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ORIGINAL ARTICLE

Morphometric Analysis of Accessory Sutural Bones with an Emphasis on Association with Parietal Emissary Foramina

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Abstract

Background: The sutural bones and fontanelle of the skull display unique morphological characters. Sutural bones are also called supernumerary bones, ossicles or Wormian bones (WB). In the present study, we aimed to determine the morphological characteristics of sutural bones and emphasize the significance of the same. One interesting near the posterior fontanelle is the presence of Inca bones.

Methods: The current study undertaken in Department of Anatomy of our institution. 128 dry human skulls included for this study by a convenient sampling method and significant characteristic features of Inca and Wormian bones like shape, number, size, and location were recorded. X-ray was done for 24 skulls.

Results: Of the 128 dry skulls examined Wormian bones were seen in 13.2 % of skulls and Inca bones in 5.4 % of skulls. Incorporation of Wormian bones in lambdoid suture was noted in 12.5 % in sagittal suture in 0.7 % skulls respectively. The Wormian bones were found frequently on the left side (n=12) as compared to the right side (n=5). The morphometry of the accessory bones showed quadrilateral as the most common shape (n=9, 37.5%) followed by triangular (n=4, 16.6%). Radiological examination of all 24 skulls with accessory bones showed a zigzag pattern of accessory suture lines.

Conclusions: The presence of Wormian and Inca bones can be easily confused with fractures of the related bony regions. The Surgeons need to be aware of these types of supernumerary bones to make a proper and accurate diagnosis. Knowledge regarding these bones is highly beneficial to clinicians, radiologists, and neurosurgeons.

Key Words: *Interparietal bones; Accessory bones; Sutural bones; Supraoccipital bones; Parietal emissary foramen.*

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Introduction

Skull is a complex bony structure. In young adults, the skull consists of 28 separate bones, many of which are paired. In advanced age, the skull is composed of 22 bones. Most of these bones are held together by fibrous joints called sutures. The junction of the sutures undergoes series of morphological changes from birth to adulthood. The cranial bones are ossified in membrane and the ossification is incomplete at birth marked by the fontanelles and posterior fontanelles. Most of these bones are fused by fibrous or cartilage tissue. During this process, additional ossification centers may appear which are considered as potential sites of development of Wormian bones (WBs) [1,2]. Between 1460 and 1541 CE Paracelsus first described the WBs. These bones were officially named by Olaus Worm, a Danish anatomist, as Ossa Wormiana, but are also referred to as intersutural bones, and Inca bones or Goethe's ossicle. WBs are frequently found in the lambdoid suture and near the fontanelles [3]. WBs are commonly seen in the lambdoid suture, the presence and occurrence of WB in the coronal, sagittal, and squamosal sutures are very rare [4]. The neurocranium and viscerocranium are the two parts of the human skull. The neurocranium forms the back and base of the cranium. The occipital bone consists of a squamosal part, a basilar part, and condyles [5]. The squamous part of the occipital bone consists of an upper membranous part and a lower cartilaginous part; the membranous part is also called inter parietal part and a cartilaginous part is called as supraoccipital part. The interparietal part lies above the highest nuchal line and is developed in a fibrous membrane and is ossified from 2 pairs of centers. Each center consists of two nuclei. If these centers fail to fuse to each other, the supraoccipital part may give rise to various accessory bones in the interparietal region [6-8]. Occurrence of accessory bones can be explained based on an incomplete union of corresponding ossification centers [8]. The accessory bones develop from the separate ossification centers in the interparietal region. The interparietal portion remains separated from the supraoccipital part by a transverse suture, resulting in the occurrence of an Inca bone [9]. The variations in size, shape, number, and position of accessory bones are very common [10]. WBs can be found in healthy individuals, and with congenital disorders, such as osteogenesis imperfecta, cretinism, cleidocranial dysostosis, and enlarged parietal foramina [11]. Knowledge of the normal anatomy, development, and timing of sutural closure is also important in the evaluation of fractures. The presence of intersutural bones can be misdiagnose as fractures of skull bones [12]. It may also affect posterior craniotomy approaches to the skull. Awareness of morphology, morphometry, and prevalence of accessory sutural bones is important in medicolegal cases and neurosurgery. Hence, the current study was designed. The current study aimed to report the prevalence and morphology of accessory sutural bones in dry human skulls.

Methods

The current study undertaken in department of anatomy, Pondicherry Institute of Medical Sciences. A total of 128 adult dry human skulls of unknown sex and age were included in the study. Each skull was observed for the presence of WBs and Inca bones. The morphology and morphometry of the accessory bones were also noted. Along with the occurrence of the WBs and Inca bones associated parietal emissary foramen abnormalities were noted. All the skull sutures were examined, and findings were recorded.

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Inclusive criteria: All adult skulls.

Exclusive criteria: Fetal skulls and skulls with fractures were excluded from the study.

Results

Of the 128 dry skulls examined WBs were seen in 17 (13.2%) skulls and Inca bones in seven (5.4%) skulls. Incorporation of WBs in lambdoid suture was noted in 16 skulls (12.5%) and incorporation in sagittal suture in one skull (0.7%) respectively as shown in (Figure1A-1D). The WBs were found more frequently on the left side (n=12) as compared to the right side (n=5). The parietal emissary foramen variations were noted in the majority of the skulls with accessory bones. The commonly noted variations were bilateral absence, (Figure1A and 1B) and unilateral presence (Figure1D-1F), presence on the sagittal suture (Figure 1G), and multiplicity (Figure1H). The morphometry of the WBs and Inca bones showed quadrilateral (Figure 2) as the most common shape (n=9, 37.5%) followed by triangular (n=4, 16.6%). Majority of the bones were of large size. The chief morphometric features are depicted in (Figure 3). Radiological examination of all 24 skulls with accessory bones showed a zigzag pattern of accessory suture lines (Figures2).

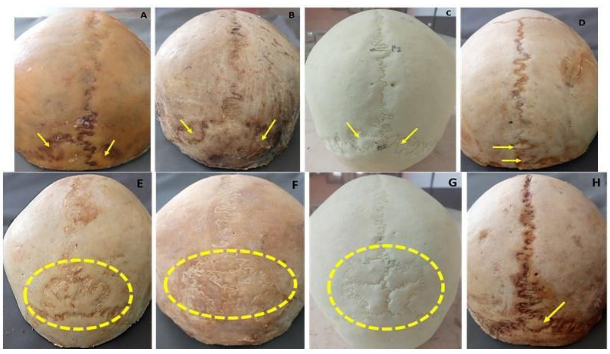

Figure 1) *A, B, C arrows showing bilateral WBs in the lambdoid suture, C arrow showing WB in sagittal suture E, F, G circle showing Inca bones, A, B skulls showing bilateral absences of Parietal foramen, and D, E, F, H skulls showing unilateral Parietal foramen, C skull showing left Parietal foramen on the sagittal suture.*

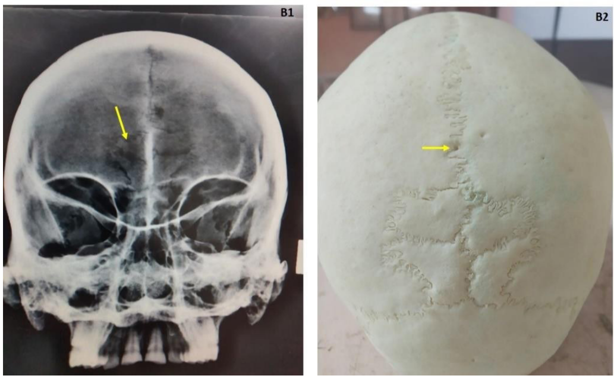

Figure 2) ***B1)** Plain skull X-Ray showing zigzag pattern of accessory suture lines. **B2)** photograph of the radiographed skull.*

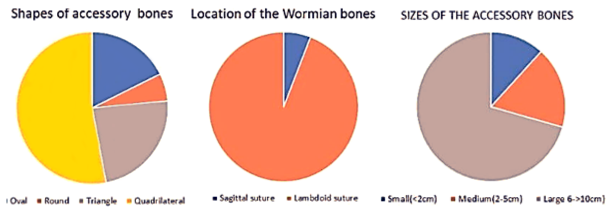

Figure 3) *The chief morphometric features of accessory bones are depicted in pie chart.*

Discussion

The current study aimed at identifying the presence of WBs and Inca bones, and their morphology and morphometry. WBs can be seen in normal and pathological crania. Their etiology is still unclear if it could be related to genetics [13]. Studies have reported that WBs are under genetic influence, and they may be inherited as an autosomal dominant trait with about 50% variable expression [14]. The different shapes and sizes of the WBs have been reported in literature. Frequently encountered shapes are triangular and quadrilateral, which is consistent with the findings of the current study. The size measures from millimetres in diameter to 10 centimetres (cm) [15]. In the present study, 50% of the accessory bones are between 5 -10 cm and these bones articulate with the surrounding bones by sutures.

The prevalence of WBs has been estimated as 52.99% in the lambdoid suture and multiple WBs were seen in lambdoid suture in 0.01%

[16]. In the occipital region, the accessory bones can be multiple and bilateral [17]. In the present study, the prevalence of WBs is approximately 13.2%, out of which multiple and bilateral WBs were seen in the lambdoid suture. The occurrence of interparietal bone or Inca bone at the lambda has been reported in previous literature, but these are associated with other cranial and central nervous system abnormalities [18,19]. The present study found Inca bones that could be associated only with parietal emissary foramen abnormalities. There are multiple studies available about the presence of accessory bones at the lambda, lambdoid suture, sagittal suture, and at the pterion. In a unique case reported by Satheesha Nayak (2008), the presence of accessory bone at the bregma may occur because of the appearance of an abnormal ossification center in the fibrous membrane at the anterior median fontanelle in foetal life [20].

The presence of series of WBs in the lambdoid sutures causes difficulty in the posterior approach to the cranial cavity [21]. The presence of multiple WBs can be misdiagnosed as skull fractures [22]. The salient features that differentiate skull fracture and accessory sutures are tabulated as shown in table 1. The radiologic appearance of accessory bone and fracture is different. The radiologic pattern of simple skull fractures can be shown as non-sclerotic edges, in sutural bones show as a zigzag pattern with sclerotic borders [23-27].

Table 1

The salient features the differentiate skull fractures and accessory sutures are tabulated. [27]

S. No	Parameter	Skull Fracture	Accessory Suture
1	Radiologic pattern	Non-sclerotic borders	Sclerotic borders
2	Appearance	Sharp lucency	Zig-Zag
3	Laterality	Often unilateral	Often bilateral
4	Soft tissue reaction swelling/hematoma	Yes	No
5	Relation with suture lines	Crosses adjacent suture line	Merges with adjacent line
6	Diastasis	Yes	No

Conclusion

The presence of WBs is quite common and sometimes occur in high numbers in children even when there is no background of osteogenesis imperfecta or other syndromes, and they must usually be considered to be a simple anatomical variant whose mechanism of development is not entirely understood. When identified in radiography investigations carried out due to a suspicion of physical abuse, the presence and number of WBs should always be reported and distinguished from fracture. In view of our results, it is important to bear in mind that accessory sutural bones are common in a normal population before drawing any diagnostic conclusions from such findings.

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