sides, respectively. When the pterion was 40.0 mm superior to the zygomatic arch, it was named as *high pterion*. The frequency of high pterion was reported to be higher in Nigerians on both sides in that study. They reported that these observations might be of racial significance. Lee et al,[23] in 2001, reported that the metric location of the pterion was 36.9 (3.8) mm above the upper margin of the zygomatic arch in Koreans. Mwachaka et al[6] stated that the pterion had been 30.35 (3.40) mm and 30.34 (4.34) mm above the midpoint of the zygomatic arch on the right and left sides, respectively. These differences might have resulted from ethnic, genetic, or environmental factors.[9,24]

Pterion and Frontozygomatic Suture

Some surgical procedures have been identified for the pterional approach, which is used in the treatment of various diseases. The frontozygomatic suture is of special importance for the approach.[14] The frontozygomatic suture is located on the orbital rim 2.5 cm above the level at which the upper edge of the zygomatic arch joins the orbital rim and just below the junction point of the lateral and superior margins of the orbital rim. In addition, the pterion is located 3 cm behind the frontozygomatic suture.[14] The pterion has been reported to lie 30.0 to 35.0 mm behind the frontozygomatic suture.[2,4]

The current study has shown that the mean (SD) of pterion was 31.80 (4.51) and 31.44 (4.73) posterior to the frontozygomatic suture on the right and left sides, respectively. Among male Turks, Oguz et al,[21] in 2004, reported that the mean (SD) pterion was localized to be 33.0 (4.0) mm and 34.4 (3.9) mm behind the frontozygomatic suture on the right and left sides, respectively. The difference between our results and theirs might arise from the fact that the specimens of Oguz et al[21] had all been male skulls. It is known that male skulls have a larger size than that of female skulls.[4] Mwachaka et al[6] reported that the pterion lied 30.35 (3.61) mm posterior to the frontozygomatic suture in Kenyans. Our results are similar with this study. Previously, it had been reported that the pterion was located 26.8 (4.5) mm from

TABLE 3. Comparison of the Percentage of Pterion Types in Different Populations

	Type of Pterion, %			
Study/Populationn (skull)	**Sphenoparietal**	**Frontotemporal**	**Stellate**	**Epipteric**
Saxena et al[3], Nigerian, n = 40	87.79	10.11	5.06	3.79
Saxena et al[3], Indian, n = 72	95.3	3.46	1.38	11.79
Manjunath et al[22], South Indian, n = 172	93.55	3.52	2.93	17.3
Asala et al[26], Nigerian, n = 212	82.1	23.6	—	5.7
Lee et al[23], Korean, n = 149	76.5	—	—	40.3
Saxena et al[3], North Indian, n = 203	87.72	10.01	5.17	0
Oguz et al[21], Turkish, n = 26	88	10	0	2
Mwachaka et al[6], Kenyan, n = 50	66	15	7	12
Zalawadia et al[7], Western Indian, n = 42	91.7	2.4	1.2	4.8
Ma et al[9], New Zeland, n = 76	78	5	—	16
Current study, West Anatolian People, n = 128	85.2	1.1	5.5	8.2

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the frontozygomatic suture in Koreans.[23] Ma et al,[9] in 2012, also reported that the pterion was located at a mean of 26.6 (4) mm behind the posterolateral margin of the frontozygomatic suture. These differences may have resulted from ethnic or genetic factors.

Pterion and Zygomatic Angle

As far as we know, this measurement was performed for the first time in the current study. The mean (SD) distance between the center of the pterion and the zygomatic angle was measured as 41.54 (4.95) mm and 41.35 (5.14) mm on the right and left sides, respectively.

Pterion and Mastoid Process

As far as we know, this measurement was also performed for the first time in adults in the current study. We determined the mean (SD) distance between the center of the pterion and the mastoid process to be 82.48 (5.45) mm and 81.81 (5.50) mm on the right and left sides, respectively. In a study that was performed on skulls of newborn cadavers, Aydin et al,[25] in 2010, reported the same mean (SD) distance as 37.96 (5.72) mm and 37.55 (5.53) mm on the right and left sides, respectively.

Pterion and External Acoustic Meatus

This measurement was also performed for the first time to the best of our knowledge. The mean (SD) distance between the center of the pterion and the upper border of the external acoustic meatus was measured as 53.29 (4.55) mm and 56.22 (4.60) mm on the right and left sides, respectively.

Epipteric Type of Pterion and Surgical Difficulties

Ersoy et al,[1] in 2003, had determined some negative factors that may be caused by variations of the pterion in a study that was performed on 300 adult skulls. In that study, 44 (9%) skulls had epipteric bone. When the epipteric bone is present, the distance between the orbit and the pterion is shorter than what is expected. Although it has been proven that the pterional approach is the most convenient method for reaching the skull base, it is emphasized that the number of complications may increase when the epipteric bone is present. Considering these complications, only in cases with epipteric type of pterion, Ersoy et al[1] measured the distance between the most anterior junction of the bones forming the pterion and the lateral orbital rim. The mean (SD) distances were 27.9 (5.6) mm and 33.2 (5.0) mm on the right and left sides, respectively. In the current study, 21 (8.2%) skulls had epipteric type of the pterion. We found that the mean (SD) distance between the most anterior junction of the pterion and the nearest lateral border of the orbit is 31.02 (5.78) mm and 32.31 (5.79) mm on the right and left sides, respectively. The results of these 2 studies are similar, but the mean distances are longer than that in the study of Ersoy et al[1] on the right side. Their materials were gathered from Middle Anatolia in the 19th century, but this study was conducted on West Anatolian skulls; this case may be the cause of the differences from the other studies.[26]

CONCLUSIONS

In the current study, our limitation was that we did not have any information about the sex of the skulls. However, we believe that the information on both shape of the pterion and its localization may be considered as significant data. The data may also have worth during surgical procedures.

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