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Review Article

Anatomy Section

Wormian Bones Revisited: A Narrative Review

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ABSTRACT

Wormian bones, which are classified as small intrasutural ossicles, may sometimes distort the shape of the skull. They are not included in the conventional count of 206 bones listed in the adult human body. Their emergence and ossification in and around the sutures of the skull have remained controversial to date, with researchers speculating that their origins may be similar to how sesamoid bones arise within tendons at pressure points. The occurrence of wormian bones within the cranial sutures has been met with uncertainty, as it has a role in affecting the shape of the fontanelles. Hence, this review focuses on the morphology, occurrence, and pressure effects of these bones, as well as their implications for skull growth from foetal to postnatal life. The primary objective of this review is to highlight the impact of wormian bones on the surrounding cranium. It also summarises the collaborative findings of various researchers who have studied these bones in the dry skulls of diverse population groups. The prevalence of wormian bones in the general population is estimated to be 35% in adult skulls. A thorough knowledge of the characteristics of these bones may assist neurosurgeons in positioning scalp flaps and cranial sutures correctly in neonatal skulls. This review aims to provide readers with an in-depth understanding of the consequential effects of these miniaturised bones on other bones of the face and skull, due to the ripple-like effects surrounding wormian bones, thus helping to delineate the pathways that cause distortion of joints as a result of these bones.

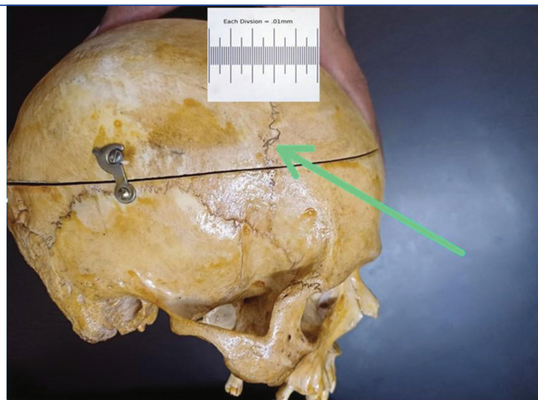
Keywords: Cranium, Fontanelles, Intrasutural bones, Ossicles, Ossification

INTRODUCTION

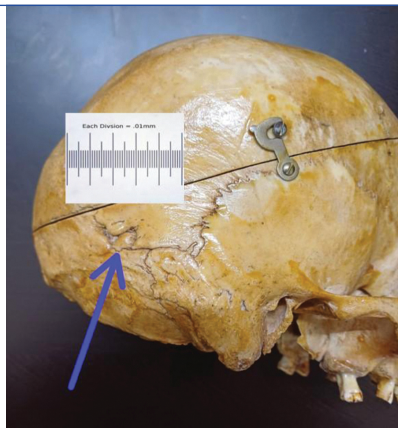
Wormian bones are small, irregular bones found within the sutures of the skull. They are also known as intrasutural bones or sutural bones. These bones are formed during foetal development and are present in the skulls of infants and young children [1,2]. The presence of wormian bones in the skull is generally considered a normal anatomical variation, and they can be found in approximately 40% to 90% of adult skulls [2]. However, the number, size, and location of these bones can vary greatly between individuals [2,3].

The exact functions of wormian bones are not fully understood. However, it is believed that they may play a role in the growth and development of the skull during foetal development and early childhood [3,4]. These bones develop from additional secondary centres of ossification that are not usually formed in the skull and can be considered accessory centres of ossification. Thus, these bones are considered controversial as they do not fall into the category of regular adult human bones [4]. They may also serve as a buffer zone between the bones of the skull, allowing for greater flexibility and movement.

Wormian bones are typically small, ranging in size from a few millimetres to several centimetres [5]. They are usually irregular in shape and may be round, oval, or fragmented. These bones are formed from cartilage or membranous tissue and are eventually replaced by bone tissue [Table/Fig-1,2] [6]. The purpose of this narrative literature review is to enlighten readers regarding the key morphological characteristics and occurrence patterns of wormian bones, along with their role in distorting the skull shape.



[Table/Fig-1]: Wormian bone within the coronal suture (Green arrow).



[Table/Fig-2]: Wormian bone within the occipito-parietal suture (Blue arrow).

Morphological, Developmental and Ancestral Characteristics of Wormian Bones

Wormian bones are named after the Danish anatomist Ole Worm, who first described them in the 17th century. Since then, numerous studies have been conducted to investigate the prevalence, characteristics, and clinical significance of these bones. One of the most significant studies on wormian bones was conducted by the American anatomist Todd TW in the early 20th century [7]. Todd's study involved the examination of over 1,000 skulls, finding that wormian bones were present in approximately 90% of the specimens [7].

More recent studies have used advanced imaging techniques, such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), to investigate the presence and characteristics of wormian bones [2,3,5]. These studies have confirmed that wormian bones are a common anatomical variation and have provided new insights into their development and function.

In addition to their anatomical significance, wormian bones have also garnered interest in forensic anthropology and archaeology [6-8]. The presence and characteristics of wormian bones can provide valuable information about an individual's ancestry, age, and sex [6-8]. For example, a study conducted by the forensic anthropologist Maples WR et al., found that the presence and size of wormian bones could be used to estimate an individual's age [8]. The study found that the number and size of wormian bones decreased with increasing age [8]. Wormian bones have also been used in archaeological studies to investigate the ancestry and origins of ancient populations. For example, a study by the archaeologists Jackes M and Meiklejohn C found that the presence and characteristics of wormian bones could be used to distinguish between different ancient populations [9].

The development of wormian bones is closely tied to the development of the skull. During foetal development, the skull is formed from several bony plates that eventually fuse together. Wormian bones are thought to arise from the membranous tissue that covers these bony plates [8-10]. Studies have shown that wormian bones are more common in certain populations, such as individuals of African or Asian descent, and are also more prevalent in females than in males [8-10].

In addition to their anatomical significance, wormian bones have also attracted attention in clinical medicine [8-10]. They are sometimes associated with certain medical conditions, such as craniosynostosis, a condition in which the bones of the skull fuse together prematurely. Wormian bones have also been used as a marker for certain genetic disorders, such as osteogenesis imperfecta, a condition characterised by brittle bones [7,11].

In forensic anthropology, wormian bones can aid in identifying human remains. By analysing the presence and characteristics of wormian bones, forensic anthropologists can gain valuable information about an individual's ethnicity and geographical roots [11,12].

Clinical Significance and Functional Effects of Wormian Bones

The clinical significance of wormian bones remains a topic of debate among medical professionals. Some studies have suggested that wormian bones may be associated with certain medical conditions, such as craniosynostosis or osteogenesis imperfecta [11,12]. However, other studies have found no significant correlation between wormian bones and these conditions. Further research is needed to fully understand the clinical significance of these bones [12,13].

In addition to their clinical significance, wormian bones have also been of interest in the fields of obstetrics and neurosurgery. Obstetricians use wormian bones to help identify patterns in the labour process and to determine if a foetus may experience obstructed labour. This is due to the fact that these bones may prevent the overriding of skull bones during labour, thereby hindering the process of moulding [14,15]. By analysing the presence and characteristics of wormian bones, neurosurgeons can gain valuable information about the sutural points on the surface of the skull [13-15]. wormian bones can also be used to determine the location of intra-osseous suture points within the skull [15,16].

These bones are known to distort the shape of the sutures, leading to irregularities in synostotic fusions, which may, in turn, hamper the growth of the skull. Since these bones have their own extra centres of ossification, they may form prematurely during foetal life, leading to compression effects on the moulding patterns of the skull at birth, which could eventually lead to obstructed labour [15-17]. As most of these bones form at recognised sutural star points, such as lambda or asterion, they might also impede the timely closure of fontanelles, potentially resulting in either delayed or premature closure. Delayed closure of fontanelles may increase the risk of meningeal infections in newborns, whereas premature closure could distort the shape of the skull or cause the splitting of already existing sutures [17,18].

The [Table/Fig-3] below highlights the frequency of occurrence of wormian bones at different sutural points within the skull across various populations [14-18]. It is evident from [Table/Fig-3] that the most common site of occurrence of these bones is the lambdoid suture, which could possibly explain their role in distorting the fontanelles [15]. However, most studies [15-17] on these bones have been conducted using adult dry skulls, with limited imaging employed, which restricts the reliability of using these bones as synostotic markers [15-17]. Therefore, to address this issue, large-scale studies on neonatal skulls should be conducted alongside CT imaging studies.

Pressure Effects of Wormian Bones

These bones are known to impede the flow of cerebrospinal fluid, especially if they are found at the junction between two or more major skull sutures [14-16]. This is due to the fact that these bones are made of compact bone, just like any other normal bone in the body. Some studies [14-16] have also found that trace amounts of fibrous and cartilaginous tissues are present within these bones, offering resilience to them. This resilience may compress the meninges at the sutural points, leading to added strain [15-17]. Consequently, the formation of arachnoid granulations and arachnoid villi may be hampered if these bones are present, resulting in a vicious cycle in which pressure causes meningeal stress, which in turn may lead to further pressure obstructing the cerebrospinal fluid pathways [17].

The RUNX2 gene mutations, whether de novo or due to point mutations, are known to weaken these bones, leading to osteogenesis imperfecta [17]. Due to these mechanisms, hydrocephalus may sometimes be associated with the presence of wormian bones, which, over time, may flatten the skull, resulting in conditions such as dolichocephaly or brachycephaly [16]. However, the exact causal relationship between wormian bones and hydrocephalus has yet to be deciphered.

Contrary to the negative effects of these bones mentioned earlier, some researchers have also posited positive attributes, particularly regarding their role as functioning stabilisers in sealing tears between the sutures in the unlikely event of concussive trauma to the skull. These bones may also act as adhesives, helping to hold the skull sutures together during a sudden blow [15,16-18].

Researchers	Country and year	Most common location of wormian bones	Least common location of wormian bones	Shape of wormian bones	Physical effects produced by wormian bones on skull	Predominant side of the skull where wormian bones were found	Sample size of dry skulls observed
Singh R et al., [14]	India, 2024	Lambdoid suture	Point Lambda	Irregular	Nil	Right	200
Natsis K et al., [15]	Greece, 2019	Lambdoid suture	Parieto-mastoid suture	Irregular	Nil	Left	124
Cirpan S et al., [16]	Turkey, 2016	Lambdoid suture	Squamous suture	Circular	Metopism in frontal midline	Left	160
Li JH et al., [17]	China, 2023	Lambdoid suture	Inca bone	oval	Metopism in frontal midline	Equal predominance between right and left	285
Basnet LM et al., [18]	Nepal, 2019	Lambdoid suture	Coronal suture	Irregular	Shape of skull affected	Right	70

[Table/Fig-3]: Frequency, shape, and dominance of wormian bones in various populations with their physical effects on the skull [14-18].

The mandible and maxilla may become loosely detached from each other due to the presence of wormian bones, which could subsequently affect the shape of the face over time and may be of utmost concern to maxillofacial surgeons [17,18]. This is because the temporomandibular joint may get affected due to the extraneous strain created by these bones at the sutural sites, leading to a pulling effect on the maxilla and thereby loosening the mandible [18,19].

CONCLUSION(S)

Wormian bones are small, irregular bones found within the sutures of the skull. They are a normal anatomical variation and are present in approximately 80% of adult skulls. The exact function of wormian bones is not fully understood, but they may play a role in the growth and development of the skull during fetal development and early childhood. Wormian bones have been of interest in the fields of anatomy, forensic anthropology, and archaeology, providing valuable information about an individual's ancestry, age, and sex. Further studies are needed to fully understand the development, function, and clinical significance of wormian bones.

Authors' contribution: LD: Idea, concept, literature search; SS: Idea, literature search, writing, tables.

REFERENCES

[1] Bellary SS, Steinberg A, Mirzayan N, Shirak M, Tubbs RS, Cohen-Gadol AA, et al. Wormian bones: A review. Clin Anat. 2013;26(8):922-27. Doi: 10.1002/ca.22262.

[2] Johal J, Iwanaga J, Loukas M, Tubbs RS. Anterior fontanelle wormian bone/fontanellar bone: A review of this rare anomaly with case illustration. Cureus. 2017;9(7):e1443. Doi: 10.7759/cureus.1443.

[3] Sanchez-Lara PA, Graham JM Jr, Hing AV, Lee J, Cunningham M. The morphogenesis of wormian bones: A study of craniosynostosis and purposeful cranial deformation. Am J Med Genet A. 2007;143A(24):3243-51. Doi: 10.1002/ajmg.a.32073.

[4] Gonzalez-Reinoso M, Pimentel H, Fermin-Delgado R, Stoeter P. Unusually large anterior fontanellar bone and diffuse capillary malformation with overgrowth in a three-month-old child-A computed tomography case report. Neuroradiol J. 2014;27(5):613-15. Epub 2014 Sep 25. Doi: 10.15274/NRJ-2014-10063. PMID: 25260208; PMCID: PMC4237103.

[5] Rizvi A, Iwanaga J, Oskouian RJ, Loukas M, Tubbs RS. Wormian bone of the orbit: A case report. Cureus. 2018;10(8):e3117. Doi: 10.7759/cureus.3117.

[6] Agrawal D, Steinbok P, Cochrane DD. Pseudoclosure of anterior fontanelle by wormian bone in isolated sagittal craniosynostosis. Pediatr Neurosurg. 2006;42(3):135-37. Doi: 10.1159/000091854.

[7] Todd TW, Lyon DW. Endocranial suture closure. Its progress and age relationship. Part I.—Adult males of white stock. Am J Phys Anthrop. 2005;7(3):325-84. Doi: 10.1002/ajpa.1330070320.

[8] Maples WR, Gatliff BP, Ludeña H, Benfer R, Goza W. The death and mortal remains of Francisco Pizarro. J Forensic Sci. 1989;34(4):1021-36. Doi: 10.1520/JFS12733J.PMID: 2668443.

[9] Jackes M, Meiklejohn C. Building a method for the study of the Mesolithic-Neolithic transition in Portugal. Documenta Praehistorica. 2004;31:88-111. Doi: 10.4312/dp.31.7.

[10] Woods RH, Johnson D. Absence of the anterior fontanelle due to a fontanellar bone. J Craniofac Surg. 2010;21(2):448-49. Doi: 10.1097/SCS.0b013e3181cfe970. PMID: 20216454.

[11] Cirpan S, Aksu F, Mas N. The incidence and topographic distribution of sutures including wormian bones in human skulls. J Craniofac Surg. 2015;26(5):1687-90. Doi: 10.1097/SCS.0000000000001933.

[12] Pryles CV, Khan AJ. Wormian bones. A marker of CNS abnormality? Am J Dis Child. 1979;133(4):380-82. PMID: 433853.

[13] Reid TH, Tam A, Antoniou G, Ong J. Anterior fontanelle wormian bone with exomphalos major and dysmorphic facial features: A previously unseen association? J Craniofac Surg. 2016;27(7):1799-801. Doi: 10.1097/SCS.0000000000002962.

[14] Singh R. Wormian bones: Prevalence, topography, and implications. J Craniofac Surg. 2024;35(1):247-50. Doi: 10.1097/SCS.0000000000009746. Epub 2023 Sep 9. PMID: 37695065.

[15] Natsis K, Piagkou M, Lazaridis N, Anastasopoulos N, Nousios G, Piagkos G, et al. Incidence, number and topography of wormian bones in Greek adult dry skulls. Folia Morphol (Warsz). 2019;78(2):359-70. Doi: 10.5603/FM.a2018.0078. Epub 2018 Aug 29. PMID: 30155873.

[16] Cirpan S, Aksu F, Mas N, Magden AO. Coexistence of wormian bones with metopism, and vice versa, in adult skulls. J Craniofac Surg. 2016;27(2):493-95. Doi: 10.1097/SCS.0000000000002370. PMID: 26845093.

[17] Li JH, Chen ZJ, Zhong WX, Yang H, Liu D, Li YK. Anatomical characteristics and significance of the metopism and Wormian bones in dry adult-Chinese skulls. Folia Morphol (Warsz). 2023;82(1):166-75. Doi: 10.5603/FM.a2022.0006. Epub 2022 Jan 31. PMID: 35099043.

[18] Basnet LM, Shrestha S, Sapkota S. Prevalence of wormian bones in dried adult human skulls: An osteo-morphometric study in Nepal. Anat Sci Int. 2019;94(1):101-09. Doi: 10.1007/s12565-018-0454-x. Epub 2018 Aug 14. Erratum in: Anat Sci Int. 2019;94(1):110. Doi: 10.1007/s12565-018-0458-6. PMID: 30109567.

[19] Al Kaissi A, Ryabykh S, Ben Chehida F, Al Kaissi H, Kircher SG, Stransky MJ, et al. The tomographic study and the phenotype of wormian bones. Diagnostics (Basel). 2023;13(5):874. Doi: 10.3390/diagnostics13050874. PMID: 36900016; PMCID: PMC10000840.

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