The Incidence and Topographic Distribution of Sutures Including Wormian Bones in Human Skulls

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Objective: The Wormian Bones are accessory bones located within the cranial sutures and fontanelles. The present article examines the incidence of Wormian Bones and compares the number and topographic distribution between the sutures including Wormian Bones in skulls of West Anatolian Population.

Methods: One hundred fifty crania were examined. The parameters evaluated in the present study were as follows: the rate of skulls including Wormian Bones; the topographic distribution and frequencies of the sutures including Wormian Bones; the number of these sutures for each skull; the name and number of sutures that were bilaterally and symmetrically located on the right and left side of skull (paired sutures) and which coincidentally had Wormian Bones for each skull; the differences of frequencies between the paired sutures including Wormian Bones.

Results: The rate of skulls including Wormian Bones was determined as 59.3%. The maximum and minimum numbers of sutures, including Wormian Bones, were 6 in 1 skull and 1 in each of 30 skulls, respectively. The maximum and minimum rates of sutures that had Wormian Bones were found in left lambdoid 40.7% and right occipitomastoid 1.3% sutures, respectively. There was only a significant difference between the rate of right and left squamous sutures ($P = 0.04$). Forty-five skulls were including 55 pairs of bilaterally and symmetrically located sutures that coincidentally had Wormian Bones in each pair. Each of 35 skulls had 1 pair of sutures including Wormian Bones and each of 10 skulls had 2 pairs.

Conclusions: In the present study, the rate of Wormian Bones was determined as 59.3% in West Anatolian Population. This incidence rate is considerably lower than the other reports, and it may be as a result of racial variations. These divergent bones were more frequently found in left lambdoid sutures (40.7%) and less frequently in right occipitomastoid sutures (1.3%). This study may guide the investigators dealing with the neurosurgery, orthopedy, radiology, anatomy, and anthropology in their practice.

Key Words: Neurocranium, sutural bones, west Anatolia, Wormian Bones

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The accessory bones that are located within the cranial sutures (usually in the posteriorly located sutures) and fontanelles are called Wormian Bones (WBs). They were first described by the Danish anatomist Olaus Worm in 1643.[1] The spaces between the cranial sutures are filled by WBs.[2] They are usually accepted as normal variants of ossification and appear to have genetic inheritance in certain populations.[3] It is also postulated that the formation of bregmatic bones is due to delayed closure of the anterior fontanelle.[4]

The size of the WBs may vary from less than a millimeter in diameter to 5 by 9 cm, and their shapes may be observed as round, oval, oblong, triangular, quadrilateral, or polygonal.[5] El-Najjar et al[6] declared that the WBs are seen more frequently in adults (62.1%–76.2%) than fetuses (11.3%). Although Berry et al[7] concluded that there is no significant difference in the frequency of the sutural bones between the sexes, the males are affected more than females in some studies.[1,5,8]

WBs may be a sign of the anomalies of the central nervous system although the exact mechanisms of formation of WBs are not exactly known.[8] Although WBs can be seen in healthy individuals, in congenital disorders such as osteogenesis imperfecta, cretinism (hypothyroidism), cleidocranial dysostosis, progeria, hypophosphatasia, rickets, etc, the higher incidence of multiple WBs has been observed.[9] A bone dysplasia affecting early skull development such as osteogenesis imperfecta can cause the formation of these irregular bones.[10]

WBs located posteriorly are influenced by environmental factors more than the anteriorly located ones.[1] WBs that are more frequently seen in Chinese crania compared with western cultures may be due to traditional supine infant sleep position causing brachycephalic deformations in Chinese crania.[11] Both environmental and genetic influences are responsible in the occurence of WBs.[12]

The present article aimed to report the incidence of WBs and to compare the frequency of topographic distribution between the sutures that were symmetrically located on each side (right and left) of skull and that were including WBs in skulls of West Anatolian Population.

METHODS

One hundred fifty crania of West Anatolian people of unknown ages and sex belonging to the Anatomy Department Laboratory of Dokuz Eylul University Medical School were examined. Official permission for this investigation was obtained from Dokuz Eylul University Medical School. None of the specimens showed signs of prior cranial surgery or trauma. All the skulls were accepted as adults, regarding tooth eruption of the bones. The topographic distribution and frequencies of the sutures that had WBs were evaluated with macroscopic observation of the skulls. The other parameters evaluated in the present study were as follows: first, the rate of skulls that had WBs, second, the number of sutures that had WBs for each skull, third, the name and number of sutures that were bilaterally and symmetrically located on the right and left sides of skull (paired sutures) and that coincidentally had WBs for each skull, and fourth, the name and number of pair of sutures that coincidentally had WBs in each pair. We also compared the

TABLE 1. No of Sutures Which Had WBs for Each Skull

No of Sutures	No of Skulls	No of WBs	%	%
0	61	0	40.7	40.7
1	30	30	20.0	59.3*
2	26	52	17.3	
3	13	39	8.7	
4	15	60	10.0	
5	4	20	2.7	
6	1	6	0.7	
Total	150	207	100	100

WBs = Wormian Bones.
*Incidence of skulls which had WBs.

frequency in between the sutures that were bilaterally and symmetrically located on the right and left sides of skulls and that had WBs. The samples were photographed with Canon 400B (55 mm objective). The descriptive and analytic (McNemar's test) statistical analyses of collected data were performed with SPSS 15.0.

RESULTS

We examined 150 skulls and found that the incidence of skulls that had sutures including WBs were as 59.3% (89 of 150) (Table 1). We also evaluated the number of sutures that were including WBs for each skull. We found that maximum numbers of these sutures were 6 in 1 skull and minimum number of these sutures was 1 in each of 30 skulls (Table 1).

The name, site of location (Fig. 1), and frequencies of these sutures are shown in Table 2. The maximum and minimum rate of sutures that had WBs were found in left lambdoid 40.7% (61/150) and right occipitomastoid 1.3% (2/150) sutures, respectively. We also statistically compared the frequencies of sutures that were symmetrically located on each side of skulls and that were including WBs. We found that there was only a significant difference between the rate of right and left squamous sutures ($P = 0.04$) (Table 2).

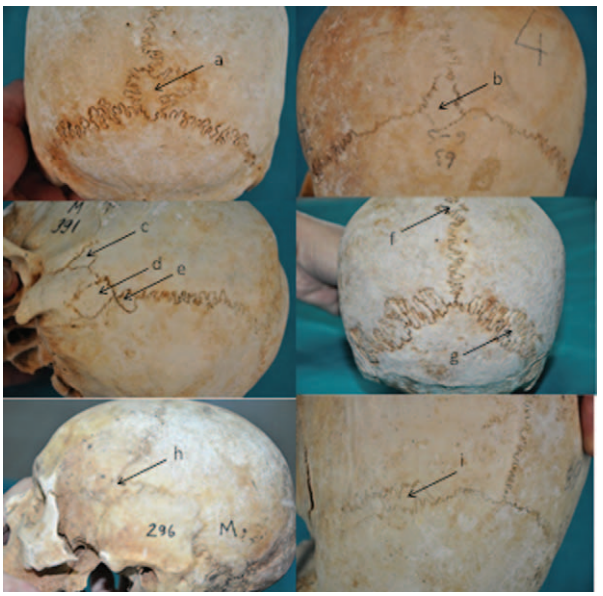

FIGURE 1. WBs at a-lambda, b-bregma, c-squamous suture, d-occipitomastoid suture, e-asterion, f-sagittal suture, g-lambdoid suture, h-pterion, i-coronal suture.

TABLE 2. The Name and Number of Sutures Which Had WBs

Names of Sutures	No of Sutures	%	P
Lambdoid^{R}	56	37.3	0.44
Lambdoid^{L}	61	40.7	
Coronal^{R}	5	3.3	1.00
Coronal^{L}	5	3.3	
Pterion^{R}	8	5.3	0.38
Pterion^{L}	12	8.0	
Asterion^{R}	10	6.7	1.00
Asterion^{L}	11	7.3	
Squamous^{R}	3	2.0	0.04
Squamous^{L}	10	6.7	
Occipitomastoid^{R}	2	1.3	0.68
Occipitomastoid^{L}	4	2.7	
Bregma	3	2.0	–
Sagittal	7	4.7	–
Lambda	10	6.7	–
Total	207	100	–

WBs = Wormian Bones. ^{R}: at right side of skull, ^{L}: at left side of skull.

We found that 45 skulls were including 55 pairs of bilaterally and symmetrically located sutures that coincidentally had WBs in each pair. We also determined that each of 35 skulls had 1 pair of sutures including WBs and each of 10 skulls had 2 pairs. The number of skulls and the name and number of pair of sutures are given in Table 3. The name and number of pair of sutures that coincidentally had WBs in each pair are shown in Table 4. Forty-five pairs of these sutures were belonging to lambdoid sutures, whereas 2 pairs of them were belonging to squamous and 2 pairs to coronal sutures.

TABLE 3. The Name and Number of Pair of Sutures Which Concidentally Had WBs for Each Skull

Number of Skulls	No of Pair of Sutures in Each Skull	Total Number of Pair of Sutures	Name of Sutures
35	1	35	Lambdoid
3	2	6	Lambdoid, Asterion
3	2	6	Lambdoid, Pterion
2	2	4	Lambdoid, Coronal
2	2	4	Lambdoid, Squamous
Total-45	–	Total-55	–

TABLE 4. The Pair of Sutures Which Concidentally Had WBs in Each Pair

Name of Sutures	No of Sutures	No of Pair of Sutures
Lambdoid^{R}	45	45
Lambdoid^{L}	45	
Pterion^{R}	3	3
Pterion^{L}	3	
Asterion^{R}	3	3
Asterion^{L}	3	
Squamous^{R}	2	2
Squamous^{L}	2	
Coronal^{R}	2	2
Coronal^{L}	2	
Total	110	55

WBs = Wormian Bones.
^{R}: at right side of skull, ^{L}: at left side of skull.

TABLE 5. Rate of WBs in Different Populations*

Population	Prevalence (%)
Chinese	80.32
German	75
Indian	73.1
Australian	72.58
Iron Age/Romano-British	71.03
Melanesian	64.15
Lachish	63.41
Turkey (West Anatolian)†	59.3
Anglo-Saxon	55.56

WBs = Wormian Bones.
*According to Brothwell.[20]
†Present study.

The incidence of WBs in descending order among different populations is shown in Table 5.

DISCUSSION

The several bones fuse together to form the human skull after birth.[13] WBs are located in the cranial sutures.[1,8] They originated from independent ossification centers found along cranial suture lines and fontanelles, and are irregularly shaped bones.[14] The detached portions of the primary ossification centers of the adjacent membrane bones form WBs.[10]

The external mechanical factors that increase the sutural width and dural strain may cause the formation the WBs.[15]

WBs are usually found in lambdoid sutures, followed by coronal, sagittal, and metopic sutures. In the present study, the sutures including WBs were determined in descending order of frequencies: lambdoid, pterion, asterion, squamous, lambda, sagittal, coronal, occipitomastoid, and bregma. Ninety-three percent of WBs are seen in sutures bordering the parietal bones.[1] In another study, WBs were also observed 50% at the lambdoidal suture and 25% at the coronal suture.[8]

Their frequency within fontanelles is in descending order of occurrence: asterion, posterior, anterior, and orbital fontanelle.[1] Bergman et al[16] and Murlimanju et al[12] reported the rate of WBs along lambdoid sutures as 40% and 56.4%, respectively. We also found that the rates of WBs along the right and left lambdoid sutures were 37.3% and 40.7%, respectively.

Chambellan[17] found that the second most common site of occurrence was along the coronal suture as 25%; however, in the present study, the second most common location site was found as left pterion (8.0%). Some investigators also reported that the epipteric bone (pterion ossicle) is the second most common site[18]. Murlimanju et al[12] showed that the rate of presence of WBs in coronal and sagittal sutures was minimum as 1.3% and the rate was null in bregma. The rate of bregma which had WBs was shown as 2.0% in the present study.

In a recent perioperative study with skulls that had sagittal synostosis, the incidence of WBs that replaced anterior fontanelle was found as 4 out of 100.[19]

The incidence of the WBs varies in different ethnic groups, whereas the highest incidence (80.32%) is found in Chinese population.[8] The rate of sutures including WBs was found as 59.3% in West Anatolian skulls; furthermore, the rates of these sutures among different populations are compared in Table 5.[20] The West Anatolian population had the second lowest rate of WBs after Anglo-Saxon. It may be because probable racial variations seem to exist. The Anatolia was also exposed to migration along centuries; the effect of the migration on the genetic variations of the Anatolian Population may cause the differences in the incidence of the WBs in skulls of the West Anatolia.

Sanchez-Lara et al[1] and Jeanty et al[8] showed that WBs were more frequently observed unilaterally on the right side of the skulls; however, in our study, the rate of left-side sutures including WBs was found higher than the right side, except coronal sutures of which rates were equal on each side. Parker[5] declared that there is a positive correlation between the number of WBs, the capacity of the skulls, and the total length of sutures.

The customs that alter the shape of the cranium in infancy and early childhood are described as ''cultural cranial deformation.''[21] Dorsey[22] was among the first to state that the incidence of WBs may be influenced by the pressure on the cranium from cultural cranial deformation. El-Najjar et al[6] concluded that the occurrence of lambdoid WBs was genetically controlled, whereas the cultural cranial deformation influenced the number of WBs.

They may be important signs for silent disorders.[23] Osteogenesis imperfecta, a bone dysplasia, skull growth is impaired early in development, can result in the formation of these irregular bones. The number, order of arrangement, and size of WBs are considerable attributes when deciding if they are normal or pathologic variants.[10] WBs are usually smaller and less numerous in normal than pathologic variant such as skeletal dysplasias.[23] It is anthropologically demonstrated that the circumferentially deformed crania have fewer WBs than undeformed crania, and the most WBs have been located in anteroposteriorly deformed crania.[21,24]

In order to determine the incidence and significance of the WBs in a random group of infants and children, an investigation was formed at the Jewish Hospital Medical Center of Brooklyn. It is found that 17% (91 of 515) infants and children had WBs; 90% (82) of these children had a gross disorder of the CNS and 6% (5) had the minimal brain dysfunction syndrome. They concluded that the presence of WBs is almost associated with abnormal development of the CNS and this may be a sign for the early identification and treatment of affected infants and children.[25]

In the present study, there were also 45 skulls that were including 55 pairs of bilaterally and symmetrically located sutures that coincidentally had WBs in each pair of sutures. We determined that each of 35 skulls and each of 10 skulls had 1 and 2 pairs of sutures including WBs, respectively. Forty-five pairs of these paired sutures were belonging to lambdoid sutures.

The presence of WBs may occasionally cause misinterpretation during the radiological examination of the skull due to simulating normal sutures or fractures.[6]

The performing burr holes perioperatively at the pterion that has WBs may cause complications.[26]

The medical doctors must be aware of this sutural bones for the prevention of misdiagnosis of fractures in the clinical practice; therefore, we conclude that the present study provides additional information on topography of the sutures including WBs and that guides the investigators dealing with the neurosurgery, orthopedy, radiology, anatomy, and anthropology in their practice.

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