Original article

Variant morphogenesis of squamous part of occipital bone in human skulls

Murlimanju, BV.*, Prabhu, LV., Paul, MT., Pai, MM., Krishnamurthy, A. and Rai, A.

Department of Anatomy, Centre for Basic Sciences, Kasturba Medical College, Manipal University, Mangalore, India
*E-mail: flutesnowmm@gmail.com

Abstract

Introduction: The interparietal part of squamous occipital bone which lies above the highest nuchal line develops from membranous ossification. The failure of fusion of ossification centres in this region leads to the development of interparietal and pre-interparietal bones. These bones are very rare in occurrence compared to the sutural bones. In this study, the objectives were to find the incidence of interparietal and preinterparietal bones in South Indian population. Material and methods: The study included a total number of 78 human adult dried skulls of South Indian population. The skulls were studied for the gross incidence, sexual dimorphism and the number of fragments of the interparietal and preinterparietal bones. Results: From our observations, the interparietal bone was observed in only 3 skulls (3.8%) and the preinterparietal bones were observed in 8 (10.3%) skulls. The incidence rates of interparietal and preinterparietal bones were higher in females (2:1 and 5:3). The interparietal bone was single in two cases and was fragmented in the other case. The preinterparietal was single in 5 cases and fragmented in 3 cases. Conclusion: The South Indian population showed higher incidence of preinterparietal bones (10.3%) than interparietal bones (3.8%) and are more common in females. The study has provided additional information on the squamous part of occipital bone, the interparietal and preinterparietal bones, their incidence, sexual dimorphism and morphology. The knowledge of these variants is of importance to the neurosurgeons, radiologists and morphologists.

Keywords: incidence, interparietal bone, morphology, occipital bone, preinterparietal bone.

1 Introduction

The squamous part of the occipital bone above the highest nuchal line develops in membrane and it ossifies from 2 pairs of ossification centres, with an occasional 3rd pair for the upper central part. Nonunion of the parts developed from these ossification centres result in the formation of anomalous ossicles (GOPINATHAN, 1992). These separate single or multiple bones developed from the first 2 pairs of centres of ossification have been named as interparietal or inca bones and those developed from the occasional 3rd pair of centres have been termed preinterparietal bones (SRIVASTAVA, 1977; PAL, TAMANKER, ROUTAL, et al., 1984). The occurrences of these bones are very rare and are considered as variants. These unusual bones may confuse the radiologists and clinicians as fractures in the skull. They may end up in complications during neurosurgical interventions like burr hole surgeries and their extensions may lead to continuation of fracture lines (MARATHE, YOGESH, PANDIT et al., 2010). These may be used as identification features by the forensic experts while investigating the medicolegal cases (PURKAIT and CHANDRA, 1989). Since this area is of interest to the clinicians, the present investigation was undertaken. The detailed anatomical studies on this subject are scarce and from South India are not reported. The objectives of the study were to note the gross incidence, sexual dimorphism and morphology of the interparietal, preinterparietal bones.

2 Materials and methods

To carry out this study, a total number of 78 apparently normal human adult dried skulls (47 male and 31 female), which were available in the Department of Anatomy of the Manipal University were utilized. The genders of the skulls were determined on the basis of obvious gender-specific morphological characteristics. The skulls were analyzed for the gross incidence, sexual dimorphism and number of fragments of the interparietal and preinterparietal bones. The data obtained was tabulated and analyzed statistically. The incidence rate was compared with the other studies available in the literature.

3 Results

The interparietal or inca bone was observed only in 3 skulls (3.8%), among them 2 were female and 1 male (Figures 2 and 3). However the preinterparietal bones were observed in 8 skulls (10.3%) (Table 1). The incidence rate of preinterparietal bone was more in females (5:3). The incidence rate from different studies were compared and tabulated in Table 2. The interparietal bone was single in two cases and fragmented in the other case. In 5 skulls, the preinterparietal bones were observed single (Figure 1) and in the other 3 skulls, the pre-interparietal bone consisted of small ossicles posterior to the lambda and anterior to the inca bone (Figure 2). The suture separating the inca bone from the rest of the squamous occipital was seen to be

Table 1. Gross incidence of interparietal and preinterparietal bones (n = 55).

Type of variant	Number of cases	Incidence rate
Interparietal bone	3	3.8%
Preinterparietal bone	8	10.3%

Table 2. Incidence of interparietal bone from various studies.

Author and year	Incidence (%)
Singh, Gupta and Arora (1979)	1.6
Cireli, Ustun and Tetik (1985)	4.0
Saxena, Chowdhary and Jain (1986)	2.5
Gopinathan (1992)	0.8
Zambare (2001)	0.9
Present Study (2010)	3.6

6.2 cm above the external occipital protuberance and 2.1 cm posteroinferior to the lambda in one case (Figure 2) and 3.3, 4.6 cm respectively in the other case (Figure 3).

4 Discussion

It was reported that the faulty ossification of the occipital bone leads to various types of anomalous bones, particularly in the region of the squamous part and in the vicinity of the lambdoid suture (SINGH, GUPTA and ARORA, 1979). The development of ossification centres in the squamous part of occipital bone is described on the basis of variations observed in the dried skulls (SRIVASTAVA, 1977). The ossification of the interparietal bone and the morphology of the pre-interparietal bone have been reported earlier by Pal, Tamanker, Routal et al. (1984). The interparietal portion of the squamous occipital bone may remain partially separated from the supra-occipital portion by a suture and that separate bone is called as the interparietal or inca bone. Sometimes, the additional centres occurring in front of the interparietal bone may fail to fuse and are called pre-interparietal bones (FRAZER, 1965). The interparietal may exist as a single bone, two symmetrical halves or in three pieces or even four, in which case the upper two constitute the pre-interparietal (BRASH, 1951). Kolte and Mysorekar (1966) published a case of tripartite interparietal bone. The presence of as many as 5 ossicles in the preinterparietal part of the squamous occipital in a skull has been reported by Gopinathan (1992) and the percentage of incidence was 0.8%. Pal, Tamanker, Routal et al. (1984) reported a case of single upper central piece (preinterparietal) and Pal (1987) also reported the presence of 2 pre-interparietals in a skull from the collection in the Mutter Museum, Philadelphia. Pal, Tamanker, Routal et al. (1984) also suggested that the term 'pre-interparietal' is misleading and in case the third pair of ossification centres fails to fuse, the bones should be referred as the upper central pieces of the interparietal bone. Instances of 1 to 3 ossicles in the upper central part of squamous occipital were also observed by Saxena, Chowdhary and Jain (1986) from adult Nigerian skulls.

In 1948, Keith stated that a single interparietal bone in man is extremely rare and in 1960, Misra reported a skull

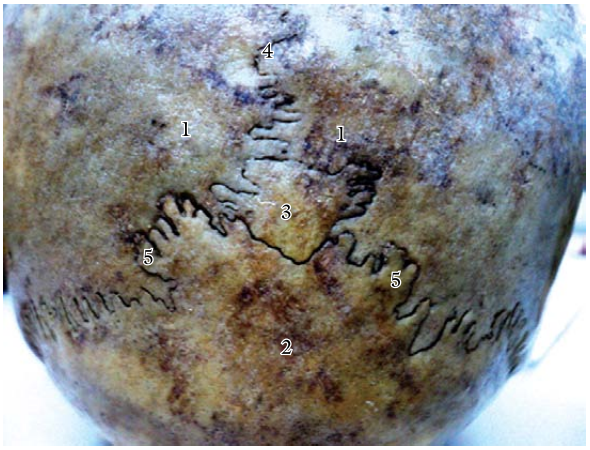

Figure 1. Photograph showing single preinterparietal bone near lambda. 1) parietal bone, 2) occipital bone, 3) single preinterparietal bone, 4) sagittal suture, 5) lambdoid suture.

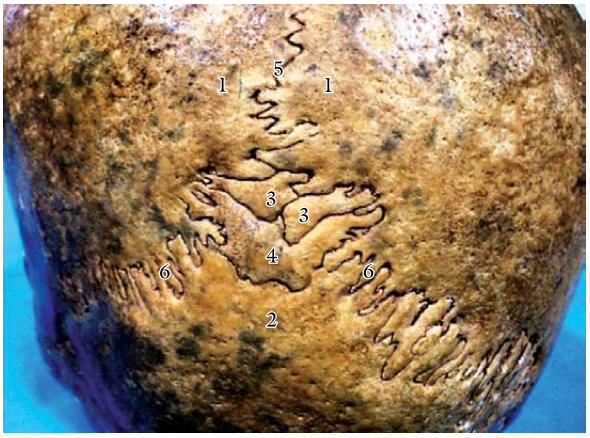

Figure 2. Photograph showing the single interparietal bone and two preinterparietal bones in the squamous part of occipital bone. 1) parietal bone, 2) occipital bone, 3) preinterparietal ossicles, 4) single interparietal (inca) bone, 5) sagittal suture, 6) lambdoid suture.

Figure 3. Photograph showing the fragmented interparietal bones and three preinterparietal bones in the squamous part of occipital bone. 1) parietal bone, 2) occipital bone, 3) preinterparietal ossicles, 4) interparietal (inca) bones, 5) sagittal suture, 6) lambdoid suture, W) wormial bones in the lambdoid suture.

with a single interparietal bone. Saxena, Chowdhary and Jain (1986) reported the occurrence of a single interparietal bone in only one skull with an incidence of 2-5%. In contrast, the incidence of 0.4% was observed by Singh, Gupta and Arora (1979). Multiple and unilateral interparietal bones were reported by Srivastava (1977). Marathe, Yogesh, Pandit et al. (2010) reported 1.3% incidence of inca bones. A very high incidence (27.71%) of inca bones were observed in Hispanic skulls between 300-1200 AC (MARATHE, YOGESH, PANDIT et al., 2010). Carolineberry and Berry (1967) reported 2.9 to 4.6% incidence of interparietal bones in American population. Das, Suri and Kapur (2005) reported that the frequency of Inca bones is varied in different population of the world. In the present study, the inca bone was observed in 3 skulls (3.8%). There is some variability (Table 2) among different ethnic populations and it may be because of racial variations. The pre-interparietal bones were observed in 8 skulls (10.3%). This is similar to the findings of Saxena, Chowdhary and Jain (1986), in their study the pre-interparietal bones were observed singly in four skulls (10%) and multiply in one skull (2-5%). In the present study, the preinterparietal bones were of higher incidence in females (5:3) and the inca bones were also observed more in female skulls. This is different from the studies by Carolineberry and Berry (1967) and Marathe, Yogesh, Pandit et al. (2010). Both of their studies observed higher incidence among the male skulls.

Pal, Tamanker, Routa et al. (1984) reported that these preinterparietals were separated from the lower part of the squamous occipital by a transverse suture which was about 4 cm above the external occipital protuberance. He also observed that the distance between the lambda and the external occipital protuberance in these skulls ranged from 7 to 8 cm. The distance, when measured on the skulls shown in Figure 2 and 3 of the present study was found to be identical, 8.3 and 7.9 cm. Thus the size and location of these ossicles, seen in the skulls shown in Figure 2 and 3 of the present study strongly suggest that they are part of the upper central portion of the squamous occipital bone. Probably they have resulted from the faulty ossification of this part of the occipital bone.

The presence of sutural bones in the lambda may be misleading and it was reported that the differentiation of pre-interparietal bones from the sutural bones and from other variations of interparietal region is of importance because of the increased use of these bones in classification of non-metric cranial variants for separation of populations (PAL, BHAGWAT and ROUTAL, 1986). We differentiated the sutural (wormian) bones in all the skulls, for example the same can be seen in Figure 3. In conclusion, the present study observed the higher incidence of preinterparietal bones (10.3%) than the interparietal bones (3.8%) in the Karnataka population. The interparietal and preinterparietal bones were of higher incidence among females. The study has provided additional information on the squamous part of occipital bone, the interparietal and preinterparietal bones, their incidence, sexual dimorphism and morphology. The knowledge of these variants is of importance to the neurosurgeons, radiologists and morphologists.

Acknowledgements: The authors thank Mr. D. Samiullah, Mohammed Ashraf C. and all the non teaching staff members of the department of anatomy, kasturba medical college, mangalore for the valuable help while conducting this study.

References

BRASH, JC. *Cunningham's text book of anatomy*. 9th ed. London: Oxford University Press, 1951. p. 220.

CAROLINEBERRY, A. and BERRY, RJ. Epigenetic variation in the human cranium. *Journal of Anatomy*, 1967, vol. 101, n. 2, p. 361-379.

CIRELI, E., USTUN, EE. and TETIK, S. Os occipital varyasyonlarive radyolojik Ozellikleri. *Ege Universities Tip Faultesi Dergisi*, 1985, vol. 24, p. 33-35.

DAS, S., SURI, R. and KAPUR, V. Anatomical observations on os inca and associated cranial deformities. *Folia Morphologica*, 2005, vol. 64, p. 118-121.

FRAZER, JE. *Anatomy of the Human Skeleton*. 6th ed. London: J & A Churchill Ltd, 1965. p. 187-190.

GOPINATHAN, K. A rare anomaly of 5 ossicles in the pre-interparietal part of the squamous occipital bone in north Indians. *Journal of Anatomy*, 1992, vol. 180, n. 1, p. 201-202.

KEITH, A. *Human embryology and morphology*. 6th ed. London: Edward Arnold and Co, 1948. p. 223-224.

KOLTE, DT. and MYSOREKAR, VR. Tripartite interparietal bone. *Journal of Anatomical Society of India*, 1966, vol. 15, n. 1, p. 96.

MARATHE, RR., YOGESH, AS., PANDIT, SV., JOSHI, M. and TRIVEDI, GN. Inca – interparietal bones in neurocranium of human skulls in central India. *Journal of Neurosciences in Rural Practice*. 2010, vol. 1, no. 1, p. 14-16.

MISRA, BD. Interparietal bone: a case report. *Journal of Anatomical Society of India*, 1960, vol. 9, n. 1, p. 39.

PAL, GP. Variations of the interparietal bone in man. *Journal of Anatomy*, 1987, vol. 152, p. 205-208.

PAL, GP., BHAGWAT, SS. and ROUTAL, RV. A study of sutural bones in Gujarati (Indian) crania. *Anthropologischer Anzeiger*, 1986, vol. 44, n. 1, p. 67-76.

PAL, GP., TAMANKER, BP., ROUTAL, RV. and BHAGWAT, SS. The ossification of the membranous part of the squamous occipital bone in man. *Journal of Anatomy*, 1984, vol. 138, n. 2, p. 259-266.

PURKAIT, R. and CHANDRA, H. The identity of Inca, medicolegal importance and suggested nomenclature of variants. *Journal of Anatomical Society of India*, 1989, vol. 38, n. 3, p. 162-171.

SAXENA, SK., CHOWDHARY, DS. and JAIN, SP. Interparietal bones in Nigerian skulls. *Journal of Anatomy*. 1986, vol. 144, p. 235-237.

SINGH, PJ., GUPTA, CD. and ARORA, AK. Incidence of interparietal bones in adult skulls of the Agra region. *Anatomischer Anzeiger*, 1979, vol. 145, n. 5, p. 528-531.

SRIVASTAVA, HC. Development of ossification centres in the squamous portion of the occipital bone in man. *Journal of Anatomy*, 1977, vol. 124, n. 3, p. 643-649.

ZAMBARE, BR. Incidence of interparietal bones in adult skulls. *Journal of Anatomical Society of India*, 2001, vol. 50, n. 1, p. 11-12.

Received August 12, 2010
Accepted November 10, 2010