VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 70, No. 3, pp. 185–190

ISSN 0015–5659
www.fm.viamedica.pl

Interparietal and pre-interparietal bones in the population of south coastal Andhra Pradesh, India

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[Received 11 March 2011; Accepted 21 April 2011]

The squamous occipital bone consists of two parts: a cartilaginous supraoccipital part below and a membranous interparietal (IP) part above the highest nuchal line. The IP part develops from two pairs of ossification centres which form the two lateral plates and a median central piece. Any anomalous ossification of these centres gives rise to IP bones. Occasional separate ossified part of the IP region give rise pre-interparietal (PIP) bones which, when present, should be within the territory of the lambdoid suture. The present study was undertaken to observe the incidence of IP and PIP bones in skulls belonging to the south coastal population of Andhra Pradesh, India, hitherto unreported. In a total of 84 skulls, IP bones were found in 8 (9.5%) skulls and PIP bones in 6 (7.1%) skulls. The occurrence of IP and PIP bones can be correlated with the development of the squamous part of the occipital bones, and any alterations in the fusion of its ossification centres and its nuclei result in these anomalous bones. Knowledge of these bones may be important in dealing with situations resulting from fractures of occipital bones, and to rule out their incidence between races or populations in different parts of the world. (Folia Morphol 2011; 70, 3: 185–190)

Key words: squamous occipital bone, interparietal bone, occipital anomalies, skull development

INTRODUCTION

The squamous occipital bone develops from two parts: a membranous interparietal part above and cartilaginous supra-occipital part below the highest nuchal line. The early reports of Ranke [19] describe, one pair of centre in cartilage with develop into supraoccipital part and two pairs of centres in the membrane that develop into the interparietal (IP) part. In the development of the IP part, the first pair of centres appears above the supraoccipital part, which forms the two lateral plates, and the second pair appears between the two lateral plates and forms the central plate [17, 18, 24, 26]. Any anomalous ossification of these centres in the membranous part or failure of their fusion with each other gives rise to an IP bone [3, 17, 18, 24, 25].

Occasionally a third pair of centres appears near the upper angle of the occipital bone as one on either side of the midline immediately above the central plate [1, 2, 19, 20]. In cases of this third pair of centres, the part behind the angle of the lambdoid suture develops into the pre-interparietal (PIP) bones, a part of interparietal bone [17, 18, 24]. The PIP part of the IP bone can be identified with its separation from the rest of the IP part by a transverse suture

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and when present within the territory of the lambdoid suture [18].

The formation of IP bones has long been studied from embryological aspects by many authors [14, 16, 22, 25]. From the findings of Srivastava [25] and Matsumura et al. [13] on the development of squamous occipital bones of human foetuses, it has been confirmed that membranous IP parts ossify from three pairs of centres above the superior nuchal line.

Srivastava [25] described an intermediate segment between the superior and highest nuchal lines formed from the first pair of centres, consisting of single nuclei on either side of the median plane and the *torus occipitalis transverses* separated from the rest of the IP bone by a lateral fissure or mendosal suture [7, 22]. The second pair of centres appears anterior to this intermediate segment and forms the right and left lateral plates, each having a pair of medial and lateral nuclei. A third pair, arising between the two lateral plates consisting of two pairs of upper and lower nuclei, forms the central plate of the IP part (Fig. 1A). Further, regarding the development of PIP bones, it was described that they are formed by the fusion of upper nuclei of the third pair of centres with each other and their failure to fuse with the rest of the IP parts. This may result in unilateral, bilateral, or a single median piece of IP bone/s.

The incidence and knowledge of IP and PIP bones are important regarding which racial and ethnic differences are observed and may vary in different parts of the world [7, 9, 11]. In addition, the difference in ossification and fusion times of these bones with the other skull bones may be associated with neural problems [3] and is useful to neurosurgeons, radiologists, and anthropologists [12].

The present study was undertaken to observe the incidence of anomalous bones in the membranous IP part of occipital bones of the south coastal population of Andhra Pradesh, India, hitherto unreported, and to correlate the findings according to different developmental aspects reported in the literature.

MATERIAL AND METHODS

A total of eighty-four adult human skulls irrespective of sex, obtained from the Department of Anatomy, Narayana Medical College, Nellore (AP), belonging to a south costal population of AP, were examined for IP and PIP bones. All types of anomalous ossicles found in the present study were traced over the photographs with the help of the Scribbling Tool of PowerPoint 2007 and schematically represented with their centres of nuclei.

Table 1. The incidence of interparietal and pre-interparietal bone in AP population

Present study	Interparietal	Pre-interparietal
Single	3 (3.6%)	4 (4.8%)
Unilateral	2 (2.4%)	1 (1.2%)
Bilateral	1 (1.2%)	1 (1.2%)
Bilateral with central	1 (1.2%)	–
Unilateral with central	1 (1.2%)	–

RESULTS

Out of 84 skulls, IP bones were found in 8 skulls with an incidence of 9.52% and PIP part of IP bones were found in 6 skulls with an incidence of 7.14% (Table 1). The IP bones were found to present as unilateral, bilateral, a single central piece, or as a combination of these three types.

A complete single median IP bone was found in three skulls (Fig. 1B–D). In Figure 1B a large piece of IP bone can be seen to be separated by a transverse suture above the superior nuchal line as a result of fusion of a second and third pair of centres with each other, and its failure to fuse with the lower supraoccipital part.

In Figure 1C and D the skull shows a separate triangular piece of bone as a result of fusion of the upper and lower nuclei of the third pair of centres, which have articulated with rest of the IP and supra occipital bones.

In Figure 1E and F the right unilateral IP bones were found as a separate piece formed as a result of non-fusion of right lateral nuclei of the second pair of centres with the rest of the nuclei of the interparietal part.

In Figure 1G bilateral IP bones were observed formed from the union of both lateral and medial nuclei of a second pair of centres. The two lateral plates were found to be articulated one on either side of the central piece, and below with the supraoccipital part.

In Figure 1H a single central plate articulating with a left lateral plate of IP bone was found. The left lateral and medial nuclei of the second pair of centres formed a separate lateral plate, which articulated by a suture with the central plate formed by the fusion of both the upper and lower nuclei with each other.

In Figure 1I three independent bones were found articulating with each other by two vertical sutures

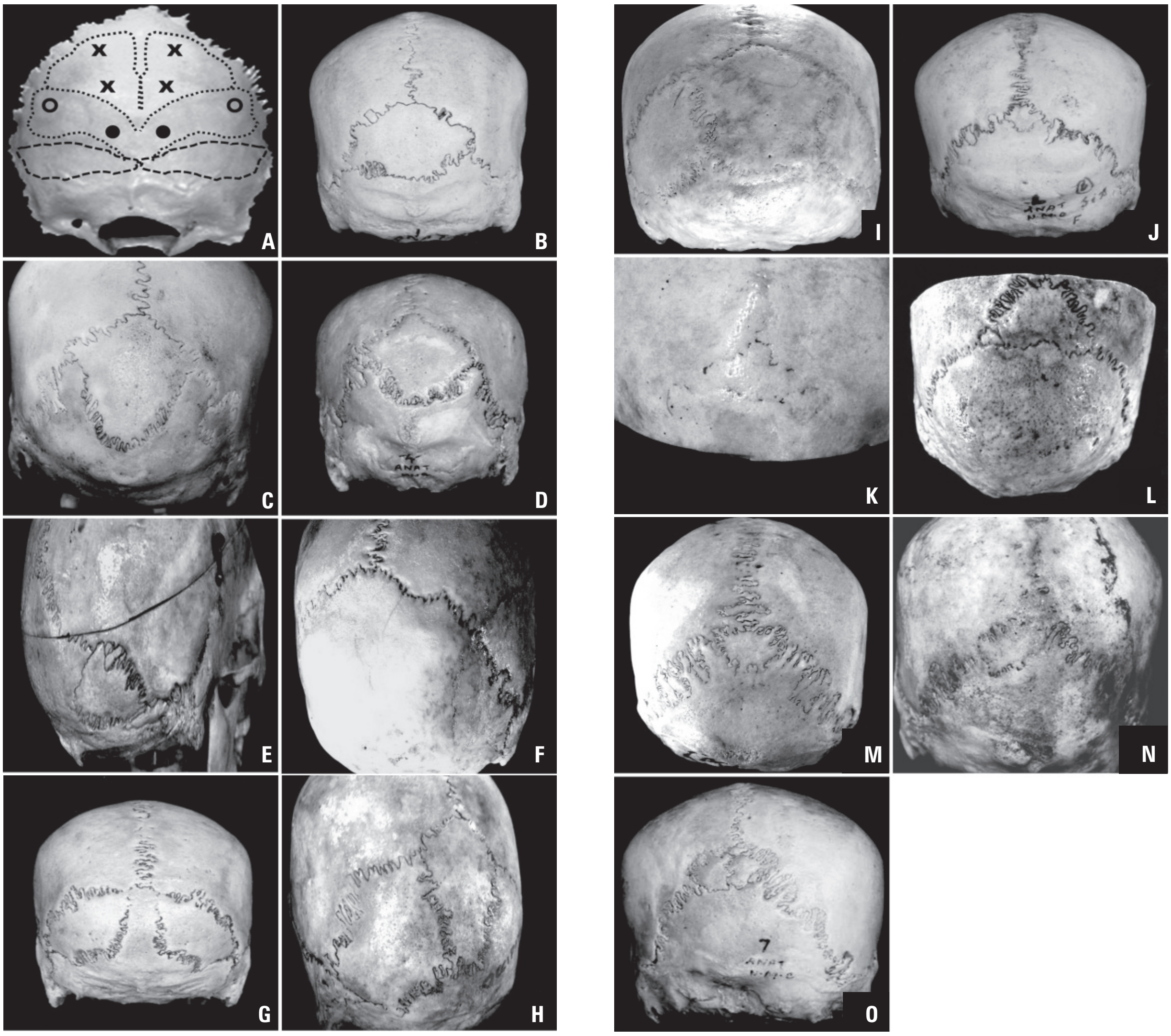

Figure 1. A. Squamous occipital bone showing the schematic representation of the nuclei in the membranous interparietal part; x — two pairs of upper and lower nuclei forming the central plate; white circle — lateral nucleus of the lateral plate; black circle — medial nucleus of lateral plate; dashed line — torus occipitalis transversus (intermediate segment). **B–D.** The single median interparietal bone. **E, F.** The right unilateral interparietal bone. **G.** The bilateral interparietal bone. **H.** The median and left unilateral interparietal bone. **I.** The median and bilateral interparietal bones (tri-partite). **J–M.** The single median pre-interparietal bones. **N.** The left unilateral pre-interparietal bone. **O.** The bilateral pre-interparietal bones.

in between and by a transverse suture from the supraoccipital part. The two lateral plates formed separately from the lateral and medial nuclei of the second pairs of centres have articulated with the central plate formed by the upper and lower nuclei of the third pair of centres.

The PIP bones were found as a single piece in four skulls (Fig. 1J–M), which are formed from the fusion of the upper two nuclei of the third pair of centres and its failure to fuse with the rest of its IP part.

In Figure 1N the unilateral PIP bone was found on the left side formed from the left upper nuclei of the third pair of centres, which have failed to fuse with the right upper nuclei of the third pair and the rest of the nuclei of the IP part.

In Figure 1O the bilateral PIP bones have formed separately from the ossification of the upper two nuclei of the third pair of centres articulating with each other by a suture in between the two bones.

The line diagrams of various types of IP and PIP, part of the interparietal bone formation with their nuclei found in this study, are represented in Figure 2.

DISCUSSION

Mammals are the descendants of primitive reptiles which, when evolved to the mammalian level, attained drastic changes in the skull bones. The human skull, like that of any other vertebrate, is made of both membranous and cartilaginous parts

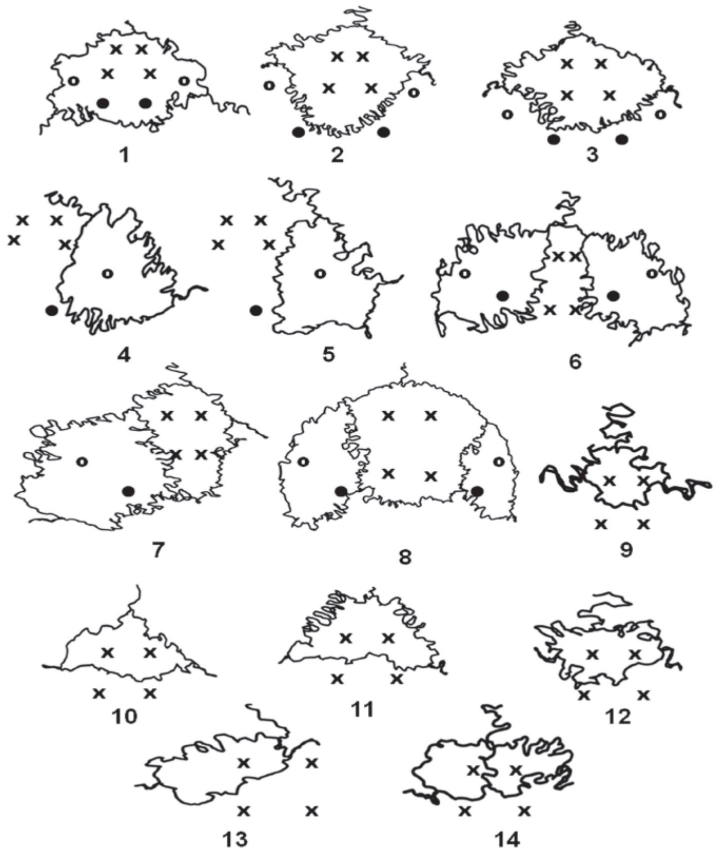

Figure 2. 1–14. Diagrammatic representation of ossification centres and their nuclei of interparietal and pre-interparietal bone as shown in figures 1B–O; x — upper and lower pair of nuclei forming the central plate; white circle — lateral nucleus of lateral plate; black circle — medial nucleus of lateral plate.

and visceral palatal complex. The occipital element, which formed the floor in lower vertebrates, underwent enormous modifications in mammals to form a single large bone partly contributing to the roof of the skull [23]. The development of the occipital bone has been studied in a series of several developmental stages of human foetuses and has been well documented in the literature [13, 14, 22, 24, 25].

The development of squamous occipital bone from a membranous IP part above and a cartilaginous supraoccipital part below the highest nuchal line has been reported by various authors [18, 19, 24]. Failure of fusion of the ossification centres in the IP part with rest of the occipital region remains as a separate IP bone by a suture. The IP or post-parietal bone is an old integrated part of the reptilian and mammalian skull [5], which in some species united with the parietal bones and in some remained as separate bones. In man these separated bones are named *os inca*, and may be as single triangular piece or in multiples.

Ranke [19] described three pairs of centres for the squamous occipital bone: one for the cartilaginous supraoccipital part and two for the membranous IP part. An occasional third pair anterior to the IP part develops into the IP bone. In later developmental views of the membranous occipital bone, three pairs of centres with their nuclei were described by Srivastava [24]. The first pair appears between the superior and the highest nuchal line and develops into an intermediate segment, the *torus occipitalis transversus*, and fuses below with the supraoccipital region [13, 25]. The rest of the membranous IP part develops from the second and third pair of centres or four pairs of nuclei. The second pair of centres, one on either side of the midline, each consisting a medial and lateral nuclei, forms the lateral plate, and a third pair, between the lateral plates, consisting of an upper and lower pair of nuclei, develop into the central plate [25]. Failure of fusion of the second and third pairs of centres or their nuclei with the supraoccipital part can result in the anomalous formation of bones in the interparietal region. If the pair of centres for the central piece fails to unite with each other or with the lateral plates, the IP may develop as two symmetrical halves [1] or as four pieces.

In a similar developmental study of the IP part by Matsumara et al. [14], three pairs of ossification centres were observed in the membranous part of the occipital bone. A primary ossification centre develops into an intermediate segment and medial and lateral secondary centres forming the central and lateral plates, respectively. An additional pair anterior to the secondary centre develops into PIP. However, the different nuclei of the centres observed by Srivastava [25] were not mentioned by Matsumara et al. [13].

In our study the IP bone was found to be a separate piece in one skull, which is the result of the fusion of the first and second pair of centres (Fig. 1B), and its failure to fuse with the supra-occipital part and is similar to the report of Saxena et al. [21] in Nigerian skulls. A central piece found in two skulls in this study was similar to the findings of Srivastava [24], maybe due to the non-fusion of the second pair of centres with the lateral plate and its failure to fuse with the supra-occipital part (Fig. 1C, D).

In the present study, the right unilateral IP bone (Fig. 1E, F), a combination of left unilateral with central piece of IP bone (Fig. 1H) and bilateral with central piece of IP (Fig. 1I), were found are similar to the findings of Srivastava [24] and Pal et al. [18]. The bilateral IP bones (Fig. 1G) cited in this study are similar to one of the types of IP bone reported by Hanihara and Ishida [9].

In the past decades there was a great controversy in the development and differentiation of PIP bones. The first description of occurrence of PIP bones was illustrated by Sappey [20] and was confirmed by various authors. The occasional third pair of centres anterior to the IP part, at the upper angle of the occipital bone, develops into separate individual PIP bones [2, 14, 17–19, 21, 24].

According to Srivastava [25] in his developmental studies of the IP part, the upper two nuclei of the central plate, when it fails to fuse with the rest of the IP part, results in the PIP bone. These upper two nuclei of the central plate were considered as the third pair of centres by Pal [17] who reported that the central portion is formed by two pairs of centres, the failure of which results in PIP bones.

The PIP bones could be in the form of a single or two symmetrical pieces, one on either side of the midline, and remain separated from the IP part by a transverse suture [17, 21, 27].

As the PIP bones are occasional, these bones should be differentiated from sutural bones by their shape and position. The sutural or the Wormian bones, when present, are found along the lambdoid suture and numerically vary from a minimum of one to a maximum of ten ossicles [6, 7, 8, 15]. In the present study, apart from the IP and PIP bones, numerous sutural bones were also observed in 7 out of 14 skulls. PIP bones are identified from the sutural bones by the fact that they should be within the territory of the membranous (interparietal) part of the occipital bone, and only when present behind the lambda [4, 10, 17, 25, 27].

However, the development of PIP bone may be either from the third pair of centres anterior to the IP part [17] or from the fusion of the upper two nuclei of the central plate [25]; these bones can be considered as a part of the IP. According to the various authors [17, 25, 27] regarding the developmental basis of PIP, the bones present behind the lambdoid suture should be part of IP bone and the term pre-interparietal should strictly restricted. Other bones developing outside the limits of the lambda include the sutural bones, which have their own ossification centres [25]. The present study concludes with the findings of previous authors by naming these bones as part of the IP and not PIP bones, because they develop within the territory of the IP part of the occipital bone.

The increase in the incidence of IP bones and Wormian bones is a significant trait, which may be considered in the classical differentiation of the various ethnic groups, and meticulous knowledge of its variable incidences can provide immense support to neurosurgeons, radiologists in dealing with situations regarding skull fractures. The various types of IP bones found in the present study from the south Andhra population add to the other prevailing data and may be of interest to clinicians and surgeons.

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