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Original Research Article

INCIDENCE OF WORMIAN BONES IN DRY HUMAN SKULLS IN SOUTH INDIAN POPULATION

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ABSTRACT

Background: The Wormian bones are small bones located in or near the sutures of the skull which are irregular in size, shape and number. The present study is to look into the morphological details of such supernumerary bones of skull with regards to their incidence, number and topography in skulls from the South Indian population.

Materials and Methods: This study was carried out in the Department of Anatomy, Yenepoya Medical College. A total of 200 dry human skulls for wormian sutures in 7 bilateral sites and 4 unilateral sites. The parameters such as; percentage of skulls with wormian bones, Incidence of wormian bones with respect to sutures and topographic distribution of wormian bones in the skull were noted.

Results and Discussion: In the present study the incidence of wormian bones was seen in 123 (61.5%), with a maximum incidence at the lambdoid suture (112 skulls, 91.05%), followed by the asterion (98 skulls, 79.67%) and coronal suture (66 skulls, 53.65%). We also found that 70 (14.17%) wormian bones were present along the midline of the skull.

Conclusion: The radiologist and neurosurgeons should keep in mind about such occurrence of accessory bones before doing craniotomy surgeries. The topographical distribution of wormian bones could be useful to radiologists and forensic experts in successfully differentiating a skull fracture/injury and a normal suture, and thereby exclude possibilities of physical abuse and brittle bones. It also helps neurosurgeons, neuroanatomists, orthopedicians, radiologists, anthropologists and morphologists to arrive at an early diagnosis and timely management of disorders associated with it.

KEY WORDS: Wormian bones, Sutures, Skull, Frontanella, Genetic factors.

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INTRODUCTION

The Wormian bones or Sutural bones are islands of small bones found in or near the sutures of the skull [1]. Wormian bones also called as ossa suturalia, are accessory ossicles which are irregular in size, shape and number, that appear in addition to the usual centres of ossification of the human cranium and, although unusual, are not rare [2]. The term “wormian bones” is derived from Olans Worm, a Danish anatomist.

These wormian bones do not follow a regular pattern and are unnamed as they vary in size, shape and number. Literature names such accessory bones as supernumerary ossicles, intercalary, sutural and intrasutural bones [3]. These bones are separated parts of the primary ossification centers of the skull which were identified in normal healthy individuals, but a correlation was also found between the incidence of wormian bones and congenital diseases like osteogenesis imperfecta, cleidocranial dysostosis, progeria etc [4]. The incidence of wormian bones is variable, being 10% in Caucasians, 40% in Indians and 80% in Chinese skulls [5]. They are frequently found in lambdoid suture [4,5]. Wormian bones are the markers for various metabolic diseases like Rickets, Kinky Hair Menkes Syndrome, Cliedocranial Dysostosis, Hypothyroidism, Otopalatodigital Syndrome, Primary Acroosteolysis [Hajducheney Syndrome] and Downs Syndrome [6].

When the wormian bones occur as a normal variant, they tend to be smaller and lesser in number than when they are associated with skeletal dysplasia [7]. Anatomical details of wormian bones are also valuable from medico-legal point of view in the forensic investigation of non-accidental skull injuries in children as well as adults [8]. It is important to know about these bones because they can be misleaded in the diagnosis of fracture of skull bones [3]. The radiologist and neurosurgeons should keep in mind about such occurrence of accessory bones before doing craniotomy surgeries. Hence, the present study is to look into the morphological details of such supernumerary bones of skull with regards to their incidence, number and topography in skulls from the South Indian population.

MATERIALS AND METHODS

This study was conducted on 200 dry adult human cadaveric skulls of unknown age and sex in the department of anatomy of Yenepoya Medical College, Mangalore. We ensured that all selected skulls were without any evident signs of ante-mortem or post-mortem injuries. Any deformed or irregularly cut skulls were excluded from the study. The data was tabulated and compared with earlier studies.

All the sutures were observed systematically from anterior to posterior aspect at 7 bilateral sites (lambdoid suture, coronal suture, parietomastoid suture, occipitomastoid suture, frontozygomatic suture, asterion, pterion) and 4 unilateral sites (bregma, lambda, metopic suture and sagittal suture) for the presence of wormian bones and their numbers in relation to sutures.

The following parameters were evaluated in the present study: (a) Percentage of skulls where wormian bones were present, (b) Incidence of wormian bones with respect to sutures in the skull, (c) Topographic distribution of wormian bones in the skull.

RESULTS

Table 1: Overall Incidence of Wormian Bones.

Wormian Bones	Number (%)
Present	123 (61.5%)
Absent	77 (38.5%)

Table 2: Incidence of wormian bones at different areas of skull.

Location	Left	Right	Total (%)
Lambdoid Suture	54	58	112 (91.05%)
Parieto-Temporal Suture	30	26	56 (45.52%)
Occipito-Mastoid Suture	19	14	33 (26.82%)
Fronto-Zygomatic Suture	16	23	39 (31.70%)
Asterion	48	50	98 (79.67%)
Pterion	11	9	20 (16.26%)
Coronal Suture	30	36	66 (53.65%)
Bregma	3		3 (2.43%)
Lambda	29		29 (23.57%)
Saggital Suture	34		34 (27.64%)
Metopic Suture	4		4 (3.25%)

In the present study the incidence of wormian bones was seen in 123 (61.5%) out of 200 skulls. We also found that the maximum incidence of wormian bones were observed at the lambdoid suture (112 skulls, 91.05%) [Figure 1], followed by the asterion (98 skulls, 79.67%) [Figure 2] and coronal suture (66 skulls, 53.65%). Also found such bones at parietotemporal suture (45.52%), frontozygomatic suture (31.70%), sagittal suture (27.64%), occipitomastoid suture

Table 3: Comparison between anatomical details of wormian bones as observed in the present study and previous ones.

No	Authors	Geographical region to which study skulls belong	Total number of dry human skulls	Incidence of the wormian Bones present	Incidence of wormian bones with respect to sutures in skull	
					Maximum incidence	Minimum incidence
1	Murlimanj et al. (2011) [20]	South India	78	57 (73.10%)	Lambdoid suture	Coronal and sagittal suture
2	Khan et al. (2011) [21]	Malaysia	25	7 (28 %)	Lambdoid suture	Coronal, Squamosal and sagittal suture
3	Walulkar et al. (2012) [22]	Western India	225	77 (34.22%)	Lambdoid suture	Coronal suture
4	Patil and Sheelavant (2012) [23]	South India	180	94 (52.20%)	Lambdoid suture	Coronal suture and bregma
5	Marti et al. (2013) [24]	France	605 (CT scan analysisiin 0-3 yrs age group	320 (53%)	Left lambdoid suture	Sagittal suture
6	Govsa et al. (2014) [8]	Turkey	300	27 (9 %)	Right & left lambdoid suture	Sagittal suture
7	Vedula et al.(2015) [26]	South India	58	14 (24.13%)	Only in lambdoid Suture	-
8	Cirpan et al.(2015) [25]	West Anatolia	150	89 (59.30%)	Left lambdoid suture	Right Occipito mastoid suture
9	Ghosh et al. (2016) [30]	Eastern India	120	54 (45%)	Left lambdoid suture	Bregma, right coronal and metopic suture
10	Present Study	South India	200	123 (61.5%)	Lambdoid suture	Bregma

Table 4: Showing incidence of wormian bones in present study and compared with other authors studied in different regions of the world according to Brothwell [1963].

Sl No.	Population	Incidence [%]
1	Chinese	80.32
2	German	75
3	Australian	72.58
4	Romano-British	71.03
5	Melanesian	64.15
6	Lachish	63.41
7	Anglo-Saxon	55.56
8	India [North Karnataka]	56.5
9	India [South Karnataka]	73
10	Present Study [South Indian]	61.5

Fig. 1: Showing lambdoid suture with inca bones.

Fig. 2: Showing asterion with wormian bones.

Fig. 3: Showing lambda with wormian bones.

Fig. 4 (a): Schematic representation of the sites of the skull, both bilateral and unilateral, where wormian bones were observed in the present study.

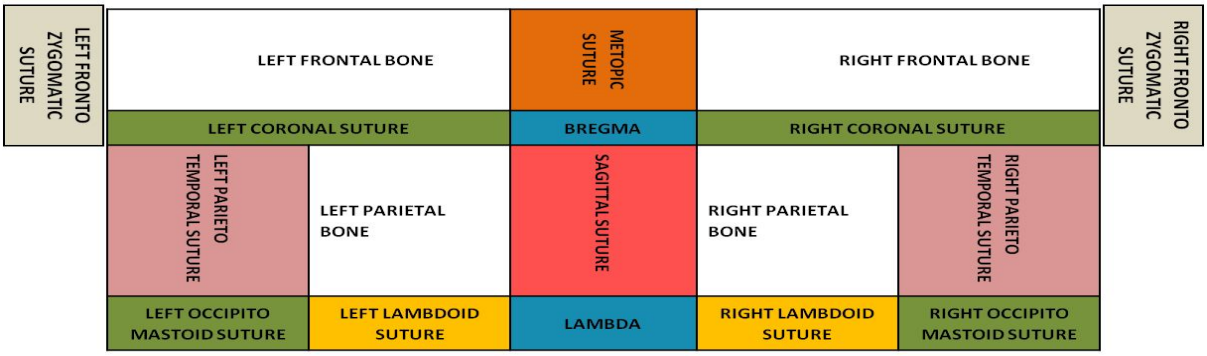
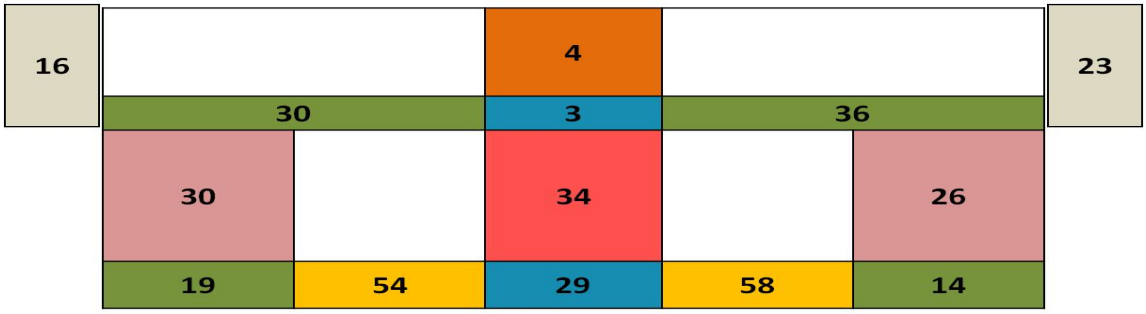


Fig. 4 (b): Schematic representation of the topographic distribution of the wormian bones in the skulls observed in the present study.



(26.82%), lambda (23.57%) [Figure 3], pterion (16.26%), metopic suture (3.25%) and bregma (2.43%).

A total of 494 wormian bones were observed in the skulls, and the topographical distribution of these bones has been detailed in a schematic manner in Figure 4 (a,b). We found that 70 (14.17%) wormian bones were present along the midline of the skull, whereas 208 (42.10%) and 216 (43.72%) wormian bones were present at the left side and right side of the skull, respectively (Figure 4b).

DISCUSSION

Wormian bones are a matter of discussion in several researches since decades. Over the years, numerous theories have been suggested to explain the development of wormian bones, but none of these has been universally accepted [9]. Some of the causes can be as racial feature, as a consequence of skull deformation, an adaptation to cranial enlargement, metabolic disorders of mesoderm, autosomal dominant traits [10]. Earlier, environmental factors were the most cited cause in the literature regarding the development of wormian bones, and it was suggested that wormian bones developed in response to mechanical deformities of the cranium that were either pathological or induced artificially [11,12].

In 1977, El-Najjar and Dawson concluded this theory by comparing the incidence of wormian bones between skulls with deformities and those without [13], and supported the existence of both environmental as well as genetic factors in its formation [14]. Bergman et al. in 1988 [15] suggested that development of wormian bones could possibly may develop due to the rapid cranial expansion that spreads sutures apart and develops dural strain within the sutures and fontanelles.

Recent studies have reported an increased frequency of wormian bones associated with craniosynostosis (premature fusion of cranial sutures), hydrocephalus, cerebral palsy, epilepsy which results in the abnormal dural strain (mechanical stress) that initiates formation of islands of wormian bones in the membranous portion of the fontanelle [5,16]. It can be concluded that there is disagreement among the researchers regarding the extent of morphology of the wormian bones can be attributed to environmental or genetic influences [17,18].

In 16th century Andernach and Vesale were the first to associate wormian bones with cerebral disorders. The increased interest in the skull

during the past century has resulted in many studies and reports describing the associated diseases and hypothetical causes [5,10,11]. Parker had mentioned several synonyms that were used as follows: according to the discoverer (ossicula Andernaci, ossa Grethiano), according to shape (ossa triquetra, ossa triangularis, ossa quadratum), according to localization (suturaux, fontanellaires, insules, intercalaria, raphogeminantia, apicis), according to function (complementaria, ossa accessorii) [4].

In the present study, overall incidence of wormian bones was seen in 123 skulls [61.5%] (Table 1). Pryles and Khan reported the prevalence of cerebral abnormalities in a population with wormian bones in a random group of infants and childrens [5]. The occurrence varied from 93% to 100% in a random group and 100% in mentally retarded patients. The percentage of skulls with wormian bones as reported by different authors has been highly variable (Table 3). Considerable genetic variations have been documented among population groups residing in different regions of India [19].

In the present study, an overall incidence of 61.5% of wormian bones in dry human skulls is seen from the population of the south Indians. Our finding is significantly lower than that reported by Murlimanju et al. who studied in 78 skull bones and found 57 (73.1%) skulls positive. But is higher than the studies done by Patil and Sheelavanth with 94 (52.22%) positive skulls in 180 bones and Vedula et al. with 14 (24.13%) in 58 skull bones on the same population.

Majority of the studies on wormian bones showed that the incidence is more along the lambdoid suture, which is also termed as pre-interparietal bone or Inca bone. Murlimanju et al reported 56.4% incidence of wormian bones along the lambdoid suture [20]. Bergman et al reported 40% of wormian bones in the same location [15]. In our study, we observed 91.05% of lambdoid sutural bones. De facto in one of the studies it was noted that the wormian bones were present only in the lambdoid suture [26]. The archaeologist Brothwell studied the incidence of wormian bones in different population groups across the world, and observed remarkable variations, reporting the highest incidence among the Chinese (80 %) [27] [Table 4]. Brothwell (1963) reported the prevalence of wormian bones among different populations and the data is represented in Table 4, which also includes the incidence rate of the current study. This implies that we have to consider the co-existence of genetic influence as well as mechanical factors regarding the incidence of wormian bones, as researchers have suggested that the high incidence of wormian bones in crania of Chinese populations as compared to other population groups could be due to the traditional supine infant sleep position leading to brachiocephalic deformations among the Chinese [28]. We also noted a very high incidence of 79.67% of wormian bones at the asterion which is higher than the study done by Udaya kumar (40.70%) [29] in North Karnataka region and Manjunath (4.50%) [30] in south Indian population. Also, we have identified 53.65% sutural bones incidence in the coronal suture which is absent in the other two populations.

In the current study, we also noticed a high incidence (23.57%) of wormian bones at the lambda; which is also known as Os Incae or Inca bone, with a highly variable incidence in other populations like; 21.21% in East Indian population [31], 46% in North Karnataka region [29], 1.32% in Central India [32] and 14% in South Indian population [20]. The reason for the presence of wormian bones at Lambda may be that the interparietal part of the squamous occipital bone and the highest nuchal lines develops in membrane, usually from two pairs of ossification centres [33]. After reviewing the table-2 the present study is in acceptance that the presence of wormian bones is very rare at Bregma which correlates with the previous studies done by Brasilli P et al [34] and Manjula patil et al [35].

If there are more than two or three Inca bones, it may lead to complications while performing craniotomy surgeries when done by posterior approach. Such bones may also create confusion among radiologist to misdiagnose it as skull fractures during the severe head injuries.

Our study shows the incidence of Inca bone [Table 2] to be 91.05% of total 123 skulls which is close to the studies done earlier and after seeing the Table 4, proves and totally agree to the point that lambdoid suture is most common

area of occurrence of wormian bones in skull. In line with the orientation of wormian bones, incidence are seen almost equal at the right and left half of the skull.

CONCLUSION

In the current study reports, we observed an incidence rate of 61.5% wormian bones in Indian skulls, which is slightly higher compared to other reports which may be due to the racial variations or genetic factors which determines the morphology of wormian bones. Thus the present study also confirmed that wormian bones are not so uncommon. Also the incidence of wormian bones is more frequent at the lambdoid suture which is in correlation with the earlier authors. The neurosurgeons should check before performing craniotomy surgeries especially at lambdoid region. Also the presence of wormian bones should be kept in mind in case of any intervensions or investigations on skull or cranial cavity.

Knowledge of the anatomy of wormian bones could be critical for radiological diagnosis of wormian bones, which is a useful primary screening measure for central nervous system disorders early in life. The knowledge of sutural bones, their incidence and features is enlightening for the neurosurgeons, neuroanatomists, orthopedicians, radiologists, anthropologists and morphologists to arrive at an early diagnosis and timely management of disorders associated with it. The topographical distribution of wormian bones could be useful to radiologists and forensic experts in successfully differentiating a skull fracture/injury and a normal suture, and thereby exclude possibilities of physical abuse and brittle bones.

This study also showed that the incidence of wormian bones are almost equal at the right and left side of the skull in terms of its orientation. We hope that the current study has provided additional information on the morphology and topography about the wormian bones.

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Conflicts of Interests: **None**

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