Study of Sutures: Anatomical Variations in the Fusion of Sutures

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Research Article

Abstract: **Background:** The cranial sutures are the fibrous tissues uniting the skull bones as they approximate one another during development**.** The coronal, sagittal and lambdoid sutures were analyzed for quantifying the sutural patency as maintenance of suture patency depends on various factors in skull. Metopic sutures are a vertical sutures occurring as a result of failure of ossification between the two halves of frontal bone. It is very often mistaken for fracture of the frontal bone in the A-P view X-Ray of skull. **Objective:** The goal of the study was to evaluate the gross morphology of the coronal, sagittal, lambdoid and metopic sutures in human adult dried skulls and to determine if any difference exists in terms of fusion. **Material and methods:** The study included 150 human dry skulls of Indian population were selected from the museum of anatomy department of GMERS Medical College Gotri, Vadodara, and Government Medical College Bhavnagar. Result: the study shows the patency of the lambdoid suture is more compared to the other sutures and incidence of metopism was 2%.

Keywords: skull; coronal suture; sagittal suture; lambdoid suture; metopism.

Introduction

In anatomy, a suture is a fairly rigid joint between two or more hard elements such as the bony plates of the skull that part of the skull enclosing the brain, the braincase. The word suture is derived from Latin word sutura, which means seam like or series of stitches [2]. A suture is a type of fibrous joint (or synarthrosis) which only occurs in the skull (or," cranium") [1]. It is normal for many of the bones of the skull to remain unfused at birth. The term "fontanelle" is used to describe the resulting "soft spots." The relative positions of the bones continue to change during the life of the adult (though less rapidly), which can provide useful information in forensics and archaeology. In old age, cranial sutures may ossify (turn to bone) completely. It is normal for many of the bones of the skull to remain unfused at birth. This allows a tiny amount of movement at sutures, which contributes to the compliance and elasticity of the skull. The sutures form an integral part of the skull, but their role has long been debated among vertebrate morphologists and palaeontologists. Their role in cranial biomechanics has interested many morphologists for decades, but there are many unanswered questions. It was reported that the growth and morphology of craniofacial sutures are thought to reflect their functional environment. Maintenance of suture patency depends on various factors. The suture between the two halves of the frontal bone usually disappears during infancy or in early childhood In some cases it persists as a complete suture extending from the nasion to the anterior angle of the bregma and this condition is called metopism, which ossifies in membrane from two primary centres, which appear by the end of the second month of fetal life and fuse first at the inner surface of the skull [10]. The morphology of the metopic suture varies. When the metopic suture is extended from the nasion to the bregma uninterruptedly they were considered as complete. Whereas those extending from the nasion to varied points of the frontal bone anterior to the bregma were considered as incomplete metopic suture. The incomplete metopic sutures were further grouped according to their shape namely linear, 'U' shaped and 'V' shaped [9]. It's a vertical sutures occurring as a result of failure of ossification between the two halves of frontal bone. It is very often mistaken for fracture of the frontal bone in the A-P view X-Ray of skull. It also called Median frontal Sutures usually present between two super ciliary arches.

Materials and Methods

The study was conducted after ethical clearance was obtained from the Institutional Ethics committee. A total of 150 dry skulls were selected from the museum of anatomy department of GMERS Medical College Gotri, Vadodara, and Government Medical College Bhavnagar and collected from the students. All skulls were regular in shape, without obvious evidences of deformities. The skulls, which were deformed and fractured, were excluded from the study. The exact ages and sex of the skulls were not determined.

The coronal, sagittal and lambdoid sutures were analyzed using the modified grading scale for quantifying the sutural patency. An open suture was graded as 0, a fused suture as 1 and an obliterated suture as 2, 3 or 4, depending on the extent of obliteration [6] **(Table-1)**. When the metopic suture is extended from the nasion to the bregma uninterruptedly they were considered as complete (figure-6), whereas those extending from the nasion to varied points of the frontal bone anterior to the bregma were considered as incomplete metopic suture. The incomplete metopic sutures were further grouped according to their shape namely linear (figure-7), 'U' shaped (figure-8) and 'V' shaped (figure-9). Those with single and shallower suture were considered as linear, double linear sutures originating from fronto nasal suture and resembling like 'U' were considered as 'U' shaped and those with bifurcation are considered as 'V' shaped[26].

Statistical Analysis

Each measurement was performed for three times and averaged them. The data obtained were tabulated and analyzed through descriptive statistics. The incidence of The coronal, sagittal land lambdoid sutures were analyzed using the modified grading scale for quantifying the sutural patency and each type of metopic suture were noted in percentages and compared with other studies. Epi info 7.0.8.0 Atlanta USA software was used for data analysis.

Result

In the present study the grade 0 suture morphology was observed 2% in sagittal and 6% in lambdoid suture. In coronal suture, the grade 1 suture was observed in 4%, grade 2 in 50%, grade 3 in 26% and grade 4 in 20% of the cases. The sagittal sutures had grade 1 in 2%, grade 2 in 30%, grade 3 in 40% and grade 4 in 26% of the cases. In contrast, the lambdoid suture showed 10%, grade 1, 48%, grade 2, 30%, grade 3 and 6%, grade 4 sutures **(Table-2)**. Morphology of patency were seen in lambdoid suture in grade 0 and grade 1, coronal suture in grade 2, sagittal suture in grade 3 and grade 4.On applying the chi-square test to know the association it found to be significant*(chi square=17.30,p<0.05).*

Out of 150 skulls only 3 skulls have complete (2%) and 35 skulls have incomplete (23.33%) metopic suture. Three different types of incomplete sutures namely linear, 'U' shaped, 'V' shaped, were identified. Among the incomplete metopic sutures, the incidence of linear incomplete metopic suture was 20/150 (13.33%), 'U' shaped incomplete metopic suture was 10/150 (6%) and 'V' shaped incomplete suture was 5/150(3.33%) **(Table-3).** In the present study, metopism was found in three skulls (2.0 %), which similar to the study done by Woo. et al. In the present study variation were seen in incomplete type of metopic suture. Compared with the other studies we had found out 'U' shaped 6.66% and higher frequency of 'V' shaped 3.33% **(Table-5)**.

Discussion

Maintenance of suture patency depends on various factors, which include tissue interactions, mechanical influences and biochemical signaling [11]. The sutures do not play a substantial role in reducing the total strain within the skull, but probably act in various combinations to allow the skull to respond to different loading conditions by distributing the strain around the skull [8]. In contrast, much remains to be understood regarding the tissue interactions and maintenance of suture patency [12]. The morphology of the skull is influenced by genetic and environmental factors. The muscle function is believed to affect the bone shape and size [13]. It was also reported that, there is a large range of variations in human skull morphology, which is often multifactorial [14]. Although intrinsic factors may have an influence, extrinsic or environmental factors such as tensile forces, a growing brain and active muscle demands, are more likely to affect the characteristics of sutures [2, 6]. Determining the presence of morphologic differences among the coronal, sagittal and lambdoid sutures can provide additional details of the cranium. The more complex the interdigitations or the longer a suture remains patent, the greater the force on that particular suture [6]. Previous work has shown that some cranial sutures experience large strains during mastication [7]. Gratiolet observed that ectocranial suture closure progressed sequentially: sagittal, lambdoid, and then coronal. Parsons and Box suggested that less serrated (simple) sutures closed before all other sutures, and that there were no differences in closure periods for the left or right side of the skull [15]. They proposed that the lambdoid was the last of the vault sutures to reach complete closure .Patency or obliteration of sutures can be attributed to the presence or lack of physical forces acting on the skull. The stress exhibited by muscle pull is one of several external factors that are believed to impose changes on the sutures [2, 3]. The muscles and ligaments that have attachment to the occipital bone and those confer mobility to the cervical spine can cause stress on the lambdoid suture and may be the reason for increased patency of the sagittal suture [6, 3].In the present study 2% incidence of the patency of the sagittal suture and 6% incidence of patency of the lambdoid suture detected .This concept is known as myofascial continuity, where origins of muscles, which begin in one location, cross the joints to reach distant regions for insertion and exert their actions on those areas [4]. It is obvious that more muscles affect the occipital bone than the frontal and parietal bones. The occipital bone is affected by muscles like obliquus capitis superior, rectus capitis posterior major and minor, rectus capitis anterior and lateralis, semispinalis capitis, splenius capitis, longissimus capitis, occipitalis and sternocleidomastoid [5].The ligamentum nuchae can also be a source of force on the occiput since it inserts on the external occipital protuberance. It also forms aponeurotic attachments to the trapezius, rhomboideus minor, splenius capitis and serratus posterior [5]. The concept of external forces maintaining suture patency and complexity can be supported by the morphologic characteristics of facial sutures, which are more serrated and interdigitated than the cranial sutures and remain patent for longer time [3]. This is presumed to correlate with facial muscles necessary for speaking, mastication and facial expression. Relative to the lambdoid suture, the coronal and sagittal sutures are affected by far fewer associated muscular attachments like frontalis, temporalis and occipitalis [6]. The smaller amount of forces exerted on the coronal and sagittal sutures may explain their tendency to be more obliterated than the lambdoid suture. The knowledge of suture patency of the cranial bones may have clinical implications in the field of biomedical science and osteopathic medicine. The muscles of the cervical and thoracic spine that attach to the occiput can increase the strain, making the occipital region vital to examine. The joints and muscles will need treatments accordingly that are interrelated [6]. In addition, the presence of strains in the occipital region and subocciput are vital in the clinical diagnosis and therapeutics as they are related to the autonomic nervous system. For example, compression of the vagus nerve while passing through the jugular foramen, joint involvements likes atlanto-occipital and atlanto-axial dysfunctions can affect the autonomic function [16]. In the present study, the guidelines of Sabini RC and Elkowitz DE [6] was followed and we observed that the lambdoid suture was more likely to be patent compared with the other sutures. This is similar to the observations of Sabini and Elkowitz [6] and our observations confirm their findings.Sabini RC and Elkowitz DE opined that, how exactly the forces and stresses act on the sutures and how the resultant suture structure may correlate with structure and function of individuals, may require further investigation. Keeping view of these facts, we may conclude that the external factors, such as muscle may contribute to the maintenance of the sutural patency. The greater number of muscles acting on the lambdoid suture might be considered as the cause. We believe that, this study might be of help to the researchers who are interested in biomedical sciences and osteopathic manipulative medicine. Variations of the metopic sutures have been mentioned by various workers with some agreement over dates of closure, or persistence, whether partial or complete. Incidence of metopic suture varies in different races. Metopic suture can be due to various causes such as abnormal growth of cranial bones, growth interruption, heredity, sexual, hormonal influence, atavism, cranial malformations, and hydrocephalus [17]. Keith (1948) mentioned that the metopic suture disappears at the end of the first year, or in the beginning of the second year of life [18], but Piersol (1916) had claimed that it may close by the end of the fourth year, with a faint trace persisting at the lower end [19]. According to Romanes (1972), the metopic suture is present at birth but is normally closed by the fifth or sixth year, only traces of it being left above and below [20]. Metopism may be present till the age of six years (Torgerson, 1951) and also in old age even after the other sutures have disappeared (Piersol, 1916)[21]. Warwick & Williams (1980) state that the two halves of the frontal bone begin to unite in the second year, and that the suture is usually obliterated by the eighth year, but, in a percentage of cases which show some racial variations, the two halves of the frontal bone remain separate, and the metopic suture persists[22]. Hamilton (1976) has stated that the metopic suture is always present at birth but disappears by the seventh year[23], While Basmajian (1975) claims that the frontal bone is in two halves; at birth these fuse about the second year but in some skulls they remain separate, i.e. the inter frontal or metopic suture persists [24]. When a complete metopic suture separating the two halves is present, the condition is termed metopism, which is said to occur more frequently in higher races, and has no definite relation to brachycephaly (Bryce, 1915)[9]. Wood Jones (1953) was of the opinion that when the metopic suture persists it has very definite characteristics. It is a typical dentate suture [25]. The edges of the two bones are finely serrated from the nasion to a point about 2 cm anterior to the coronal suture, where its closure becomes more simple and direct. This simple posterior part is the pars bregmatica and the area included within the anterior fontanelle. The posterior end of the suture does not meet the sagittal suture and may miss it by an interval as great as 15 mm. In the same way, the anterior end of the suture fails to meet the suture between two nasal bones. It is commonly said that, even in the adult, some traces of the suture persist at the nasion. In the case of a true persistent metopic suture, the part immediately above the nasion is normally linear and simple, the so-called persistent lower remnant of the otherwise obliterated suture is highly complex and marked by wide side-to-side excursions.

Conclusion

The prolonged patency of the lambdoid suture may be due to external forces acting on it. The greater number of muscles acting on the lambdoid suture compared to coronal and sagittal sutures may be considered as the cause. Metopism is due to abnormal growth of cranial bones, growth interruption, heredity, sexual, hormonal influence, atavism, cranial malformations, and hydrocephalus. The findings are also enlightening to the neuroscientists, morphologists, anthropologists and clinician. For a more accurate and better assessment of suture closure various other modalities like radiology (X-ray, CT-scan, MRI), histology may have to be combined with the present osteological study.

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Tables and Figures

Table 1: Modified grading scale of cranial sutures [6]

Suture Grade	Modified grading scale of the cranial sutures
0	Open, not fused
1	Fused but not obliterated
2	Less than 50% obliterated
3	>50% obliterated
4	100% obliterated

Table 2: Distribution and frequencies of cranial sutures according to patency grade

Suture Grade	Coronal	Sagittal	Lambdoid
0	0 (0%)	1(2%)	3(6%)
1	2 (4%)	1(2%)	5(10%)
2	25 (50%)	15 (30%)	24 (48%)
3	13 (26%)	20 (40%)	15(30%)
4	10 (20%)	13 (26%)	3 (6%)

Table 3: Incidence of the metopic suture

Extent of suture	Number	%
Complete	3	2%
Incomplete	35	23.33%
Linear	20	13.33%
U shaped	10	6.66%
V shaped	5	3.33%

Sr. No.	Type of metopic suture	Position	Outer aspect of skull
1	Complete	Midline	Present in 3 skull
2	Split Incomplete	Right to bregma	Present in 2 skull
3	Split Incomplete	Left to bregma	Present in 3 skull
4	Incomplete	Serrated near nasion	Present in 30 skull

Table 4: Incidence of metopism reported by various workers

Worker	Race	Percentage
Jit & Shah. et al., (1948)	Indian (Punjabi)	5.00%
Das. et al., (1973)	Indian (U.P)	3.31%
Agarwal. et al., (1979)	Indian (Kanpur)	2.66%
Bryce. et al., (1915)	European	8.70%
Keith. et al., (1948)	Subject to race	3-8%
Woo. et al., (1949)	Negroids	2.0%
Romanes. et al., (1972)	Europeans	Up to 8.00%
M. L. Ajmani. et al.,(1983)	Nigerians	3.40%
S Chandrasekaran et al., (2011)	South India	5%
In the present study(2013)	India (Gujarat)	2.0%

Table 5: Comparison of incidence of incomplete metopic suture with other workers

Extent 7 shape of suture	Agarwal *et. al.* (1979) %	Das et al. (1973)%	MLAjmani *et. al.* (1983) %	S Chandrasekaran *et. al.*,(2011)	Present study(2013) %
Incomplete	35.51	17.57	31.57	40	23.33
Linear	23.12	-	24.27	17	13.33
'U' shape	-	-	-	15	6.66
'V' shape	3.25	1.01	0.49	7.5	3.33

Figure 1: Grade 0

Figure 2: Grade 1

Figure 3: Grade 2

Figure 4: Grade 3

Figure 5: Grade 4

Figure 6: complete metopicsuture

Figure 7: linear incomplete metopic suture

Figure 8: U shaped incomplete metopic suture

Figure 9: V shaped incomplete metopic suture