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Original Research Article

ANATOMICAL VARIATIONS OF INCA BONE IN ADULT HUMAN EGYPTIAN SKULLS

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ABSTRACT

Background: The Inca bone is integral part of the occipital bone of the skull in its interparietal region and appears during radiological examination of the skull.

Aim of the work: This study aimed to estimate the incidence rates and variations of interparietal (Inca) and preinterparietal bones in adult human Egyptian skulls .

Materials and methods: In the present study 60 dry human Egyptian skulls (37 males and 23 females) were examined to determine the incidence rates of Inca and preinterparietal bones with detailed measurements for Inca bone in mm using electronic digital caliber.

Results: The incidence rates of Inca and preinterparietal bones were higher in male skulls than female skulls and the interparietal or Inca bone was observed in only 4 skulls (6.66%) while the preinterparietal bone was observed only in 2 skulls (3.33 %) .

Conclusion: The presence of the Inca and preinterparietal bones was rare in the human Egyptian skulls and their incidence rates were higher in male skulls .

KEY WORDS: Inca, Interparietal Bone, Preinterparietal Bone.

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INTRODUCTION

The interparietal area of squamous part of occipital bone above the level of highest nuchal line develops in membranous ossification from two pairs of ossification centers and additional third pair for the upper central part of the interparietal region. Sometimes, the parts that developed from these previous ossification centers fail to fuse and lead to the occurrence of different anomalous ossicles [1,2]. The separate bones (single or multiple) that developed from the first two pairs of ossification centers have been known as Inca bones while that developed from the additional third pair of ossification centers have been known as preinterparietal bones [3]. Also, Shah et al. [4] added that the squamous part of occipital bone formed of two parts; upper interparietal and lower supraoccipital parts that may be separated from each other by a suture . The variations of Inca bones depend on the possible fusion and non fusion of ossification centers of the interparietal area of squamous part of occipital bone [5-7] . The Inca bone may be divided by single or multiple longitudinal sutures leading to bipartite or tripartite Inca bones [8]. Also, according to the number of the ossification centers in the membranous part of the interparietal

area , failure of fusion between these ossification centers may result in formation of three pieces of bones on either side of the midline of the interparietal region as a maximum number (upper, lower and lateral pieces) [9]. So the variations in size, shape, number and position of Inca bones are very common [10]. Khan et al.[9] revealed that, the developed bone in the upper central part of the interparietal region and behind the lambda is considered a part of the interparietal (Inca) bone and is not a preinterparietal bone . The incidence rate of the complete Inca bone is low in Asia and Europe [11], also the authors added that the incidence rate of wormian bones in the skulls that have Inca bones was higher than the skulls without these bones. In Walulkar et al.[12] study that was conducted on 175 skulls, the Inca bone was appeared in 5 skulls (3 male skulls & 2 female skulls) and the measurements of these Inca bones were observed in table (1).

Table 1: Measurements of Inca bones in Walulkar et al. [12] study.

Shape of Inca bones	Maximum breadth	Maximum length
Single median	42 mm	80 mm
Partial	38 mm	45 mm
Bipartite	45 mm 41 mm	72 mm 53 mm
Tripartite	47 mm	98 mm

Accordingly, this study aimed to put a light on the incidence rates, number of pieces or fragments and sexual dimorphism of Inca and preinterparietal bones in adult human Egyptian skulls with more detailed description of Inca bone dimensions and this has an important value specially for radiologists, neurosurgeons and in forensic medicine to avoid false diagnosis.

MATERIALS AND METHODS

Sixty adult human dry skulls (37 males and 23 females) were used in this work. The skulls were collected from department of Human Anatomy and Embryology and from medical students (used them for studying) in Faculty of medicine, Zagazig University, Egypt. The study was approved by Institutional Review Board, faculty of medicine, Zagazig University (ZU-IRB #5170-27-1-2019). The sex determination of the skulls was based on standard facts as described by Saukko & Knight [13] & Standring [14].

Inclusion criteria: All the skulls used in this study were normal without any pathological deformities and had erupted wisdom tooth in the upper jaw.

The skulls were examined for the sex , presence of the interparietal and preinterparietal bones and the coexistence of the two bones together, also the number of fragments of these bones were observed. The maximum length and breadth of the interparietal bone in each skull were measured in mm by electronic digital caliber (three readings were taken for each parameter and the maximum reading was recorded). To decide the maximum length of Inca bone a longitudinal axis was drawn as a straight line between the widest points along the margin of the bone , also the maximum breadth was obtained by drawing a perpendicular axis at the maximum width of the bone [12] as shown in Figs. (1&2).

Statistical Analysis: For statistical study of the results of the present study SPSS program (version 23, Armonk, New York : IBM Corp.) was used. The incidence rates of Inca and preinterparietal bones were determined. Also, the maximum length, maximum breadth of Inca bones, the mean value of each parameter and the standard deviation (SD) were expressed.

RESULTS

In the present study the presence of interparietal (Inca) and the preinterparietal bones were not observed in most examined skulls as shown in (Fig. 3). The incidence rates of these bones were shown in table (2) in which the interparietal bone was observed only in 4 skulls with incidence rate was (6.66%) among them 3 males (Figs. 4,6,7) and one female (Fig. 5) while the preinterparietal bone was observed only in 2 male skulls with incidence rate was (3.33%) (Figs. 8,9).

There was no coexistence of the interparietal (Inca) and the preinterparietal bones together in all the examined skulls. The interparietal (Inca) bone was single in 2 skulls , one male (Fig. 4) & one female (Fig. 5) and fragmented in 2 male skulls, one of these fragmented Inca bones was bipartite as shown in fig. (6) and the other bone was tripartite as shown in fig. (7) while the preinterparietal bone was single in one

male skull (Fig. 8) and consisted of 2 parts in the other male skull (Fig. 9). The previous results were tabulated in table (3)and measurements of the Inca bones were shown in table (4).

Fig. 1: Photograph showing measurement of the maximum length of inca bone by using electronic digital caliber .

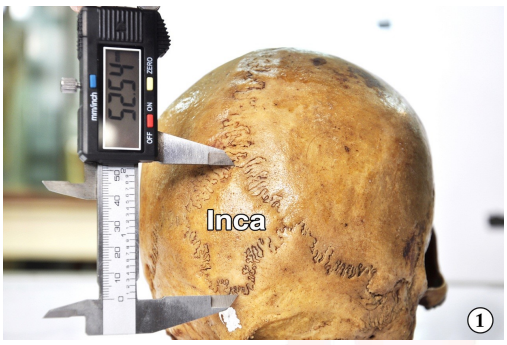

Fig. 2: Photograph showing measurement of the maximum breadth of inca bone by using electronic digital caliber.

Fig. 3: Photograph showing no Inca or preinterparietal bone . (1) Sagittal suture & (2 & 3) Lambdoid sutures.

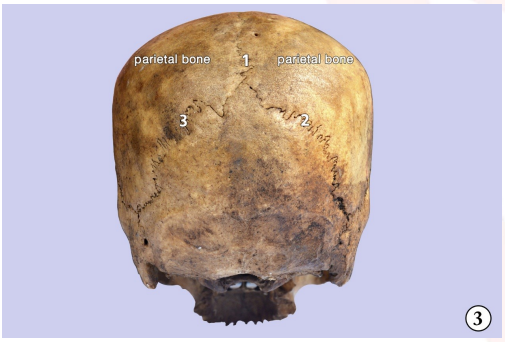

Fig. 4: Photograph showing single median Inca bone (arrow) in male skull . (1) Sagittal suture & (2) Lambdoid suture & (3) Suture separating the interparietal (Inca) bone from the rest of squamous occipital bone.

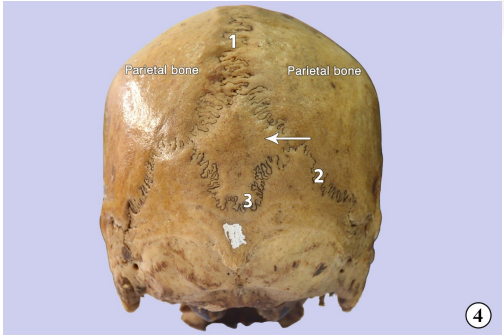

Fig. 5: Photograph showing single median Inca bone (arrow) in female skull . (1) Lambdoid suture & (2) Suture separating the interparietal (Inca) bone from the rest of squamous occipital bone .

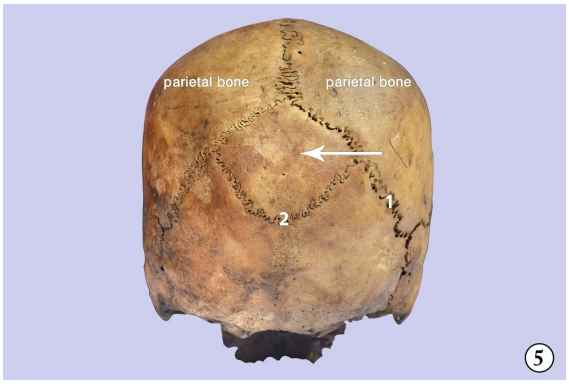

Fig. 6: Photograph showing bipartite Inca bone in male skull . It divided into two parts (1&2) by a suture (3) & (4) Suture separating the interparietal (Inca) bone from the rest of squamous occipital bone .

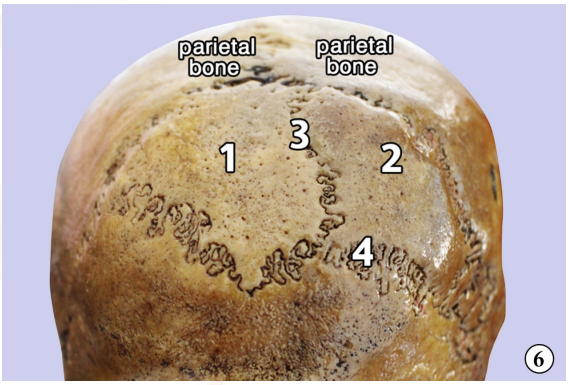

Fig. 7: Photograph showing tripartite Inca bone in male skull . It formed of three parts (1&2&3) . Also wormian bone (arrow) was observed at the right lambdoid suture .

Fig. 8: Photograph showing single preinterparietal bone in male skull (arrow) behind the lambda.

Table 2: Incidence percentage (%) of Inca bone and Preinterparietal bone in male and female skulls.

Inca bone alone %			Preinterparietal bone alone %			Coexistence of both bones together %
Total	Male	Female	Total	Male	Female	
6.66	5	1.66	3.33	3.33	0	0

Table 3: Number of male and female skulls with fragmentation of Inca and preinterparietal bones.

Fragmentation of Inca bone in 4 skulls						Fragmentation of Preinterparietal bone in 2 skulls				
Single		Bipartite		Tripartite		Single		Bipartite		Tripartite
Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
1	1	1	0	1	0	1	0	1	0	0

Fig. 9: Photograph showing preinterparietal bone in male skull formed of two parts (1&2).

Table 4: The maximum length, maximum breadth of Inca bones (mm).

Skull	Maximum Length (mm)	Maximum breadth (mm)
Inca in fig. 4	52.54	43.57
Inca in fig. 5	54.65	50.28
Inca in fig. 6	91.67	56.12
Inca in fig. 7	61.86	33.98
Mean value ± SD	65.18 ± 18.1	45.98 ± 9.5

SD = Standard Deviation

DISCUSSION

The rate of incidence of the Inca bones differs among different races (15% in Nigerians ,4.8% in North Americans , 1.2% in Europeans , 0.8% in Australians and 2.8% in Turkish) [15]. The membranous part of the occipital bone is ossified from three pairs of ossification centers and failure of fusion of the parts that developed from these previous centers (completely or partially) results in the formation of single or fragmented Inca bones [12]. Srivastava [16] and Sharma et al.[11] stated that the squamous occipital bone developed in membranous ossification above the level of highest nuchal line and this region may be separated as Inca bone while the rest of the bone below the level of the highest nuchal line developed in cartilaginous ossification , finally the two parts of squama fuse in the 3rd post natal month. The Inca bone may be present as a single bone, two halves or formed of three parts and sometimes failure of fusion of additional pair of ossification centers present in front of Inca bone may result in formation of preinterparietal bones [11,17]. The presence of the interparietal and preinterparietal bones is rare , unusual and may lead to complications in the neurosurgery as in burr-hole surgery [17,18].

In a study by Murlimanju et al. [17] conducted on 78 adult skulls , three skulls (two female and one male) showing Inca bone that was single in two skulls and fragmented in the other skull . Also , in the same study there were 8 skulls (5 female and 3 male) showing preinterparietal bones that were single in 5 skulls and fragmented in 3 skulls . In another study by Sharma et al. [11] conducted on 270 skulls , there was single undivided Inca bone in one male skull. Nagarajan & Ganesh [19] revealed that in a study conducted on 60 skulls , 8 Inca bones were observed (Inca bone was single in 7 skulls and bipartite in one skull only). In the present study the Inca bone was present only in 4 skulls (6.66%) . The interparietal (Inca) bone was single median in 2 skulls (one male and one female) and fragmented in 2 male skulls (one of these fragmented Inca bones was bipartite and the other bone was tripartite). According to Walulkar et al. [12] there are three ossification centers on each side of the midline of the membranous part of the interparietal area for three pieces of bones (upper , lower and lateral pieces) , so as in fig. (7) the presence of two fragments of Inca bone on the left side of the midline of the occipital bone can be explained by occurrence of fusion between the ossification centers of the upper and lower pieces while there was defective fusion between the ossification center of the lateral piece with that of the upper and lower pieces . Pal et al. [3] stated

that the preinterparietal bone was single and Pal [20] added that it may be formed of two parts (fragmented). In the present study , the presence of preinterparietal bone was only in 2 male skulls (single in one male skull and consisted of two parts posterior to the lambda in the other male skull). The incidence rates of Inca and preinterparietal bones in the present study were compared with other available studies as in table (5).

Table 5: The incidence rates of Inca and preinterparietal bones in various studies.

Study	Incidence Percentage	
	Inca bone	Preinterparietal bone
Srivastava [21]	0.8	2.99
Singh et al. [22]	1.6	0.8
Saxena et al. [1]	2.5	12.5
Yücel et al. [15]	2.8	Not Studied
Zambare [23]	0.9	Not Studied
Murlimanju et al. [17]	3.8	10.3
Marathe et al. [18]	1.3	Not Studied
Kumud [24]	2.7	Not Studied
Nirmale et al. [8]	4.05	Not Studied
Walulkar et al .[12]	2.86	Not Studied
Shah et al. [4]	3.81	2.86
Nagarajan & Ganesh [19]	13.33	Not Studied
Present study	6.66	3.33

Walulkar et al. [12] revealed that the maximum and minimum length of Inca bone was 98 mm and 45 mm respectively while its maximum and minimum breadth was 47 mm and 38 mm respectively. In the present study , the maximum and minimum length of Inca bone was 91.67 mm and 52.54 mm respectively while its maximum and minimum breadth was 56.12 mm and 33.98 mm respectively.

CONCLUSION

The incidence rate of the Inca bone is variable in different human races and in this study the incidence of Inca or interparietal bone (6.66%) was higher than that of the preinterparietal bone (3.33%) in the human Egyptian skulls . Also, the incidence rates of both bones were higher in male skulls. During radiological examination, the presence of interparietal (Inca) and preinterparietal bones may lead to a false diagnosis of fracture of the skull. Also these bones may lead to some complications during neurosurgery as in burr - hole surgery. So, knowledge of the anatomical variations of interparietal and preinterparietal bones in human Egyptian skulls may be useful for neurosurgeons, radiologists and in forensic medicine for establishing the identity of the deceased.

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Conflicts of Interests: None

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