NATURALISTA CAMPANO
ISSN: 1827-7160
Volume 28 Issue 1, 2024

The Interparietal (INCA) Bones: The Cranioscopic and Craniometric Investigation

V.B.Shadlinski[1], A.S.Abdullayev[2]

[1]Honored Scientist, member of RAS, Azerbaijan Medical University, Department of Human Anatomy and Medical Terminology, doctor of medical sciences, professor.
[2]Associate professor, Ph.D. in Medicine, Head of department, Azerbaijan Medical University, Department of Human Anatomy and Medical terminology.

Corresponding author: A.S.Abdullayev
E-mail: anarabdullaev72@mail.ru

Summary: The aim was to study the interparietal bone in terms of age and gender aspects.
Materials and research methods. The material of the study was 200 (86 males and 114 females) skulls aged 16-74 years from the craniological collection of the museum of the Department of Human Anatomy and Medical Terminology of Azerbaijan Medical University. The ages of the skulls were determined based on the preservation of sutures and the condition of the teeth. Cranial measurements were made, and the anteroposterior (length) sizes and width of the interparietal bones were also determined using an electronic caliper. Skulls with the interparietal bone were also studied by computed tomography and endoscopy.
Research results. The study identified the os interparietal in three male skulls of adulthood. The frequency of occurrence of the os interparietale in the craniological material we examined was 1.5%. On the first skull, the anteroposterior (length) size was 40.59 mm, and the width was 62.36 mm. On the second skull, the anteroposterior dimension (length) of the interparietal bone was 33.63 mm and the width was 54.14 mm. On the third skull with interparietal bone, the anteroposterior dimension (length) of the interparietal bone was 43.35 mm and the width was 56.27 mm.
Conclusion. In our study of 200 skulls, the interparietal bones, or Inca bones as they are commonly called, were found on three of them; all three skulls were male. Particularly noteworthy is the identical location and almost identical shape of these bones.

Keywords: interparietal bones, Inca bones, skulls, male skulls, female skulls, ossification centers.

1. Introduction

Ossa incae, otherwise called the incarial bones, interparietal bone, Inca bone, or intercalary bone. This is a single bone found in the lambda region; it is actually a detached portion of the squama of the occipital bone, which lies between the posterior sides of the two parietal bones. The suture that separates the Inca bone from the rest of the occipital bone is called sutura mendosa (Seshayyan, 2016). There is disagreement in the literature regarding the boundaries and ossification of the membranous part of the occipital bone, known as the interparietal, in humans. The issue still remains as to how to establish their identity in the skulls of individuals of advanced age (Srivastava, 1992; Matsumura, Uchiumi, Kida,

Ichikawa, and Kodama, 1993). Meckel (1890) explained that the occipital squama develops from four pairs of ossification points. Of these, the first pair, which appears in the 10th week of intrauterine life, corresponds to the lower part of the occipital squama, and the remaining 3 pairs correspond to the upper part, with the 2nd pair serving for the development of the lower and middle parts of the upper part. The 4th pair develops at the apex of the lambda, and the 3rd pair is above and on the sides of the second pair of ossification points. At the border between the first and second pairs of ossification points, there is an embryonic fissure. Its remains are retained until the end of intrauterine life or even longer; this is the so-called Fissura transversa squamae occipitis embryonalis. If the ossification points of the occipital squama do not merge with each other (they normally merge in the fifth month of intrauterine life), then on the skull of an adult, they can represent separate abnormal bones. The last three pairs can merge into one bone. The horizontal suture separates it from the lower half of the occipital squama. Saint-Hilaire GE. (1823) called this bone interparietal bone (os interparietale) due to its similarity to the same bone of some animals.

According to Matsumura et al. (1993), the interparietal part of the occipital bone is the result of the development of the 3 pairs of ossification centers: 1 primary pair and 2 secondary pairs; an additional 4th pair is occasionally observed. The so-called separated interparietal bones (Inca bones) are formed by a failure of fusion between the primary and secondary centers. They are not formed by a failure between the supraoccipital and interparietal parts. The preinterparietal bones developed from the additional fourth pair of interparietal ossification centers. Shape and territory of location clearly differentiate the preinterparietal bones from other anomalies in the Lambda region. Pal, Tamankar, Routal, and Bhagwat (1984) indicated that two pairs of centers are the source of the development of the squamous occipital bone, above the highest nuchal line. Occasionally, the third pair, known as the preinterparietal, participates in this development and presents anterior to the interparietal centers. Srivastava (1992) has a slightly different opinion: the membranous part of the occipital bone develops above the superior nuchal lines by 3 pairs of centers: 1 for the intermediate segment and the other 2 for the lateral and medial plates.

Saxena, Chowdhary, and Jain (1986) provided an investigation, in which the material for the study was 40 adult Nigerian skulls. The study showed the occurrence of a single interparietal bone in one skull only, with an incidence of 2.5%. Multiple and unilateral interparietal bones were not observed in this study.

Hensel (1874) expressed the opinion that the appearance of the interparietal bone is associated with the expansion of the auditory organ. This is confirmed by the fact that the interparietal bone is highly developed in animals with a strong development of the auditory organ, for example, in rodents. In animals, for example, in a pig, the ossis petrosi cavity is poorly developed, and therefore the interparietal bone does not occur in them.

Shapiro and Robinson (1976) studied the skulls of vertebrates and came to the conclusion about the presence of the interparietal bone in them, which is the following: in the alligator, some birds, and many mammals (especially marsupials), intramembranous ossification centers (i.e., postparietal or interparietal bones) can be observed behind the parietal bones. According to the authors, the above-mentioned centers normally fuse to form a single complex, the interparietal bone, which unites with the supraoccipital segment in humans and other mammals. In some species (e.g., Sirenia, Sea Cow), the interparietal bone unites with the parietal bones; in other forms (e.g., Lepus, Hare), it remains separate.

According to Hanihara and Ishida (2001), in the East Asian region, the frequencies of the Os Incae are getting lower from south to north, in favor of clinality. Central Asian, Northeast Asian, and Australian samples, and to a lesser extent, the European sample,

including the UK series, have this trait that is much less common.The prevalence of Inca bones is relatively high in populations of East Asian origin, such as Arctic Eskimos, American Indians, and Tibetans/Nepalese. However, this trait is not limited to East Asians and related populations; it also occurs in Subsaharan Africa. This indicates that the Inca bone is not a unique regional East Asian feature.

A sufficient amount of craniological material allows us to study the localization, shape, and size of the interparietal bones (fig. 1, A and B). Some scarcity and inconsistency of data, in our opinion, requires an even more thorough study of the interparietal bone using significant craniological material, taking into account the age and gender of the skull. Based on the above, we set a goal to study the interparietal bone in terms of age and gender aspects.

A B

Fig. 1. Skull of a 16-month-old child (A: anterior projection, B: posterior projection). On the posterior projection, the interparietal bone is visible (from the craniological collection of the museum of the Department of Human Anatomy and Medical Terminology of the Azerbaijan Medical University).

2. Material and Research Methods

The material of the study was 200 (86 males and 114 females) skulls aged 16-74 years from the craniological collection of the museum of the Department of Human Anatomy and Medical Terminology of Azerbaijan Medical University. The ages of the skulls were determined based on the preservation of sutures and the condition of the teeth. Cranial measurements were made according to Langley, Jantz, Ousley, Jantz, and Milner (2016). The anteroposterior (length) sizes and width of the interparietal bones were also determined using an electronic digital caliper (resolution: 0.01 mm, accuracy: ±0.02 mm). Skulls with the interparietal bone were also studied by computed tomography and endoscopy.

3. Research Results

The study identified the interparietal bone in three male skulls in adulthood. The frequency of occurrence of the interparietal bone in the craniological material we examined was 1.5%. On the first skull, the anteroposterior (length) size was 40.59 mm, and the width was 62.36 mm (Fig. 2A-2B). It should also be noted that the left asterionic bone was identified on this skull.

The anteroposterior dimension of this bone was 11.62 mm, with a width of 8.19 mm. The results of cranial measurements of the first skull with the interparietal bone are presented in Table 1. On the second skull, the anteroposterior dimension (length) of the interparietal bone was 33.63 mm and the width was 54.14 mm (Fig. 3). This skull showed the bilateral location of the occipitomastoid suture bone. The anteroposterior dimension of the left occipitomastoid suture bone was 4.31 mm, and the width was 4.81 mm. The anteroposterior dimension of the right occipitomastoid suture bone was equal to 7.83 mm, and the width was equal to 5.44 mm. The results of cranial measurements of the second skull with the interparietal bone are presented in Table 2.

An interesting fact is that on both skulls studied, endoscopy of the internal base showed the incomplete type of the caroticoclinoid foramen. On the first skull, unilateral (right), and on the second skull, bilateral locations of the foramen were noted (Fig. 4).

Figs.2A and 2B. The first skull with the interparietal bone (A) and its CT reconstruction (B): the interparietal bone is indicated by the green circle.

A B

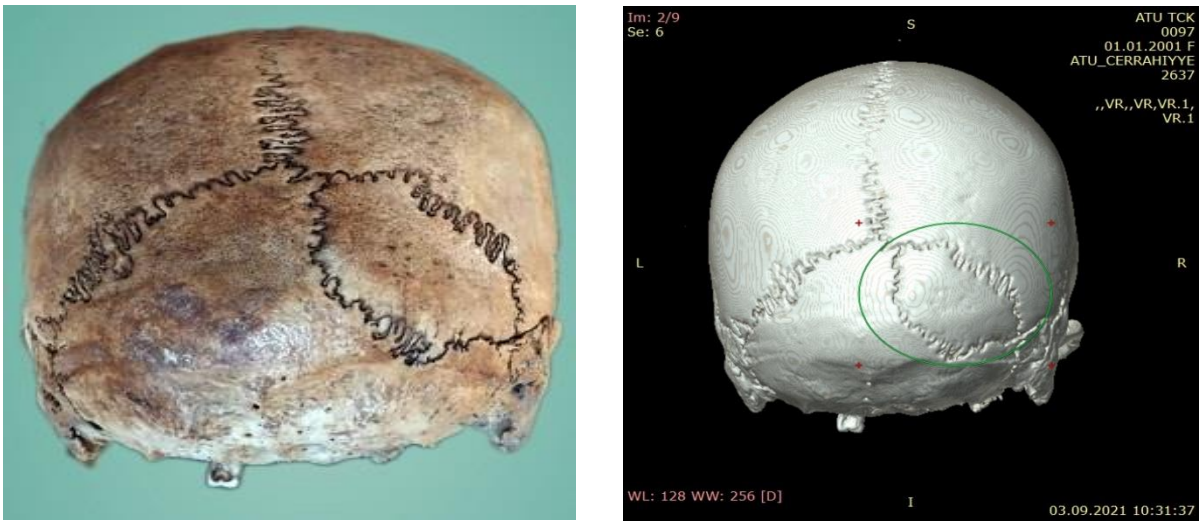


Fig. 3. The second skull with os interparietale.

On the third skull with interparietal bone that we studied, the anteroposterior dimension (length) of the interparietal bone was 43.35 mm and the width was 56.27 mm (figs. 5A-5C). The third skull showed the permanent metopic suture (fig. 6). Cranial measurement data are summarized in Table 3. The Wormian bones of the lambdoid suture were also identified on the skull: one bone was on the right side, and four bones were on the left side. The data for their measurements are given in Table 4.

Table 1. Dimensions of the studied first skull, (in mm).

Maximum cranial length (g-op)	176	Orbital breadth (d-ec), L	37.38
Naso-occipital length (n-op)	170	Orbital breadth (d-ec), R	39.17
Maximum cranial breadth (eu-eu)	140	Orbital height, L	31.14
Bizygomatic breadth (zy-zy)	125	Orbital height, R	30.24
Basion-bregma height (ba-b)	135	Biorbital breadth (ec-ec)	90.17
Cranial base length (ba-n)	107	Interorbital breadth (d-d)	22.17
Basion-prosthion length (ba-pr)	91.17	Frontal chord (n-b)	93.21
Maxillo-alveolar breadth (ecm-ecm)	51.18	Parietal chord (b-l)	112.21
Maxillo-alveolar length (pr-alv)	48.17	Occipital chord (l-o)	107.96
Biauricular breadth (ra-ra)	118.16	Foramen magnum length	31.11
Nasion-prosthion height (n-pr)	70.41	Foramen magnum breadth	29.17
Minimum frontal breadth (ft-ft)	99.61	Mastoid height (po-ms)	31.69
Upper facial breadth (fmt-fmt)	101.17	Biasterionic breadth	112.21
Nasal height	50.83	Bimaxillary breadth (zma-zma)	91.13
Nasal breadth	25.72	Zygomaticoorbitale breadth	44.16

No female skulls with interparietal bone were found in our study. The ages of the first two skulls varied in the range of 22–35 years, and the third male skull was in the range of 36–60 years. The latter is confirmed by the degree of synostosis evident at the margins of the interparietal bone (Fig. 5A). All three skulls had interparietal bone localization similar to each other—on the right side of the occipital squama. Their shape was also almost identical.

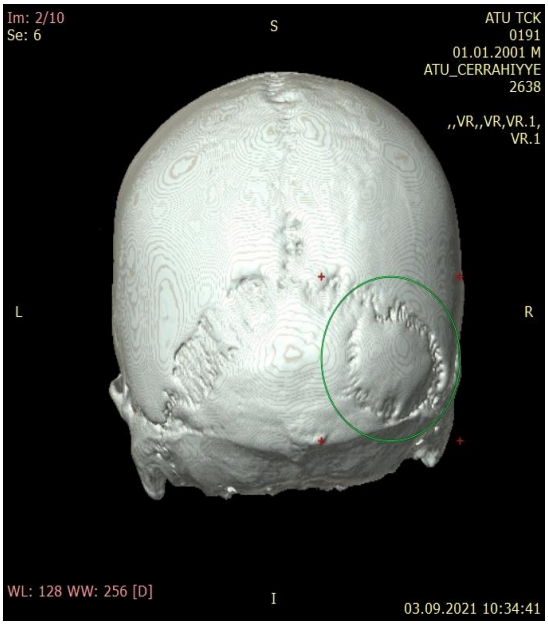
Table 2. Dimensions of the studied second skull, (in mm).

Maximum cranial length (g-op)	178	Orbital breadth (d-ec), L	37.21
Naso-occipital length (n-op)	173	Orbital breadth (d-ec), R	35.61
Maximum cranial breadth (eu-eu)	140	Orbital height, L	31.47

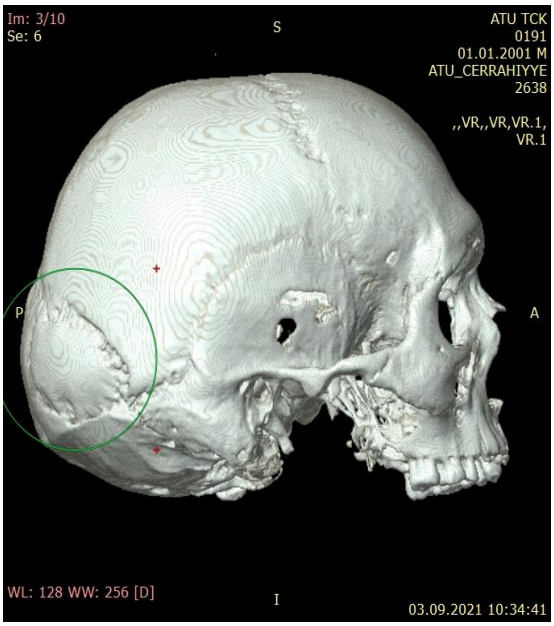
Bizygomatic breadth (zy-zy)	142	Orbital height, R	30.13
Basion-bregma height (ba-b)	131	Biorbital breadth (ec-ec)	90.7
Cranial base length (ba-n)	90.7	Interorbital breadth (d-d)	18.24
Basion-prosthion length (ba-pr)	91.6	Frontal chord (n-b)	96.37
Maxillo-alveolar breadth (ecm-ecm)	62.71	Parietal chord (b-l)	101.6
Maxillo-alveolar length (pr-alv)	46.61	Occipital chord (l-o)	84.43
Biauricular breadth (ra-ra)	113.3	Foramen magnum length	32.8
Nasion-prosthion height (n-pr)	64.4	Foramen magnum breadth	28.67
Minimum frontal breadth (ft-ft)	101.7	Mastoid height (po-ms)	20.9
Upper facial breadth (fmt-fmt)	102	Biasterionic breadth	95.5
Nasal height	50.81	Bimaxillary breadth (zma-zma)	77.91
Nasal breadth	21.17	Zygomaticoorbitale breadth	51.44

Fig. 4. The bilateral location of the incomplete caroticoclinoid foramen.

Fig. 5A. The third skull with os interparietale. The Wormian bones are also visible.

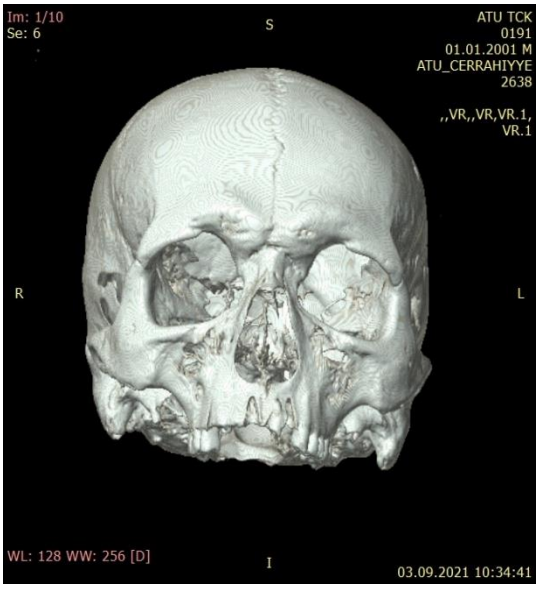


5B



5C

Figs. 5B and 5C. On CT reconstruction, the interparietal bone is indicated by a green circle.



6A

6B

Figs. 6A and 6B. On CT reconstruction of the third studied skull with the interparietal bone, the metopic suture is seen.

Table 3. Dimensions of the studied third skull, (in mm).

Maximum cranial length (g-op)	184	Orbital breadth (d-ec), L	38.02
Naso-occipital length (n-op)	180	Orbital breadth (d-ec), R	37.93
Maximum cranial breadth (eu-eu)	150	Orbital height, L	34.01

Bizygomatic breadth (zy-zy)	145	Orbital height, R	33.98
Basion-bregma height (ba-b)	134	Biorbital breadth (ec-ec)	89.04
Cranial base length (ba-n)	110	Interorbital breadth (d-d)	18.36
Basion-prosthion length (ba-pr)	101.65	Frontal chord (n-b)	97.83
Maxillo-alveolar breadth (ecm-ecm)	63.11	Parietal chord (b-l)	98.52
Maxillo-alveolar length (pr-alv)	47.19	Occipital chord (l-o)	78.94
Biauricular breadth (ra-ra)	121.6	Foramen magnum length	37.29
Nasion-prosthion height (n-pr)	68.65	Foramen magnum breadth	28.44
Minimum frontal breadth (ft-ft)	99.63	Mastoid height (po-ms)	33.72
Upper facial breadth (fmt-fmt)	105.96	Biasterionic breadth	108.99
Nasal height	52.36	Bimaxillary breadth (zma-zma)	94.27
Nasal breadth	23.2	Zygomaticoorbitale breadth	53.74

Table 4. Dimensions of the Wormian bones of the third studied skull, (in mm).

	Length	Width
Right lambdoid suture bone	14.03	5.31
Left lambdoid suture bone (1)	18.81	10.81
Left lambdoid suture bone (2)	21.99	12.74
Left lambdoid suture bone (3)	17.94	2.11
Left lambdoid suture bone (4)	16.99	6.93

4. Discussion

In 1842, Bellamy and later, in 1844, Tchudi, examining Peruvian mummies, found the presence of the interparietal bone on most of their skulls. Tchudi named this bone “Os Incae." In addition to the complete os Incae, on some skulls they found a transverse fissure in the occipital squama. Both scientists were inclined to recognize the presence of such a bone as a distinctive feature of Peruvian skulls. According to Hensel (1874), ossa interparietalia in the human embryo appear in the 7^{th} week of development as paired structures, with a jagged suture line between them in the middle. After the 10^{th} week, the completely fused os interparietale (squama occipitalis superior-Virchow) fuses with the squama of the occipital bone (squama occipitalis inferior) into one solid bone. According to Virchow (1895-1897), os Incae is caused by premature closure of cranial sutures, giving the brain the opportunity for free development; in any case, it occurs less frequently the more metopic sutures there are among a given population. This is not consistent with our data; as can be seen from the material we have presented, the interparietal bone and the metopic suture were found on the same skull (figs:5A-C, 6A-B). In his study “Os Incae s. Epactale,” Virchow (1890) distinguishes the following types of intercalary bones:

1) Os interparietale s. sagittale, found at the upper end of the occipital bone and developing at the expense of the parietal bones. This bone lies above the occipital fontanel.
2) Os fonticulare posterius s. quadratum. This includes all the intercalary bones that develop at the top of the occipital squama, in place of the occipital fontanel.
3) Os apici squamae occipitalis s. triquetrum, developing from the 4th pair of Meckel ossification points. This bone can be either whole or divided into two parts by a sagittal suture (os triquetrum bipartitum).
4) The lateral intercalary bones of the squama, corresponding to the third pair of Meckel ossification points, are sometimes very large, and if there is also a transverse occipital suture along its entire length, then the so-called os Incae tripartitum may appear, and its middle piece will correspond to the second pair of Meckel ossification points.
5) Os Incae proprim corresponds to the ossification points of the second and third pairs of Meckel merged into one bone, and this bone is distinguished by its significant size and is separated by sutura transversa squamae occipitalis from the lower part of the occipital squama.

Srivastava (1992) mentioned that in 9-week-old fetuses, two ossification centers appear in the membrane on each side of the midline in the region of the external occipital protuberance and tend to extend in a lateral direction. Centers, fusing with each other, will form the intermediate segment. A second pair of centers is seen a little above these centers, on either side of the midline in the membrane. Each center consists of two nuclei, the medial and lateral. The two nuclei on the right side are separate from each other, but on the left, they have fused. These centers will give rise to the lateral plates of the interparietal bone. A third pair of centers on each side of the midline in the interparietal area above the second pair is seen, and these will form the medial plates. The author suggested that the third pair of centers is also developed from two nuclei, the upper and lower.

A total of 348 apparently normal skulls were examined by Pal et al. (1984). Various anomalies in the interparietal region were found: a single separate interparietal bone in four skulls, a separate central piece of bone in two skulls, two separate pieces (a central and a right lateral) in one skull, and three separate pieces (one central and two lateral) in two skulls. According to Hanihara and Ishida (2001), Fisher's exact probability test and the χ^2 test for the large geographical groups with sufficient male and female sample sizes show that the expression of the Inca bone does not differ significantly between sexes except for the Melanesian sample. The Melanesian sample shows a significant sex difference in the total incidence of the Inca bone in Fisher's exact probability test. However, the result for the χ^2 test shows that there is no significant difference in the occurrence of each type between sexes. Our study covered 200 male and female skulls in the age range of 16–74 years. The interparietal bone was not found in any female skull.

Malhotra, Tewari, Pandey, and Tewari (1978) examined 1500 skulls of either gender and observed the interparietal bones in 5 cases (0.3%). According to the authors, the interparietal bone is presented as a single piece in one skull. In three skulls, the interparietal bones were observed as two pieces. In one skull, the interparietal bone showed three pieces.

Anthropological interest in the interparietal bones remains almost constant (Sharmila Bhanu and Devi Sankar, 2011; Neery Goyal, Madhur Gupta, and Bindu Aggarwal, 2012; Raber Gözil, Engin Çalgüner, and Semil Keskil, 1994). Sharmila Bhanu and Devi Sankar (2011) examined 84 skulls and found the interparietal bones on 8 of them (9.52%). According to the authors, the interparietal bones were discovered both unilaterally and bilaterally, as a single central piece or as a combination of these three types. The data obtained in our study is

much lower (1.5%). Also, our data are not consistent with those of Neery Goyal et al. (2012). In this study, the authors identified the interparietal bones in six of 150 skulls (4%). Raber Gözil et al. (1994) examined 224 skulls from Central Anatolia and found the presence of interparietal bones in 4 of them (1.8%). The data obtained are quite similar to the data obtained in our study. Also, our study is generally consistent with the data of Marathe RR, Yogesh AS, Pandit SV, Joshi M, and Trivedi GN. (2010). According to them, the overall frequency of the occurrence of Inca bones was 1.315% (5 Inca bones in 380 skulls). Sexual dimorphism in the presence of Inca bones was observed. The incidence was higher in male skulls than in female skulls. (male: 1.428%; female: 1.176%). Of the five Inca bones observed, two were fragmented.

5. Conclusion

Thus, the interparietal bones remain the focus of attention both from an anthropological point of view and in terms of their development. A review of the literature shows that despite the rather large chronological development of this issue, many aspects remain open for discussion. In our study of 200 skulls, the interparietal bones, or Inca bones as they are commonly called, were found on three of them; all three skulls were male. Particularly noteworthy is the identical location and almost identical shape of these bones.

6. References

1. Bellamy CF. (1890). *Cited in Popov M. "To the doctrine of skulls."* (112 p). Kharkov, in Russian.
2. Hanihara T., and Ishida H. (2001). Os incae: variation in frequency in major human population groups. *J Anat. Feb;198(Pt 2):*137-52. doi: 10.1046/j.1469-7580.2001.19820137.x. PMID: 11273039; PMCID: PMC1468202.
3. Hensel B. (1874). Vergleichende Betrachtungen über die ossa interparietalia des Menschen. *Archiv von Reichert und D Bois-Reymond.* S. 598
4. Langley NR., Jantz LM., Ousley SD., Jantz RL., and Milner GS. (2016). *Data Collection Procedures for Forensic Skeletal Material 2.0.* (116 p.) Forensic Anthropology Center Department of Anthropology The University of Tennessee Knoxville, Tennessee.
5. Malhotra VK., Tewari PS., Pandey SN., and Tewari SP. (1978). Interparietal bone. *Acta Anat (Basel). 101(1):*94-6. doi: 10.1159/000144953. PMID: 645338.
6. Marathe RR., Yogesh AS., Pandit SV., Joshi M., and Trivedi GN. (2010). Inca - interparietal bones in neurocranium of human skulls in central India. *Journal of Neurosciences in Rural Practice. January-June, Vol.1, Issue 1,* 14-16.
7. Matsumura G., Uchiumi T., Kida K., Ichikawa R., and Kodama G. (1993). Developmental studies on the interparietal part of the human occipital squama. *J Anat. Apr;182 (Pt 2)(Pt 2):*197-204. PMID: 8376194; PMCID: PMC1259830.
8. Meckel JF. (1890). *Cited in Popov M. "To the doctrine of skulls."* (112 p). Kharkov, in Russian.
9. Neery Goyal., Madhur Gupta., and Bindu Aggarwal. (2012). A study of the interparietal bones. *Journal of Clinical and Diagnostic Research, June, Vol 6(5):* 761-763.
10. Pal GP., Tamankar BP., Routal RV., and Bhagwat SS. (1984). The ossification of the membraneous part of the squamous occipital bone in man. *J Anat., Mar;138 (Pt 2)(Pt 2),* 259-66. PMID: 6715248; PMCID: PMC1164066

11. Raber Gözil., Engin Çaldiner., and Semil Keskil. (1994). Incidence of interparietal and preinterparietal bones in adult skulls from Central Anatoli Region. *Gazi Medical Journal 5:* 123-125.
12. Saint-Hilaire GE. (1823). Considérations et rapports noveaux d'ostéologie compare concernant les animaux. *Mem Museum d'Histoire Naturelle Paris:* 10: 165.
13. Saxena SK., Chowdhary DS., and Jain SP. (1986). Interparietal bones in Nigerian skulls. *J Anat. Feb;144:*235-7. PMID: 3693047; PMCID: PMC1166477.
14. Seshayyan, S. (2016). *Inderbir Singh's Textbook of Anatomy: Head and Neck, Neuroanatomy, Genetics.* (6th ed., 544 p., p.321). New Delhi: Jaypee Brothers Medical Publishers.
15. Shapiro R., and Robinson F. (1976). The os incae. *AJR Am J Roentgenol. Sep;127(3):*469-71. doi: 10.2214/ajr.127.3.469. PMID: 183535.
16. Shapiro R., and Robinson F. (1976). Embryogenesis of the human occipital bone. *AJR Am J Roentgenol. May;126(5):*1063-8. doi: 10.2214/ajr.126.5.1063. PMID: 178231.
17. Sharmila Banu P., and Devi Sankar K. (2011). Interparietal and peinterparietal bones in the population of South coastal Andhra Pradesh, India. *Folia Morphol. Vol. 70, 3,* 185-190.
18. Srivastava HC. (1992). Ossification of the membranous portion of the squamous part of the occipital bone in man. *J Anat. Apr;180 (Pt 2)(Pt 2):*219-24. PMID: 1506277; PMCID: PMC1259666.
19. Tchudi JJ. (1844). Über die Ureinwohner von Peru. *Arch Anat Physiol Wiss Med*, pp.98-109.
20. Virchow RLC. (1890). *Cited in Popov M. "To the doctrine of skulls."* (112 p). Kharkov, in Russian.
21. Virchow RLC. (1895-1897). *Cited in Petri E. "Anthropology. Volume 2. Somatic Anthropology."* (429 p. p.187). St. Petersburg.