Research Article

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Influence of ossification centers on the appearance of wormian bones and sutures

Abstract

The skull is formed of different types of bones composed of two plates of compact bone tissue and a hollow region of spongy bone containing the "diploe". The connections between the bones are made by different kinds of sutures. The presence of additional bones, called wormian bones (WB) and sutures is a common phenomenon. The aim of the current research is to follow up ossification centers and the origin of accessory structures like sutures and bones. Their genesis and the influence of the environmental factors would also be discussed. A few findings that have additional wormian bones and sutures in the occipital fontanelle region have been described in this case.

The variations of the skull bones and connections have the following significance: in newborns they might play an important role for the normal development of the CNS. It is known that dura mater and the calvaria release dissolved heparin connecting factor which is important for the suture's firmness. The variations described could be useful for the neurosurgery and traumatology practice.

Keywords: wormian bones, skull sutures, fontanelles, ossa suturalis, ossification center

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Introduction

During ancient time in the Inca empire an additional bone was discovered between the parietal bone and the temporal bone. The term "wormian bones" was first used by Paracelus (1460 to 1541). Later a Danish doctor called Olaus Worm, adds this term in the scientific literature as ossa wormiana. This term is used to define additional bones within the skull sutures. These bones are of great interest in the region of anatomy, pathology, judicial medicine, anthropology and diagnostic imaging.[1] Wormian sutures arise as a result of inheritance or heavy craniocerebral trauma to adult individuals. In the field of Macroscopic anatomy some of the sutures have their own names, such as the Paracelsian ossicle (the bregmatic sutural bone and the Epactal bone (the suture between the parietal and temporal bone). These bones are found in close proximity to the lambdoid suture or the fontanelles.[2] Their presence arises due to additional ossification centers close to the previously mentioned sutures. The occurrence of these additional bones can lead to misconceptions when interpreting X-rays analysis of the skull, falsely assuming the occurrence of fractures. There is still no complete clarity, as to why additional ossification centers show up and why are they more frequent in some races than others. According to modern studies between 8% and 15% have at least one WB. WB are important for the understanding and the distinction of osteogenesis imperfecta (OI), also known as brittle bone disease.[3] Under this term fall a few genetic anomalies, which relate to bones and more specifically their strength. The bones of patients who suffer from OI are very easy to break.

The skull is formed of different types of bones composed of two plates of compact bone tissue and a hollow region of spongy bone containing the "diploe". The connections between the bones are made by different kinds of sutures. It is quite common to discover additional wormian bones and sutures and their structure.

Materials and methods

Wormian bones were observed in the Medical Faculty of SU "St. Kliment Ohridski" during teaching Osteology to medical students. The skulls were obtained after maceration of heads from cadavers, which were dissected in previous years. In a departmental stock of 50 skulls, two had additional bones WBs originating from different sutures or ossification centers.

The aim of the current research is to follow up ossification centers and the origin of accessory structures like sutures and bones. Their genesis and the influence of the environmental factors would also be discussed. A few findings that have additional wormian bones and sutures in the occipital fontanelle region have been described in this case.

Results

In the current investigation there were two skulls with the presence of additional bones, which differ from the structure of normal bones. The first skull had 5 bones, which were situated on the border between sutura lambda and sutura sagitalis. The first and second WBs from the frontal part of sutura sagitalis on the side of the parietal bone were of a large size with multiple interdigitations (Figure 1). The third and forth were small to medium sized and squashed in a side orientation. The fifth bone had a medium size and merged laterally with the left part of sutura lambda.

In other skulls, a smooth suture was observed with the presence of a small bone along the length of the main suture, between the parietal bone and the temporal bone. The literature classifies them as wormian bone at squamous suture or ossa suturalis (Figure 2). In addition the ossification center could be seen on this skull, situated between the wing of sphenoid bone, temporal bone and frontal bone (Figure 3).

Figure 1 Wormian bones at lambda
1, wormian bones at lambda; 2, sutura sagitalis;

3, sutura lambda

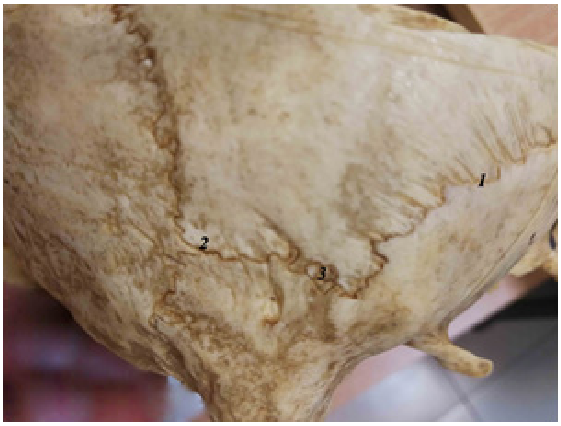

Figure 2 Wormian bones at parieto-temporal suture.

1, parieto-temporal suture; 2, asterion point; 3, ossa suturalis

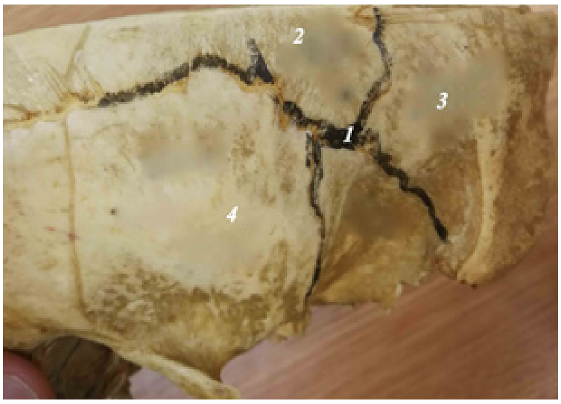

Figure 3 Ossification center.

1, ossification center; 2, parietal bone; 3, frontal bone; 4, temporal bone

Discussion

The variations of the skull bones and connections have the following significance: in the newborns they might play an important role for the normal development of CNS. It is known that the dura mater and the calvaria releases dissolved heparin connecting factor which is important for the suture's firmness. The variations described could be useful for the neurosurgery and traumatology practice.

There are two main hypotheses for the origin of WB. The first is related to the genealogy and is under the influence of a group of genes.[4] The second hypothesis is related to congenital abnormalities, as well as the influence of external factors on genes (epigenetic control of traits).[5] It is known that the occipital bones and sutures, and the size of the skull are important characteristics in relation to the skull morphology. This influence extends to diseases such as: cretinism, amplification of the parietal foramina, and rickets. According to another hypothesis, WB emergence is determined genetically but external trauma is a factor which determines their quantity.

The arrival of WBs as described above is under genetic control but also influenced from external factors. It is well known that pathologies relating to the bones. From a different perspective, their presence is of high frequency among the Chinese population. This brings a problem, which is researched from different fields such as anatomy, epigenesis and anthropology.[6]

Investigations show that nearly half of all patients in the age interval of 0-3 years have at least one WB situated close to the lambdoid suture. This shows that among babies and children, the unfinished ossification of the skull may lead to misconceptions and hasty conclusions of the presence of WB.[5]

According to the monography of Parker, WBs according to their characteristics fall into one of the following four groups: 1. According to the discoverer: ossa Goethiano. 2. According to the shape: ossa triquetra, ossa quadratum. 3. According to location: fontanellaires, insules, intercalcaria, raphogeminantia, apicis. 4. According to function: complementaria, ossa accessorii. According to Parker "the greater the sutural length of the skull the greater the number of wormian bones".

An important factor for the emergence of WBs are the ossification centers (Figure 3), they also play a part in the arrangement of these additional skull bones further along the development. According to the studies of Hess, the formation of additional skull bones had a correlation with metabolic abnormalities of the mesoderm, which consequently led to asymmetry of the skull, malformations of the bone tissue and congenital anomalies. Hess also suggested that WBs passed along the future generation as a dominant trait.[7]

To bring some clarity on the emergence and arrangement of WBs, the embryonal development of the skull and the timing of the arrival of ossification centers will be explained.[8]

At the end of gastrulation (3rd week), the mesenchyme cells migrate through the primitive streak and form the third germ layer; the embryonic mesoderm. The mesoderm forms columns of the paraxial mesoderm. The neural crest cells are presented as a multipotential migratory cells.[5]

The paraxial mesoderm (somites and somitomers) play an important function in the skeletogenesis of the parietal and occipital bones. The osteoprogenitor cells, which contain mesenchymal cells, take an important place around the developing brain. An important stage of the embryonic development of the skull is the condensation of the mesenchyme and the following selective gene specific stages of chondro and osteogenesis. During the 5th week the membranous neurocranium (calvaria) emerges as a capsular membrane (primary meninx) around the developing brain. This primitive meninx is

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divided into two layers: the secondary meninx, which derivates are the pia and arachnoid layer and the ectomeninx (which forms the inner dura mater and the superficial membrane).[4]

During the 8th week of embryonal development, the primary ossification center forms from the frontal eminence, as well as the emergence of two frontal bones8. The next three pairs of secondary centers arrive later in the zygomatic processes, the trochlear fossae and the nasal spine. During the 6-7month of fetal development, the above mentioned centers merge together. The frontal bones remain as two separate bones until the age of 7years of the child, at that age period they fuse and compose the frontal bone. Frontal sinuses do not arrive until the end of the first year after birth. Another two primary ossification centers develop from the two parietal bones, this occurs during the 8th week of the embryonal development. Ossification moves along from the center to the periphery, this occurs intensively during the 14th week from the embryonal development. During the 8th week via the intramembranously ossification, the occipital bone develops from two centers, each from each side of the bone. The remaining part of the occipital bone develops via endochondral ossification. The core of the skulls develops differently to the previously mentioned description. Initially the хрущялен модел develops, which then is replaced with bone tissue.[8]

The sutures develop during the embryonic development, at the location where membranous bones of the skull come together. In these locations there is presence of flexible fibrous tissue, which combines the bones. The manifestation of the sutures is directly dependent of the position of the dural reflections. The last structure manifests as a double fold from the dura matter. The formation of the sutures marks the formation of the second phase of development, in which there is a rapid growth of the skull and a quick proliferation as well as differentiation of osteoprogenitor tissue at every bone field in the periphery.[8]

There is an interesting correlation, that exists between WBs and some syndromes.[9,10] Frontal fontanelles, facial dysmorphisms and middle abdominal defects.

Conclusion

The current investigation provides more directions in the sphere of development and has a stance on the development of correlations related to other clinical diseases. It is important to note that the ossification centers, genetic predisposition and the presence of trauma during individual development are the main components, which have an influence on the development of WBs. The presence of WBs has stance in the fields of anatomy and medicine, not just as a variation but as structures which can give misinformation in relation to fracture of the skull. On the other hand, the genetic correlation is discussed during the phenotypic arrival of WBs and other leading diseases.

Acknowledgments

None.

Conflicts of interest

The authors declare there is no conflict of interest.

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