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Study of Wormian Bones In Relation To the Size of the Skull with an Aim for Sexual Dimorphism

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Abstract: *Bones are population-specific.Racial,regional and gender variation exists in skeletal components of bones .The present study was undertaken to observe the relationship between the cranial index and the incidence of wormian bones and to study the sexual dimorphism with regards to wormian bones inadult human dry skull.This study included 103 dried human skulls taken from the department of anatomy, GVPIHC&MT, Visakhapatnam.The bones were separated into male and female and divided into three categories based on their cranial index i.e. normal (CI<81), brachycephalic (CI 81-93) and severely brachycephalic (CI >93).Out of 103 skulls, 73 (70.8%) showed sutural bones and the most frequent site was asterion (56%). Severely brachycephalic skulls(CI >93)was found to havemore number of wormian bones. Sexual dimorphism with regards to wormian bones exists in skulls as observed thatthe male skulls had more number of wormian bones (51.4%) than female (19.4%) with a P value <0.01which proves to be statistically significant .A knowledge of distribution of wormian bone in the adult human dry skulls is useful for clinicians and radiologists in studying radiographs to avoid interpreting it as fracture.*

Keywords: *brachycephaly, lambdoid,pterion, sagittal suture, sexual dimorphism, wormian bone.*

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I. Introduction

Cranial index is useful in studies of primate phylogeny. It gives an indication of growth and development of an individual and also of abnormalities of cranial size and shape in aparticular population and age [1].It also permits comparison of cranial morphometry between parents, offspring and siblings which gives a clue to genetic transmission of inherited characters (Shah & Jadhav) [2].The cranial index was defined by Swedish professor of Anatomy Anders Retzius (1796–1860) and first used in physical anthropology to classify ancient human remains found in Europe [3].Wormian bones are the extra bones which appear as a result of accessory ossification centres in or near the sutures. They are named so because they were first discovered by the Anatomist, OlausWormius. Sometimes they are called supernumerary ossicles, sutural ,intercalary and intra-sutural bones [4].

Racial variation in cephalic index is clearly demonstrated in literature but sexual dimorphism of skull with regards to wormian bones is less documented. Wormian bones are non-metric skull variants which can be of immense help and since their number varies in different sexes they can also provide information about sexual dimorphism of skull bones. Therefore this study wascarried out inorder to contribute to the knowledge of occurrence of sutural bones in a particular population groupand in a particular gender.

II. Material and Method

The present study included 103 adult human dry skulls of south Indian origin which were obtained from the department of anatomy and forensic medicine of our institution GVPIHC&MT, Visakhapatnam. The exact age of the specimens was not known and the gender was determined by established non-metrical parameters.

2.1Inclusion criteria:

1.Adult human dry skull irrespective of sex.
2.Undamaged skull bone.
3.Third molar tooth erupted.
4.Suturesclearly seen .

2.2 Exclusion criteria:
1.Damaged skulls.
2.Skull showing pathological changes at the calvarium.
2.Skulls of newborn and children.
3.Old skulls with faint suture line

2.3Observation

For each observation,readings were taken twice to reduce the error of measurement. All measurements were recorded in millimetre and entered in the MS Excel work-sheet .The data collected was tabulated. The statistical analysis of the data was done by using SPSS version 22.

In each skull the following parameters were evaluated :
1. Incidence and percentage of skull showing wormian bones (table I)
2.Sexual dimorphism of skull in regards to wormian bones(table II)
3.Incidence of wormian bones with respect to sutures in the skull (table III)
4.Maximum Cranial Breadth= the head breadth is the widest biparietal diameter
5. Maximum Cranial Length = the head length was measured between the glabella and inion
6. Cranial index of the skull i.e. is the ratio of the maximum width (biparietal diameter or BPD of the head multiplied by 100 divided by its maximum length (occipitofrontal diameter or OFD). The maximum length and breadth were calculated using Vernier calliper (table IV,V) .The measurable point for head length was measured between glabella and inion while the head breadth was the widest biparietal diameter.
7.Classify the skull according to the cranial index (table IV)
Depending upon this index, the skull was categorized (Williams et al.) [5].
Head shape Cephalic index (CI) range (%)
Dolichocephalic CI < 74.9
Mesochepalic75 < CI < 79.9
Brachycephalic80 < CI < 84.9
Hyperbrachycphalic85 < CI < 89.9 and CI < 89.9
8. Incidence of wormian bones with respect to the cranial index (table IV)

2.4 Results

Out of 103 skulls, 73 (70.8%) showed sutural bones and the most frequent site was asterion (56%). In severely brachycephalic skulls (CI >93) wormian bones was present in almost all skulls (100%). Sexual dimorphism with regards to wormian bones exists in skulls as observed that the male skulls had more number of wormian bones (51.4%) than female (19.4%).

III. Figures And Tables

Table I: Gross Incidence and Percentage of skull showing wormian bones

GENDER	No.of skull with wormion bones	%	No.of skull without wormion bones	%	Total	%
Male	53	86.9	8	13.1	61	59.2
Female	20	47.6	22	52.4	42	40.8
Total	73	70.8	30	29.2	103	100
Chi-square value= 18.58; P<0.01						

Table II: Sexual Dimorphism in Incidence of Wormian Bones.

	Sl.No	Wormian Bones	Male	%	Female	%
	1	Asterion	32	78%	9	21.95%
	2	Lambda	14	70%	6	30%
	3	Pterion	4	44.44%	5	55.55%
	4	Parieto-temporal	3	100%	0	0
	5	Bregma	-	-	-	-
	6	Coronal	-	-	-	-
	7	Sagittal	-	-	-	-
Total		73	53		20	

Table III: Incidence of wormian bones with respect to sutures of the skull.

S.l No.	Sites of wormian bones	No.of skull	Frequency	Occurrence		
				B/l	R.t	L.t
1	Asterion	41	56.1%	28	7	6
2	Lambda	20	27.3%	15	2	3
3	Pterion	9	12.3%	1	4	4
4	Parieto-temporal	3	4.1%	3	0	0
5	Bregma	-	-	-	-	-

6	Coronal	-	-	-	-	-
7	Sagittal	-	-	-	-	-
TOTAL skull=103		73	70.8%	-	-	-

"**Fig 1"**showing incidence of wormian bones with respect to sutures of the skull

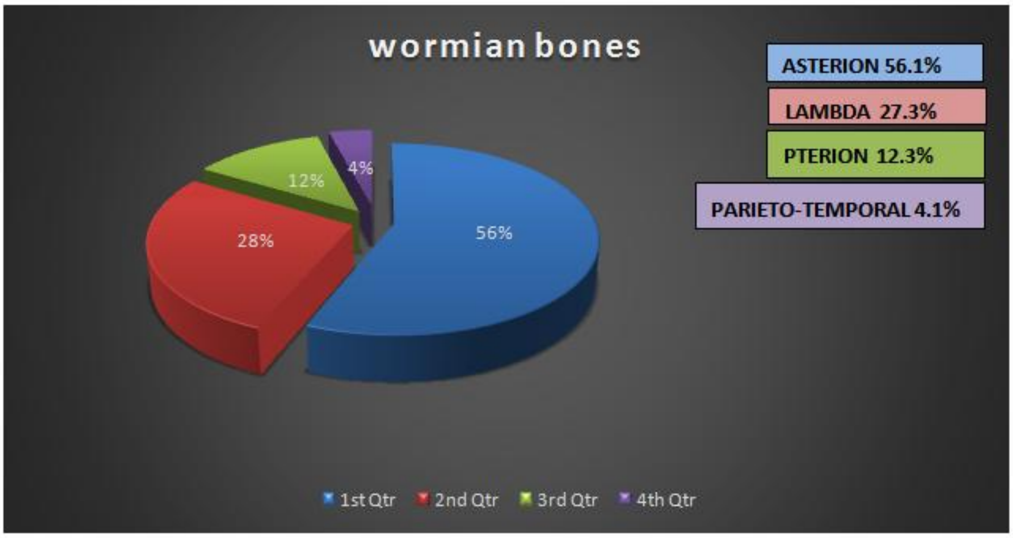

Table IV: Incidence of wormian bones with respect to the cranial index.

Head shape	C.I range	No. of skulls	WB	Male	WB	Female	WB
Mesocephalic	75-79.99	44	25	22	18	28	8
Brachycephalic	80-84.99	39	28	27	23	10	8
Hyper-brachycephalic	85<	20	20	12	12	4	4
TOTAL		103	73	61	53	42	20

"Fig 2"Skull bones showing wormian bone at Asterion

"Fig 3"Showing multiple wormian bones at lambda

"Fig 4"Showing Pterion ossicle or "Flowers bone"

"Fig 5"Showing multiple wormian bones at lambdoid sutureor "Inca bone"

IV. Discussion

The formation and distribution of wormian bones are the result of different stress factors like tension, pressure etc acting on the cranial vault during prenatal and early postnatal periods of bone growth [6].During ossification there is stretching of cranial duramater along the line of bone ossification which prevents the closure of suture. Thus intra-sutural bones are formed which are not included during bone mineralization.ButZambare (2001), Sánchez-Lara et al. (2007)) stated that the type of stress that influences the wormian bone formation or the direct influence of stress in the presence of wormian bones is still unknown [7]. Wormian bones are present in both normal and pathological crania. Their aetiology is still unclear; nevertheless it has been related to genetics, in terms of population, as well as external forces, such as stress conditions [8]. Wormian bones are not under genetic influences but Torgerson reported that wormian bones are inherited as autosomal dominant traits with about 50% penetrance and variable expression [9].

They can develop either from independent ossification centres or by their separation from primary centres and their shape may be round, oval, oblong, triangular, quadrilateral or polygonal and vary in size from less than a millimetre in diameter to the one measuring 5 by 10cm bones articulating with the surrounding bones by sutures [10].As growth and ossification takes place, gradually these fontanels become bone and the area of contact between each other becomes sutures [11]. There are five main sutures in the human skull where the wormian bones can form: two squamous (one on each side of the skull), one coronal, one lambdoid and one sagittal suture. Studies done by various author in different regions have showed that wormian bones are commonly found over the lambdoid sutures. Bergman et al.reported that 40% of skulls have sutural bone in the lambdoid suture[12].Murlimanju et al reported 56.4% incidence of wormian bones along the lambdoid suture [13].Most of the studies on wormian bones showed the highest incidence along the lambdoid suture, which is also termed as pre-interparietal bone or Inca bone. A wormian bone at Pterion is called as Pterion ossicle or Epipteric bone or Flowers bone. In a study done by Nayak B et al showed that the incidence of such bones is high in Indians (11.79%)[14]

In the present study wormian bones were reported as 70.8% and the commonest site of sutural bone in our study is Asterion which was reported as 56.1% and which is different from findings made in other studies.Similar to the observations of Berry, who noted a higher incidence of the wormian bones in male skulls especially at Asterion in the different population groups including the Indian Punjabis [15].

Wormian bones are found in both sexes in similar percentages as well as in both sides of the skull, being predominantly symmetrical (Hanihara and Ishida)[16].In our study occurrence of wormian bones in the males at asterion (78%), lambda (70%) and parieto-temporal suture (100%) is higher than female (21.95% ,70%,0% respectively) while the incidence rate of wormian bones at Pterion is higher in female as compared to male (table II).In the present study the percentage incidence of the wormian bones in male and female skulls was found to be 51.4% and 19.4% respectively with a*P value of <0.01*. which proves this study to be statistically significant. Itcan also beconsidered as*sexually dimorphic.*However earlier workers have not reported the sexual dimorphism in relation to wormian bones at different cranial sites.

V. Conclusion

The present study shows thatthough small and unimportant, sexual dimorphism does exist in the skull in terms of wormian bones. This differs from the work done by different authors.Though asymptomatic inpresence but during emergency situations it can create confusionto the radiologists and surgeons. Undetected inter-parietal bones may create an impression of extra fractures while performing the burr hole neurosurgeries.

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