A Study on the Incidence and Morphometry of Interparietal Bone in Adult Human Skulls

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ABSTRACT

BACKGROUND
Interparietal bones are accessory bones in the occipital region of human skull. As independent bones they always lie above the highest nuchal line, separated from the rest of the occipital bone by transverse occipital suture or mendosal suture. Occurrence of this bones are rare compared to the occurrence of sutural bones in this region. The human skull consists of two parts- neurocranium & viscerocranium. The neurocranium consists of eight cranial bones. Of these bones, the occipital bone forms much of the back & base of cranium. It has 4-parts- a squamosal part, a basilar part and 2 condylar parts.(1) We wanted to study the occurrence of interparietal bones in human skull and determine as to whether they are single, bipartite, tripartite or multipartite along with their size and position.

METHODS
Fifty dried intact adult human skull were examined in this study. The study samples were procured from the Department of Anatomy, Govt. T.D. Medical College, Alappuzha. They were closely inspected for the presence and number of fragments.

RESULTS
The incidence of interparietal bones was found to be 6%. The interparietal bone frequently occurred singly. Out of 50 skull bones studied, 3 bones showed presence of interparietal bones. Out of three, one was fragmented & other two were single.

CONCLUSIONS
The result obtained gives information regarding the occurrence of interparietal bones in the human skull and about their number, size, and position. The knowledge of their presence is of great significance to neurosurgeons, radiologists, anthropologists and anatomists.

KEY WORDS
Interparietal Bone, Sutural Bones, Sutura Mendosa, Squamous Occipital Bone

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BACKGROUND

The human skull consists of two parts- neurocranium & viscerocranium. The neurocranium consists of eight cranial bones. Of these bones the occipital bone forms much of the back & base of cranium. It is having 4-parts- a squamosal part, a basilar part and 2 condylar parts.[1]

The squamous part of the occipital bone has an upper membranous part which is called as the inter parietal part and a lower cartilaginous part which is called the supraoccipital part. The interparietal part lies above the highest nuchal line is developed in a fibrous membrane and is ossified from 2 pairs of centres, one pair for the lateral plate and the other pair for the medial plate. Each centre consists of two nuclei and the failure of fusion between these centres or their nuclei with each other and with the supra occipital part may give rise to various anomalies in the interparietal region. This is the true interparietal bone, which has migrated from the parietals of lower animals during evolution to become a part of the occipital bone in man.[2] All the bones developing in the lambda and lambdoid suture outside the limits of interparietal area are sutural or wormian bones which develop from their own separate ossification centres.

When it appears in the form of an independent bone, the suture in between it and the supraoccipital part lies at the level of highest nuchal line. This abnormal fissure is called transverse occipital suture or mendosal suture. This may be subdivided by presence of additional longitudinal or transverse sutures leading to bipartite, tripartite or multipartite interparietal bone. Occurrence of these bones are rare and considered to be a variant. The percentage of occurrence of inter parietal bones is within 10% in almost all earlier studies. The additional sutures present due to these bones in skiagram can be misinterpreted as posterior skull fractures which have immense radiological, surgical and forensic implications. Clinically these may be related to host of conditions like defects in development & ossification, metabolic disorders or as part of certain syndromes.

Saint Hilaire first described it as the non-wormian, epactal or interparietal bone. Tschudi labelled this bone as Inca bone. Their characteristic shape a triangle resembles a monument design of the Inca tribe of South America and Latin America. True inca bones are bounded by sutura mendosa (transverse occipital suture) and lambdoid suture. These were previously known as Os-incae, Os-ipactal or Goethe's ossicles. Later on Shapiro and Robinson 1976 reported Inca bones in Inca tribals in South Andes in America.

METHODS

A total of 50 adult dried skulls were studied to analyse the occurrence of interparietal bones through a macroscopic observation of the squamous part of the occipital bone and the lambda region. Wormian bone was excluded by shape and site. The statistical method used was a percentage relative to frequency. The size of the inter parietal bone was taken using vernier calipers. The study was conducted in the Department of Anatomy, Govt. T.D. Medical College, Alappuzha.

Sample Size Calculation

$$n = \frac{Z^2 P (1-P)}{d^2}$$

Where Z= 1.96, the standard normal value at 95% confidence interval.

P= 0.05, the desired proportion.

d = 0.07, the margin of error (high value given due to limitation of resources)

The minimum sample size required

$$n = \frac{(1.96)^2 \times 0.05 \times 0.95}{(0.07)^2} = 37.24$$

As an approximation took n=50

Inclusion Criteria

1. Intact adult skull irrespective of age and gender.
2. Eruption of tooth & intact sutures were the criteria for identifying adult skull.

Exclusion Criteria

1. Skulls that showed signs of surgery or malformations in the cranium.
2. Skulls presented with fused sutures.
3. Paediatric skulls.

Statistical Analysis

Fifty patients were included in the study. Collected data were entered in Microsoft excel and analysed using SPSS 22. Incidence of interparietal bone was analysed using percentages.

RESULTS

Out of the 50 intact human skulls studied 3 showed presence of interparietal bones. 2 among them presented single interparietal bone and one was multipartite. One case presented a large rhomboid shaped interparietal bone in between lambda and highest nuchal line, which measured 6.2 cm transversely and 5.7 cm vertically. The other single interparietal bone measured 10.1 cm transversely and 5.5 cm vertically. The multipartite one showed segments of asymmetrical shapes.

DISCUSSION

The variations observed in this study is better understood by knowing the ossification centers of the membranous part of the occipital bone. There are controversial views in the literature concerning the limits and ossification of the membranous portion of the human occipital bone, known as the interparietal. Gray (1860) was probably the first who described the ossification of the occipital bone in man. He considered that the whole of the squamous part of the occipital bone above the superior nuchal lines develops in membrane by 2 centres, one on each side, which become continuous with each other and with the supraoccipital cartilaginous part. But according to Debierre, when the

interparietal appears as a separate element, its posterior border does not coincide with the original suture between the interparietal and supraoccipital ossifications, but lies further forward and within the territory of the true interparietal. The hindmost portion of that bone remains fused to the front edge of the supraoccipital, forming the 'lamella triangularis'; the incisura lateralis may cut through in front of it, separating it from the anterior part of the interparietal.[3]

According to Keiber & Mall, in addition to the 2 centres in the interparietal portion there may be 2 other centres placed on either side of the midline not far from the future superior angle which occasionally remain as separate ossicles or may fuse and give rise to the pre-interparietal bones.[4]

According to Ranke 1913, the membranous part of the squama generally ossifies from 2 pairs of centres, the primary interparieta l which arise closely above the supraoccipital and the secondary interparietal which arise in front of the primary centres. A lateral incisure within the territory of the interparietal called the sutura mendosa or the transverse occipital suture has frequently been observed in the adult skull. When the secondary inter parietal can be identified in adult skulls it is known as inca bone or bones. These anomalies have been believe to occur by the failure of fusion between the primary and secondary interparietals.

Later Keith, 1948; Breathnach, 1965; Hamilton, 1976 supported the view that in human skull, the occipital bone above the superior nuchal lines ossifies in membrane. Brash (1951), Pal (1987) and Williams et al. (1989) stated that the part of the occipital bone above the highest nuchal lines develops in membrane. Srivastava (1992) in his study on the ossification of the membranous portion of the squamous part of the occipital bone in man stated that the squamous part of the occipital bone consists of lower supraoccipital and upper interparietal parts. According to him, the supraoccipital develops both in cartilage and membrane. The bone lying between the superior and highest nuchal lines known as the torus occipitalis transversus is ossified in membrane by a pair of centres. This part of the supraoccipital represents the original membranous part of the primitive occipital bone of lower animals where the interparietals form part of the parietals. It forms a distinct projection in anthropoids and to a lesser extent in earlier races of man.[5]

Srivastava described that the membranous part of occipital bone is ossified by 3 pairs of centres. According to him the first pair of centres lies between the superior and highest nuchal lines and forms the intermediate segment; the second pair of centres lies above the highest nuchal lines, one on each side of the midline and form the lateral plate; the third pair forms the medial plate of the interparietal bone.[2] According to him, the intermediate segment probably never separates from the cartilaginous supraoccipital part. He further stated that the centres and their nuclei in the membranous part of the occipital bone above the supraoccipital part were paired centres. The medial and lateral nuclei of the 2nd pair of centres will form the lateral plate, and upper and lower nuclei of the 3rd pair of centres will form the medial plate. The 2 medial plates are separated by the median fissure. The intermediate segment is separated from the lateral plate by the lateral fissure. Thus the interparietal bone is formed by the lateral and medial plates together. Failure of fusion between these centres or their nuclei with each other and the supraoccipital part may give rise to a maximum of six pieces of bone (3 on either side) in the interparietal region. These bony ossicles may occur singly or in groups and in various combinations. Though their size may vary from skull to skull their position and shape will remain fixed.

Earlier Pal et al described a true pre-interparietal bone which is triangular in shape, lies below the lambda and is separated from the remaining interparietal by a transverse suture.[6] This triangular bone is actually the upper half of the central piece where the upper nuclei of the 3rd pair of centres have fused with each other but have failed to unite with their lower nuclei and the remaining interparietal. This triangular bone at the lambda is therefore a part of the interparietal bone and is not a pre-interparietal.

The tectum synoticum posterior which is one of the 3 skull roof elements of the chondrocranium, temporarily exists within the territory of the interparietal in foetal life.[7] Niida et al by their studies on 117 human foetuses provided evidence that the presence of tectum synoticum posterior might be responsible for the occurrence of the sutura mendosa. They concluded that the primary cause of the occurrence of the incisure is the prior occupation of the space by the tectum synoticum posterior where bone trabeculae of the interparietal are supposed to extend. The location and length of the incisures are also decided by the morphology of the tecta. This area remains unossified to a certain period after the disappearance of the tecta and form the resultant incisures. Although in the majority of cases it is gradually replaced by the secondary bony plate with increasing post-natal age. In some it persists throughout life as the sutura mendosa. The tecta persisted during the period of 7 week from 45 mm crown rump length to 128 mm crown rump length stage within the territory of interparietal. During this period the tecta always interfere with the growth of interparietal to form lateral incisures of the bone.

The incidence of the interparietal bones varies among different populations.[8] It is 15% in Nigerians, 1.2% in Europeans, 0.8% in Australians, 4.8% in north Americans and 2.8% in Turkish, but it has been reported to be as high as 27.71% in Peruvian skulls. Hanihara and Ishida studied the presence of the Inca bones in various populations around the world. They found that the frequency distribution of os Incae is described as generally high in New World and Sub Saharan Africa, Tibetan, Nepalese, Assam and Sikkim populations in Northeast India and is low in north east, Central, west Asia, Europe and Australia. The highest percentage of 10% was noted in the West African population with the Japanese being next highest at 4.4%.[9] The geographical and ethnographical pattern of incidence of Inca bones shows a definite topographical and racial predilection and thus a possible genetic inheritance. Pedigree studies showed that the Inca bone is inherited as dominant trait with 50% penetrance and suggested genetic background for occurrence of Inca bone.[10]

According to R. R. Marathe, A.S. Yogesh and G. N. Trivedi (2010), gross incidence of Inca bones was found to be 1.315%. They identified sexual dimorphism for the presence of inca bones, the incidence being higher in males (1.43%) compared to females.[11] Dr. Kanan Shah, Dr. Pratik Shah, and Dr. Shital Shah (2013) reported five out of hundred skull studied had interparietal bone of varying size and shape.[12] Dr. Bharat Sarvaiya etal (2014) in their studies examined a

total of 250 human adult dried skulls and observed that 24 skulls showed presence of interparietal bones.[13] Khan. AA et al(2013) in their study of inter parietal bone variations in accordance with their ossification in 25 human skulls, observed 4 inter parietal bones in one skull, 2 interparietal bones in another skull and single interparietal bone at lambda in 4 skulls.[14] Neeru Goyal, Madhul Gupta, Bindu Aggarwal (2012) studied 150 adult dried skulls. In 11 cases i.e., 7%, single or multiple interparietal bones were observed.[15] Dipanjana Chakraborty, Aribam Jaishree Devi, Thonthon Daimei (2015) studied 74 dry skulls and found 6 (8%) cases presented interparietal bones.[16] A study of 500 skulls of Agra region by Singh. P. J, et al (1979) revealed that interparietal bone was present in a total of number of 8 cases. i.e., 1.6% bones. It was single in 2 cases and multiple in 5 cases. In 1 skull it was unilateral.[17]

The result of the present study also coincided with earlier studies. The percentage of occurrence of interparietal bones was 6%. Though the study was done in Govt. TDMC Alappuzha, the ethnicity of the skulls available were not sure. For authenticity of the study we assume the skulls belong to South Kerala. Sample size calculation also avoided since all the skulls available in the college were taken to study.

Interparietal bone belongs to neurocranium. It is derived from both neural crest and paraxial mesoderm. Development of the occipital bone shows phylogenetic differences. Keith stated that a separate single interparietal bone in man is an extremely rare anomaly. He observed that phylogenetically, the interparietals fuse with the parietals in marsupials, ruminants and ungulates. Whereas in rodents, they fuse both with occipital and parietal bone. In primates and carnivora as in man, they fuse with occipital. But sometimes as a variant in man, the interparietal is seen as a separate bone.(18)

Ossenberg (1969) discussed that wormian bones are more common in skulls with Inca bones than those without it.(19) She had pointed that among modern population the frequency of Inca bone are highest in marginal isolates those have retained traits of early ancestral population. Inca bone is considered to be regional character of East-Asians providing evidence of regional continuity. In evolution, there are instances in which a bone which was single in earlier phylogeny has split and come to possess more than 1 centre of ossification.(20) This splitting of bones is probably the result of fragmentation. Wormian bones in man are clearly the result of fragmentation of an originally single centre. The occasional occurrence of abnormal bones in the skull, especially in the occipital region, may be due to fragmentation. Occurrence of Inca bone has not only paleoanthropological, morphological, and evolutionary importance but plays important role in medicolegal cases for establishing identity.

CONCLUSIONS

The presence of series of bony skull variations like interparietal bone may lead to problems in surgical approach to the cranial cavity. The incidence of these skeletal variations is of extreme importance in fields like anthropology, anatomy, forensic science and is also useful on a day to day basis to neurosurgeons and orthopaedic surgeons. The Inca bones may give a false appearance of fracture in X-rays. Such bones may lead to complications during burr-hole surgeries and their extensions may lead to continuation of fracture lines. Due to clinical implication, information of presence of Inca bones, their incidence, sexual dimorphism and number of fragments is essential to clinicians. Inca bones can be used in personal identification by comparing the ante and postmortem radiographs.(21)

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