
“FUSION OF SKULL VAULT SUTURES IN RELATION TO AGE – A CROSS SECTIONAL POSTMORTEM STUDY DONE IN 3RD, 4TH & 5TH DECADES OF LIFE AT KLEs PRABHAKAR KORE HOSPITAL AND MRC, BELGAUM”.

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PRINCIPAL OF THE INSTITUTION

This is to certify that the dissertation entitled “**FUSION OF SKULL VAULT SUTURES IN RELATION TO AGE – A CROSS SECTIONAL POSTMORTEM STUDY DONE IN 3RD, 4TH & 5TH DECADES OF LIFE AT KLEs PRABHAKAR KORE HOSPITAL AND MRC, BELGAUM**” is a bonafide research work done by THE CANDIDATE REG. NO. **BF0108002**.

Dr. Prasanna S. Jirli M.D.

Associate Professor and I/C Head of
Department,
Department of Forensic Medicine
& Toxicology,
KLE University's
J. N. Medical College, Nehru Nagar,
Belgaum -10

Dr.V. D. Patil M.D., DCH

Principal,
KLE University's
J. N. Medical College,
Nehru Nagar,
Belgaum – 10

Date:
Place: **Belgaum**.

Date:
Place: **Belgaum**.

ABSTRACT

Background and Objectives

Cranial suture closure has been used since the 16th century, and since that time there has been considerable debate about its applicability and reliability in age estimation. This study is intended to find out the pattern of cranial vault suture closure with respect to age in 3rd, 4th and 5th decades of life.

Methods

In this study, all the cases brought for post-mortem examination at mortuary of KLEs PRABHAKAR KORE HOSPITAL AND MRC, BELGAUM between 01-11-2008 to 31-10-2009 has been studied.

Results

In our study, out of 70 cases there were 16 females and 54 males. When comparison between male and female subjects were made, closure was earlier in females (Mean 6.97 vs. 4.94 in case of endocranial suture closure & 5.42 vs. 2.66 in case of ectocranial suture closure). Ectocranial and Endocranial suture components were compared through sagittal, right & left coronal, right & left lambdoid sutures. This shows endocranial suture closure occurs early compared to ectocranial suture closure. When comparison was made between sagittal, coronal and lambdoid suture, overall coronal suture closes early followed by sagittal and lambdoid respectively.

Conclusions and Interpretation

In the present study we tried the possibilities for suture closure to contribute to one of the essential foundations of Paleodemography: age estimation. Our analyses

strengthen the view that, there is a significant relationship between suture closure and age.

Key Words

S – sagittal, C – coronal and L – lambdoid.

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INTRODUCTION

Age at death is one of the primary components of the biological profile that a medico-legal expert attempts to determine during a skeletal analysis. Estimation of age at death from skeletal remains is not a simple task. Regardless of what phase of life an individual is in, when assigning an age at death for a specimen, the medicologist attempts to predict chronological age based on the person's biological age.¹

Question of identification arises in everyday of medico legal practice both in civil and criminal cases. Age being one of the cardinal parameters for establishing the identity. Its estimation is of paramount importance and requires special attention in cases where bodies are found in decomposed, mutilated state or only fragmentary remains are discovered. Since bone resists putrefaction and destruction by animals, it can lead to a reliable determination of age, sex, race and stature of the individual.

The assessment of age is done by anthropologist, archeologist, anatomist and persons engaged in medico legal works. Among all these, the work of Forensic Expert requires special attention because his findings are directly related to the administration of the justice and his conclusions are debated in court of law.

At postmortem, age in early years of life especially in first two decades, can be estimated fairly accurately within 1-2 years range on either side. There are several skeletal indicators that are used to estimate age during this period.

During 3rd, 4th and 5th decades of life, the principal changes taken into consideration for age estimation are metamorphosis of pubic symphysis, closure of cranial sutures and degenerative changes in vertebral bodies and joints. From these features, it is difficult to determine the age of the person with fair degree of accuracy from 25 years onwards. Methods like, Gustafson's method, study of union of parts of sternum, lipping of joints and closure of cranial sutures are being used to estimate age

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in wide ranges. Sutures are analogous to the epiphysio-diaphysis plane, in which both are loci of growth and have a sequence of time of closure. The texture of a young adult skull is smooth on both the inner and outer surface.²

Cranial suture closure (or suture synostosis) has been used since the 16th century and since that time there has been considerable debate about its applicability and reliability in age estimation.^{3, 4.}

Data available and used for age estimation from changes in skull vault sutures are mostly foreign. Only few studies have been reported in our country and none in South India. Therefore, this study is intended to find out the pattern of cranial vault suture closure with respect to age in 3rd, 4th and 5th decades of life and also to find out whether age ranges can be minimized when used in conjunction with other indicators.

OBJECTIVES

1. To find out the pattern of cranial vault suture closure with respect to age in 3rd, 4th and 5th decades of life.
2. To detect bilateral and bisexual variations in cranial suture closure if any.
3. To specify the relationship between progression of union of cranial suture and age of the subject.
4. To formulate a practical method of estimation of age based on the status of the progression of the closure of sutures using the data collected.

REVIEW OF LITERATURE

The skull or cranium consists of a series of bones, mostly united at immovable joints. Some bones of the skull are paired, whereas others are not. Each consists of external and internal tables of compact bone and a middle spongy layer, the diploe. The skull is covered by periosteum (pericranium) externally and lined by dura (endocranium) internally. The top part (skull cap) is termed the calvaria (vault). The fibrous joints between the bones are termed sutures and they allow growth at the calvaria. With increasing age, sutures disappear by osseous fusion. Skull is comprises of frontal, parietal, temporal, occipital, nasal and maxillary bones fused at respective sutures. On the superior aspect, the two parietal bones are separated by sagittal suture, frontal and parietal bones are separated by coronal suture and the occipital and parietal bones are separated by lambdoid suture. On posterior aspect, the parietal and occipital bones meet the mastoid part of the temporal bones laterally. The two halves of the frontal bone are separated until the age of about six years by the frontal suture, which sometimes persists into adulthood as the metopic suture. On lateral aspect, the parietal bone articulates below with the squamous part of temporal bone at temporal suture.⁵

As humans age progresses, their cranial sutures undergo increasingly elaborate, changes becoming more complex and developing interdigitations through a process of growth and resorption of bone occurs. Although forensic science correlates obliteration of sutures with age, the morphologic characteristics of sutures are highly variable making age estimation difficult to determine. However, if suture obliteration is used in conjunction with other skeletal age indicators, the accuracy of age estimation increases.⁶

In the 18th century, anatomists emphasized the analogy between suture membranes and the diaphyso-epiphyseal plane. The Hippocratic idea of the relationship between cranial form and suture condition was revived in the 19th century. Since the middle of the 19th century, the growth of the brain has been viewed as a cause, rather than effect of suture closure. During the 19th century, it was observed that cranial union first occurs in the sagittal suture and that it occurred earlier within the inner table than the outer table.³

In 1856, the anatomist Louis Pierre Gratiolet (1815-1865) proposed a sequence for suture closure and stated that union occurred earlier in Negroes. It should be noted that Gratiolet made this distinction in order of cranial closure between higher and lower races of mankind with Negroid races belonging to the lower group. Gratiolet, observed that ectocranial suture closure progressed sequentially: sagittal, lambdoid, then coronal. Following the line other anatomists began to try to establish an age related sequence for cranial suture closure.³

In 1861, Physician Paul Broca observed visible sutures in males over the age of 50 and developed a 4 point rating system for cranial suture closure. Over time, it came to be accepted that, in the white stock union began between the ages of 40 and 45. However, in 1869 Pommerol F noted that the period of union for each suture, varied across individuals but followed the general pattern. Pommerol identified the following sequence (ibid.): 1) individuals under 35 years of age had open cranial sutures; 2) around 40 years, the sagittal suture begins to close; 3) around 50 years, the coronal suture begins to close; and 4) by 65 years or more the temporal suture has finished closing.³

In 1885, Ribbé FC examined 50 skulls of known age. Out of which 40 were of white stock, the other 10 presumably non-white. He found that the earliest occurrence

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of cranial suture union was at 21 years and the latest at 55 years. Taking the mean, Ribbé concluded that closure commenced between the ages of 40 and 45, with a standard deviation of 15 to 20 years. He stated that ectocranially, sagittal and lambdoid sutures closed before the coronal suture.³

In 1888, Schmidt proposed that the basal suture united between 18 to 21 years, but possibly between 25 and 40 years and was complete between 40 and 60 years.²

In 1890, Dwight T proposed that before the age of 30, all of the cranial sutures were open. He observed that suture closure began endocranially. It occurred later in females than in males. Thus he concluded that closure was irregular and as such, not of value as an indicator of age. However, his samples consisted of street urchins of indeterminate ages and he did not indicate whether his conclusions referred to internal or external suture closure. He concluded that, the time of closure of any particular part of the suture and the order in which the process advances are very uncertain. But according to him endocranial closure is more reliable than ectocranial fusion.^{2,3}

In 1905, Parsons FG and Box CR examined the significance of internal suture closures using 82 male and 82 female skulls of known age. They concluded that: 1) closure rarely occurred in a healthy skull before the age of 30; 2) between 30 and 50 years of age there is a fair amount of endocranial closure in coronal and sagittal sutures; and 3) over 60 years, all endocranial sutures were obliterated. Parsons and Box also suggested that less serrated (simple) sutures closed before all other sutures and that there were no difference in closure periods for the left or right side of the skull. They proposed that the lambdoid was the last of the vault sutures to reach complete closure. Overall, they concluded that Dwight was justified in his assessment

that cranial sutures closed later in females and that cranial sutures were not a good indicator of age.^{2,3}

In 1906, Frederic J examined 255 European and 119 non-European crania of known age. However, only 91 European and 13 non-European crania of both sexes were opened so that the internal surface could be examined. Following Broca, Frederic introduced his own rating scale of 0 to 4 (open, less than one half closed, half closed, more than one half closed, and totally closed). Examining endocranial sutures, he found that the lambdoid closed after the sagittal and coronal. Frederic concluded that it was not possible to determine the age of a skull by the condition of suture union closure with any accuracy greater than +/- one decade. However, he stated that suture closure occurred later in females, thus concurring with Dwight, Parsons and Box.^{2,3}

In 1915, Louis Bolk calculated the absolute frequency of premature obliteration in 1820 European juvenile skulls, from which he proposed the following terminology for suture closure: precocious (closure before the age of seven) and premature (closure after the age of seven but before the 'normal' age of closure). The work of Todd during the 1920s provided anthropologists with a framework for estimating age of death from both, the pubic symphysis and the cranial sutures.^{3,7,8,9}

Todd and Lyon stated that their work differed from all earlier studies in that they sought to establish a definite age relationship for suture closure, whereas earlier researchers, dealing with a number of crania of unknown and various ages. Based on their observations, solely upon a general average which was termed a 'closure tendency'.⁷

Todd and Lyon found no onset timing differences between endocranial and ectocranial closure, although endocranial closure was deemed to be more reliable since there were more occurrences of lapsed union in ectocranial sutures. They found

neither racial differences nor any differences between the left and right sides of the skull.^{3, 7, 8, 9}

The assumption that anomalous closure of one suture correlated with anomalous closure of all sutures in a given skull became the basis of all future criticisms of the Todd and Lyon methodology. Since Todd and Lyon specifically eliminated 'abnormal' crania from their experimental sample, it should not be surprising that attempts to replicate their findings, using random samples which include such crania, should fail.⁶

During the 1970s through to the 1990s, several researchers reexamined the use of cranial sutures as a means of determining age at death.^{4, 10, 11, 12}

The research of Todd and Lyon provided the groundwork for all North American forensic and physical anthropological studies for the remainder of the 20th century. In 1924, Todd and Lyon proposed to "present the facts concerning suture closure and its relation to the racial form and individual contour of the brain case".³

The research by Todd and Lyon was the first new attempt to estimate age using endo and ectocranial suture closure since Pommerol, Ribbe, Frederic, Parsons and Box, with the specific aim to create a precise numerical rating system for cranial closure.²

Todd and Lyon stated that: Until we gathered the accurately dated material in the Hamann Museum, no one possessed a sufficient collection of skulls of known age to justify the interpretation of suture closure upon its age relationship. They tried to ensure that the skeletal material was large enough to justify it as a sample of the population under study. In addition to sex and race, verifiable age at death had to be known and the crania had to be cut, so that examination of the interior surface was possible.³

REVIEW OF LITERATURE

Todd and Lyon initially examined the crania of more than 1,000 individuals, from which those of which were of uncertain age and did not have a complete post cranial skeletal for comparative study were rejected. Of the original 1000 specimens, 514 crania of known age were examined (ibid.): 307 crania of white males, 58 white females, 120 Negro males, and 29 Negro females. From this initial sample, 40 White skulls (13.3%) and 41 (34.2%) were excluded as anomalous. They provided detailed accounts by explaining both the factors in which, skulls (by catalogue number and age) were rejected and pertinent cranial features which led to the rejection. Rejections were based upon: 1) whether or not the skull belonged to skeletons belonging to the symphyseal anthropoid strain.^{2,3}

It is characteristic of the anthropoid strain that the pubic age relationships fall nearer to those of the Giant Anthropoids and there is a clear difference in age relationship of the skeleton between human beings according, as they exhibit the anthropoid strain or the regressive form of symphysis. In the first place, elimination based on the anthropoid strain in the pubic symphysis affects skeletons of the third decade; 2) precocious union; 3) no endocranial closure of vault sutures; 4) evidence of dwarfism; and 5) no endocranial closure of any cranial sutures. As stated by Todd and Lyon, they were confident in their rejections because they were able to examine the entire skeleton and they were cross referenced with legal documentation of age at death. The age of the specimens ranged from 18 to 84 years. Todd and Lyon state that this relatively small sample size was statistically accurate, since the objective of the study was to determine the progress of cranial suture union. They note that in certain instances, they observed that sutures seemed to fail to completely close. This condition was defined as 'lapsed union' of the suture. They defined it as the

incomplete union of the suture, characterized by a buildup of bone tissue along the edges of the unclosed part.³

Todd and Lyon classified incidents of lapsed union as closed, since a suture in this condition would be unlikely to close to any great extent. Following the precedent set by anatomists of the seventeenth century, Todd and Lyon grouped the sutures in the following manner: vault [sagittal (and metopic), coronal and lambdoidal], accessory [spheno-frontal and spheno-parietal] and circum-meatal [spheno-occipital].
3, 7, 8, 9

For later decades, they eliminated skulls which exhibited partial or complete closure of the sagittal and mastoid-occipital at an early age. They adopted Broca's arrangement of complication of sutures, degrees of closure and subdivision of particular sutures, except for the adoption of Frederic's inversion of Broca's categorization of the amount of suture union (i.e. 0 = no union and 4 = complete closure; 1 to 3 refer to the amount of union - one quarter... three quarters). They did not differentiate between union which had progressed halfway along a suture and closure which involved a total of half the length of a suture, but is exhibited in separate, discrete areas. The following information was recorded as the joint observation of two individuals: sample crania number, race, sex, age, greatest length, greatest breadth, cephalic index, cranial capacity and sites of wormian bones. The observations were only accurate for the external and internal surface of the crania, with no accurate information regarding suture conditions within the skull wall. The closure for each suture was then averaged and plotted. Todd and Lyon state that in spite of individual differences, there was a definite trend in the progress of suture closure in relation to age. Todd and Lyon then repeated the above procedure with the Negro male and female crania (of both 'racial stocks'). This led to the elimination of

'abnormal' progress in each of the series, giving a basis for comparison of closure progress in each sex and stock with those of the male Whites, which were thereafter used as a standard. They observed the following traits: 1) there was a clear orderly age sequence in the process of suture closure; 2) sex, racial stock, cephalic index and cranial capacity have very little effect on this closure sequence; and 3) the timing of the sequence was more obvious endocranially than ectocranially. In attempting to graph their results, Todd and Lyon decided not to arbitrarily subdivide age into units of one year. Instead, reasoning that each year of life includes, at the maximum, 18 months and successive 'years' overlap; the states of union for all individuals during three successive years of life was summed up, and the average taken in order to calculate a mean value for the state of union characteristic of the second of the three year. This 'three year averaged' age would become the focus of later criticism, since it apparently provided absolute ages at which a specific suture phase would be exhibited. Their error was not including this averaged age in their tabulated results alongside the 'arbitrary' age ranges. For example, Todd and Lyon stated that for white males, endocranial vault suture closure commences in the following order sagittal (22-23 years), coronal (24 years) and lambdoid (26 years), while closure is completed at 35, 41 and 47 years, respectively. Based upon these results, Todd and Lyon proposed that the rate of cranial suture closure was linked to the final stages of skeletal growth.³

Todd and Lyon found no onset timing difference between endocranial and ectocranial closure, but found the former more reliable age indicator since the later so frequently showed lapsed union. Lapsed union occurs more often in sagittal suture.¹³

In order to test their findings, Todd and Lyon examined 30 randomly selected crania of known age. While on average, their method provided close approximations of age at death with a standard deviation of 6 years which varied across individual

crania. Although in comparison with later, revised methods of cranial suture estimation, Todd and Lyon did manage to produce estimated age ranges within 20 years of the actual age at death. However, Todd and Lyon stated that “our results are of distinct value when they are taken in conjunction with indications given by other parts of the skeleton”.³

In 1925, Todd and Lyon published three follow papers to the above study (Parts II-IV). Part II was an examination of ectocranial suture closure in adult males of white stock, since they acknowledged that in some instances researchers would not be able to observe endocranial sutures. The sample consisted of 267 crania employed in the first study; however, new samples were added for comparison as they became available during the course of these three studies. This investigation concluded that: 1) in general, there is no tendency on the part of sutures to begin to close earlier endocranially rather than ectocranially; 2) the only exceptions to this finding were the pattern exhibited by the inferior mastoid-occipital, the sphenoid-frontal and the coronal; 3) ectocranial closure was slower and more variable with no evidence of periodic activity; 4) ectocranial suture union was never as complete as endocranial closure; and 5) ectocranially, lapsed union is evident in all sutures.⁷

In Part III of their research, Todd and Lyon focused upon endocranial suture closure in the ‘American negro’. They believed that this was an important area of study since they were attempting to ascertain whether or not their first study of white males could be employed as a standard for identifying age at death for different ‘racial stocks’. The initial sample consisted of 120 crania of known age from the Hamann collection. However, 41 crania were discarded for exhibiting abnormal traits, just as had been done in the two previous studies. Todd and Lyon concluded that, allowing

for individual variation amongst the Negro crania, the endocranial closure pattern was generally the same as for the white sample.^{3,7,8,9}

However, they also conclude that many Negro skulls have been rejected as abnormal because of delay in closure of the lambdoid suture. It appears that some change is even now taking place in this region of the Negro cranium which would indicate that, they believe, there is something different occurring within the 'Negro stock' or in more current terminology there seems to be a population specific genetic variation in the endocranial closure of the lambdoid suture.⁸

In Part IV, Todd and Lyon examined the occurrence of ectocranial suture closure in the male Negro cranium. The sample consisted of the 79 crania selected for Part III of their study. Their findings are as follows: 1) endo and ectocranial suture closure patterns are essentially the same for White and Negro males; 2) ectocranial closure is more erratic, slower and less complete than endocranial closure; and 3) lapsed union is characteristic of all ectocranial sutures, although it does not appear in all individuals. These age ranges were applicable for both White and Negro males (no racial differences in suture closure) and were a few years younger for females of both racial groups. When this methodology was tested on a random sample of 30 crania of known age, the standard deviation from the 'real' age at death was +/- 6 years.⁹

In 1937, Cattaneo studied 100 'miscellaneous' Argentinean skulls and stated that suture closure could only provide a suggestive age indicator. Hrdlicka stated that endocranial suture closure was only reliable within ten years on either side of the predicted age. Cobb, using the Todd and Lyon methodology, stated suture closure was only reliable within nine years on either side of the predicted age.²⁷

In 1948, Brooks S at the suggestion of Dr. McCown of the University of California had began an inquiry into why samples of aboriginal California Indians

showed a mean age at death consistently less than 30 years. The method employed attempted to employ Todd's methods of age determination, using both cranial suture closure and changes to the pubic symphysis, to see if they were applicable to races other than White and Negro, and to determine the correlation of these two methods when applied to one individual. However, Brooks attempted to examine the cranial sutures and pubic symphysis in isolation from the rest of the skeleton, as single variables, which, according to Todd and Lyon (1924) is neither a reliable nor valid methodology. In 1948, just fewer than 400 individual skeletons from the University of California collection were selected for testing. In 1950, some of the skeletons employed by Todd from the Hamann Museum collection were used for review.^{3,7,8,9}

In 1953, R. Singer concluded that using cranial sutures as an estimation of age at death was an unreliable assessment methodology. He found that there is a tendency for the cranial sutures of both females and males to either remain open throughout life or to close much earlier than predicted by Todd's method.²

Later, in 1953, a second series of 70 skeletons were analyzed to verify the methodology. The sample was chosen based on the following criteria: 1) the individual be over 18 years of age, as judged by long bone epiphysis-diaphysis union and fusion of the three elements of the acetabulum; 2) the crania vault must contain at least the area of the coronal, sagittal and lambdoid sutures; and 3) the symphyseal surface of at least one pubic bone must be preserved. It should be noted that all of the skeletons were from California, but no consideration was made of area or archaeological horizon.³

Following the criteria of expected suture closure set out by Todd, Brooks employed a 5 point scale (0 - open to 4 - complete closure). She stated that there was "no way of checking the accuracy of either cranial or pubic ages, should they be

divergent in one individual, except by indirect approach". Brooks found that, for females, there was a "sharp deviation" for the predicted age at death between cranial suture and pubic symphysis methods, of at least 10 years. She states that cranial suture closure tends to lag anywhere from 5 to 25 years, with a mean of +/- 9 years, behind that of the pubic symphysis. The male sample showed a deviation from 5 to 8 years, with a mean of +/- 2 years, between cranial suture and pubic symphysis methods. Brooks found that in cases where all of the sutures were open (predicted age <25), comparison with dental wear patterns, epiphyseal closure and pubic symphysis surface, all indicated that the specimen was over 35 years old. Despite obtaining linear correlations as high as 0.74, these results led her to concur with Singer (1953), that cranial suture closure was an unreliable method of age determination, especially for female skeletons.¹⁴

In 1957, McKern and Stewart revised the cranial suture closure methodology. Following the work of Singer (1953), they assigned four parts to the coronal and sagittal sutures and three to the lambdoidal sutures, but followed Todd and Lyon in the five scale rating system (0-4, but 2-3 are combined) . However, their observations were based solely upon ectocranial suture closure. They noted that closure tends to begin the the 1st and 4th parts of the coronal, 1st part of lambdoid, and 1st and 4th parts of the coronal. The final stage of closure tends to be in the 1st and 2nd parts of the sagittal, 1st or 2nd part of lambdoid, and the 1st part of the coronal (ibid). Although they found that there was an age progression in the uniformity of suture closure, they believed that it was too erratic to be of use in determination of age at death. McKern and Stewart concluded that: So erratic is the onset and progress that an adequate series will provide just about any pattern at any age level. Thus, as a guide for age determination, such a trend is of little use.²

In 1959, Genovese and Messmacher studied 101 Mexican male skulls of all ages and known identity: 47 'indigenas' and 54 'mestizos'. They found that the age difference between suture estimation and actual age was 12 years, 11 months (indigenas) and 9 years, 5 months (mesitzos).²

Krogman provided the following cranial morphological age sequence: 1) from the age of 25, muscular markings become increasingly evident, especially on the temporal, occipital and on the lateral side of the mandible; 2) around 35 to 45 years, the surface begins to assume a matted, granular appearance; 3) on the inside of the skull, the Pacchionian depressions, both deepen and occur with much more frequency; 4) after the age of 50, the diploe become less vascular channeled and there is an increasing replacement by bone. However, there is no consistent age change in the thickness of the cranial bones. The bones of the skull have two layers, the tabula interna and externa, which are separated by a vascular spongy bone space (diplöe). These bones are separated by sutures which, in a series, are analogous to the epiphyseo-diaphyseal planes that in both are loci of growth, and that both have a sequence of timing and union. Just as the epiphyseo-diaphyseal union most frequently begins centrally and proceeds peripherally, so does suture closure begin endocranially and proceed ectocranially. In many cases, complete closure will obliterate any signs of the cranial sutures. There is a difference however; the epiphyseal union is always complete in normal closures, whereas suture closure may be incomplete in normal, healthy individuals.²

As such, osteologists have developed numerous techniques which, when applied in concert, increase the accuracy of identification. In 1985, Meindl and Lovejoy re-examined the Hamann-Todd Collection. They chose 10 ectocranial landmarks, although it is unclear whether they scored for bilateral expression. They

employed the following scoring methodology: 0 - no observable closure; 1 - 1 to 50% closure; 2 - 51 to 99% closures; 3 -100% closure. Small (1 cm) lengths of a suture or specific sites were selected for inspection, for which only the judgment of one observer was required. Since they proposed that in the case of forensic anthropology, the regularity of closure during the early adult years was not critical, only ectocranial sutures were studied.^{3,7,8,9}

Meindl and Lovejoy thus chose 17 ectocranial points for 236 crania from the Hamann-Todd collection, based upon the reliability of stated age at death. During the initial analysis, they found that some of these landmark sites were of limited value for consistent age determination. These sites were as follows: (closure of) 1) parieto-mastoid; 2) squamosal point; 3) occipito-mastoid; 4) zygomatico-malar; 5) fronto-lacrimal; and 6)fronto-ethmoid. The sites which were retained were the vault system (midlambdoid, lambda, obelion, anterior sagittal, bregma, midcoronoal and pterion) and lateral anterior system (midcoronoal, pterion, speno-frontal, inferior speno-temporal and superior speno-temporal). Meindl and Lovejoy found a chronological age ranking at the pterion, speno-frontal, midlambdoid and lambdoid, respectively. These were based upon the assumption of underlying continuity of ordinal closure scales (the Kendall coefficient).¹⁴

The next phase of analysis, to determine combination of sites which could be employed in age estimation, was based upon the following assumptions: 1) sutures should demonstrate a protracted sequence of closure; 2) sutures should correlate with age during the primary period of its closure activity; and 3) the information provided by each suture should be specific to that particular suture. From these criteria, and since the calotte is usually the most durable in archaeological populations, they determined that the 5 lateral anterior sites were the best overall predictor of age. It

was assumed that the sample crania would exhibit a commencement and termination sequence which correlated with long bone epiphyseal fusion sequence.¹⁴

Using composite scores for each sample specimen, they found that the lateral anterior sites closed in the following sequence: Commencement - pterion, midcoronal, spheno-frontal, inferior spheno-temporal, superior spheno-temporal; Termination - pterion, spheno-frontal, midcoronal, inferior spheno-temporal & superior spheno-temporal. The vault sutures closed in the following sequence: Commencement - obelion, pterion, anterior sagittal, lambda, midlambdoid, midcoronal, bregma; Termination - obelion, pterion, anterior sagittal, lambda, bregma, midlambdoid & midcoronal. The overall (linear) correlation with known age was 0.57 for lateral anterior sites and 0.50 for vault sutures. It was found that the average mean deviation, for lateral anterior scoring, was 7.5 years, and 14.2 years for vault sutures. Meindl and Lovejoy also examined whether or not race or sex had any effect on suture closure, thus affecting the accuracy of age prediction. Using analysis of co-variance (ANCOVA) on the residuals, they found no measurable influence of either race or sex. However, Meindl and Lovejoy state that any age estimation should take into account postcranial indicators as a control for suture cranial variations.¹⁴

According to Meindl and Lovejoy⁵, this period of investigative research was characterized by a trend in skeletal biology, during which it was hoped that one or two highly reliable age indicators would be isolated and perfected. Despite being used since the 16th century, the use of cranial sutures for determining age at death is regarded by many forensic anthropologists as an overall weak methodology.⁶

In *Standards for Data Collection from Human Skeletal Remains*, Buikstra and Ubelaker (1994) proposed combining several aging methods, based on different cranial sutures to predict age.¹⁴

According to Hershkovitz et. al. this 'refined' method ignored the fact that correlation between the recommended areas for inspection, along the cranial sutures, and age are very low. They proposed that these new standards still turn out old results, which seems to be apparent in their own research of cranial suture closure.¹⁵

In 1995, Nawrocki examined all three categories of sutures (ectocranial, endocranial and palatine) using regression and analysis of variance techniques. He studied 100 individuals of known sex, age and race (Black/White) from the Terry Collection. Two individuals were chosen from each race/sex category in every half decade, ranging in age from 21-85 years. Although for Whites, the lowest age was 27 years. No specimens were excluded for any reason; barring damage therefore there was no control when examining 'abnormal' skulls. Following Meindl and Lovejoy, 27 landmarks were scored on each skull: ectocranial (16), endocranial (7) and palate (4). Both the left and right side of the skull were scored when bilaterally expressed.¹²

A second sample was obtained in order to test the results from the Terry sample. This consisted of the crania of 61 White individuals (27 males and 34 females), aged 58-102 years, obtained from medical dissection rooms in Syracuse and Indianapolis. However, while Nawrocki notes that the presence of soft tissues and saw cuts on the cranial vault, limited suture observations of the endo and ectocranial surfaces, he did not indicate how the age at death of the sample crania was verified. In order to produce a score, all 27 landmarks were added together, resulting in a range of 0-. It was found that there was a moderately strong correlation between the predicted age and the age of the Terry sample. However, Nawrocki does note that summing or averaging the data will result in a loss of information. One area of possible concern, regarding this reliance upon linear regression models, is that it allows for a predicted range from 25.3-82.8 years, even though the sample crania were 58-102 years old.

Additionally, when tested against the Terry samples, the predicted ages deviated, on average of 9 to 21 year. It should be noted that Todd's average age deviation was 6 years, which he deemed to be unacceptable. Creating an equation to test Meindl and Lovejoy's proposal that race or sex may affect suture closure rates, Nawrocki found that there was a correlation between suture closure and sex, but not race, although there was an interaction between race and sex. He suggests that this finding, which is contrary to that of Meindl and Lovejoy, is due to the use of more cranial landmarks.¹²

Nawrocki created 8 different equations to test each case sample, although this required dropping the number of landmarks from 27 to 15. In his conclusion, Nawrocki proposed two possible sources of error: sampling (random) and secular trends (non-random). Sampling error is said to occur when the two parent populations are similar overall, yet the test sample is drawn unevenly. However, this seems to be a rather weak argument, considering the emphasis placed on obtaining 'random' samples for statistical analysis. Secular trends systematically change the nature of the second population, or portions of it, so that the regression derived on the first are no longer as accurate. In this instance, one is concerned that the sample is too randomly varied. In other words, researchers seem to prefer finding fault with the 'sample' rather than with their chosen methodology.¹²

Use of suture closure as an age estimate is predicated upon the hypothesis that suture closure is part of the aging process. However, when suture closure patterns were first studied at the beginning of this century, there were two schools of thought (British and Italian) on this issue. The British school maintained that sutural ossification and cranial immobility were normal conditions, whereas the Italian school maintained that they were pathologic in mature human adults. In time, probably due to the increasing prominence of the English language in the scientific literature, the

British approach toward suture closure became the dominant model in physical anthropology (without actually testing that hypothesis).¹²

In 1997, Hershkovitz et. al. examined the extent of the sagittal suture closure in 3,636 skulls from the Hamann-Todd and Terry collections. The sagittal suture was chosen as it is the only ‘end to end’ type suture in the calvaria (avoiding ‘pseudoclosure’ due to overlapping of bone, as in frontal over parietal bone) and because its location at the midline neutralizes it from biomechanical influences. They identified five sutural conditions, defined as: 1) totally closed (TC): no signs of the sagittal suture were observed on the ectocranial surface, from bregma to lambda; 2) partially closed (PC): less than 10% of the suture length was open; 3) totally open (TO): the suture line was clearly visible with almost no interruptions along its entire length from bregma to lambda. Minor closure at the area of the parietal foraminae was ignored; 4) partially open (PO): between 10% and 90% of the suture length was open; and 5) premature suture closure (PMSC). PMSC was distinguished from pathological closure, which occurs very early in life (5 years or earlier), and which is characterized by sutural ridging (scaphocephally). In the PMSC category all skulls in which the sagittal suture was closed after the age of 5 years but before 18 years, were included. They provided the following conclusions: 1) the sagittal suture cannot be used for aging the skeleton; 2) although cross-sectional in nature, suture obliteration patterns are not temporary progressive stages on an age scale, but rather independent permanent phenomenon; 3) some suture closure patterns are genetically inherited; 4) females and males manifest different suture closure patterns; 5) in all ages, the relative frequency of the ‘totally open’ category is higher in females than in males; 6) the medical conditions (HFI, TB) examined in the present study are not associated with a suture closure condition; and 7) suture closure is neither a pathological

phenomenon nor the result of normal aging process. Taken as a whole, the authors stated that reliance upon cranial suture closure for age estimation is of no value for either forensic application or paleodemography studies.¹⁵

A study was conducted in 1998 in which a total of 963 skeletons were studied to examine macroscopic cranial methods of age estimation. The methods of Ascadi-Nemeskeri, Masset, Baker and Meindl-Lovejoy were applied to every skull. The results indicated that most accurate technique in this application were those that consider endocranial suture closure. The methods of Ascadi-Nemeskeri and Masset were the most accurate in all sub-samples by population, sex, within population and in total. Although the relative accuracy could vary in application to the other populations.¹⁵

Time of closure of sagittal, coronal and lambdoid sutures were studied at autopsy on 538 male and 127 female adults of known ages belonging to north-west India. Whether a segment was open or closed on either surface was recorded. On analyzing the records authors came to conclusions that obliteration of sutures commences earlier on endocranial surface than on ectocranial. Complete obliteration of a segment or the entire suture is so erratic that it is not useful for estimating the age of skull.¹⁷

The age of 20 males and 20 females was evaluated based on vault sutures. The results were compared with the actual chronological age of the deceased calculated on the basis of their date of birth and demise. In many cases a slight overestimation occurred in evaluating the age by analyzing the sutures. Thus the results show that a precise and thorough evaluation of the deceased age is not possible on the basis of cranial suture closure without maceration of the skull.¹⁸

A study was conducted which used age estimation on the basis of single rooted tooth and cranial suture obliteration on unknown persons. A comparison of the estimated age and chronological age derived after identification showed high usefulness of the mentioned methods.¹⁹

Meindl-Lovejoy method was applied to 3663 skulls from Hamman-Todd and Terry collection. It was found that sagittal suture closure was age independent and sexually biased. The wide confidence intervals appeared to preclude meaningful application of suture status for age determination. No correlation was found with tested biological stressors.¹⁵

A new method was applied using ectocranial suture closure of lateral anterior and vault suture on 236 samples from the Hamman-Todd collection. It was found that ectocranial method was superior to endocranial and that age estimates are independent of race and sex. Conclusion was that the suture closure can provide valuable estimates of age at death in both archeological and forensic context when used in conjunction with other skeletal age indicators.¹⁴

A study conducted on 256 crania of adults over 20 years of age using Acsadi-Nemeskeri method found usefulness of this method for age estimation.²⁰

Another study using three age estimation techniques (Acsadi-Nemeskeri, Meindl-Lovejoy and Perizonius method) tested on a sample of known age in order to determine the value of cranial suture for age estimation. The results indicated that Acsadi-Nemeskeri technique which is based on endocranial suture can be used to distinguish between young and middle aged individuals in the sample but gives no information for crania over the age of 50 years. Age estimation using the Meindl-Lovejoy and Perzonius old system techniques, which use ectocranial sutures, was found to be subjected to numerous complicating factors of which sexual dimorphism

in the rate and pattern of closure was most significant. A method of estimating age at death based on both endo and ectocranial suture was developed on the basis of study sample. The technique attempts to overcome some of the associated with both intra and inter population variation in cranial suture.²¹

In another study conducted at Armed Forces Medical College, Pune, 104 individuals of different age groups were taken up. Each individual was subjected to radiological examination of the skull with a view to study the sagittal, coronal and lambdoid sutures, a special view (Gaur, Sahai and Saxenas) was evolved by trial in order to get all the basic three sutures in one film. As per the results of this study, if there is complete, non fusion of all the sutures, it can be assumed with reasonable accuracy that the person is below 30 years. This finding is in agreement with most of complete fusion of this suture. The first suture to start fusion is the sagittal and in the age group 31 - 35 years. There is either complete or partial fusion of the sutures and by 40 years and above, there is complete fusion of this suture. If the sagittal suture is completely fused, the probable age can be given as above 40 years. Lambdoid suture is the last to start fuse. It commences in 31 - 35 years age group and the maximum percentage of fusion is above 40 years of age group. If there is complete or partial fusion of all the three basic sutures, it may be safely concluded, the person is above 40 years.²²

According to Nandy A, skull sutures start their fusion activity by 24-25 years of age, which usually starts at the ectocranial surface but, though they start in the endocranial surface occurs late the progress at this level is speedy, more uniform and more complete than at the ectocranial level. Hence the endocranial fusion is more reliable than ectocranium. They ossify and are completely obliterated in the advanced age, although the parietal suture may remain separate throughout life. Lapsed union as

the term implies, is incomplete union. The metopic suture which is placed between the two frontal bones and closes between 2-7 years, but some time metopic suture may remain persisting.²³

The metopic suture, which is present at birth between the right and left halves of the frontal bone, usually closes around the age of two. However, in some individuals, it is persistent into later adult life. Metopism is more frequent among white? And Mongoloid? Populations (roughly 10% occurrence) compared to a 2% occurrence among Negroid? ²³

The study by Vyas PC showed that closure of sutures although not an appropriate indicator of age, yet accuracy in age estimation in elderly persons can reasonably achieved if other indicators of ageing process are taken into consideration. eg. graying of hair, wrinkles, arcus senilis, menopause and teeth.²⁴

METHODOLOGY

In this study, all the cases brought for post-mortem examination at mortuary of KLEs PRABHAKAR KORE HOSPITAL AND MRC, BELGAUM between 1ST November 2008 to 31ST October 2009 have been studied. All autopsies performed on deceased belonging to 3rd, 4th and 5th decades of life are included in this study. It is a Cross-sectional study and sample size is 70.

Preliminary data has been recorded as per the proforma. After reflecting the scalp, coronal, sagittal, lambdoid sutures are studied applying five point scale ectocranially. For endocranial suture closure, same score system is applied after removing the calvaria by craniotome taking due care to include complete coronal and sagittal suture. Lambdoid suture was studied in-situ. The calvarium is cleaned from soft tissues on both sides and is dried, which made the sutures look more prominent. Photographs are taken in all cases. The obliteration of the sutures is ascertained endocranially as well as ectocranially. The coronal suture is studied in two parts on right side and left side each; sagittal suture in three parts and lambdoid sutures in two parts each on right and left side. Examination is done under 5 point scale of 0 to 4

0- Open,

1- Less than one half closed,

2- Half closed,

3- More than one half closed,

4- Totally closed

(For inner and outer table separately)

After completion of data collection, it has been analyzed to find out pattern of skull vault suture closure in relation to various ages. Any notable difference in suture

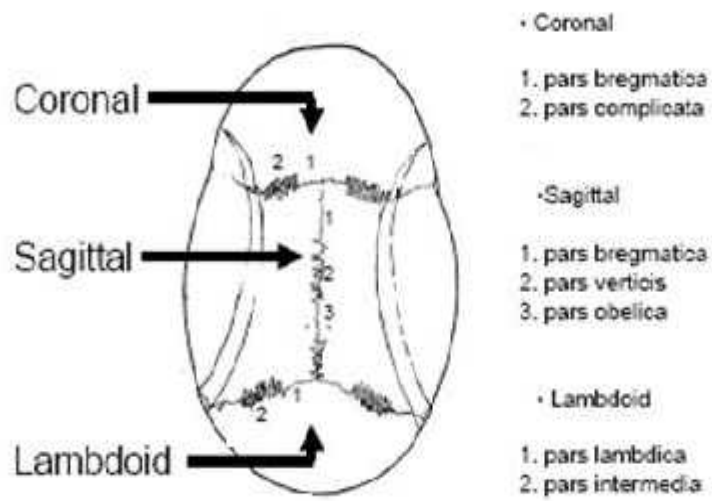
closure patterns with regards to sex of the individual and sides of skull is also analyzed.

Inclusion criteria:

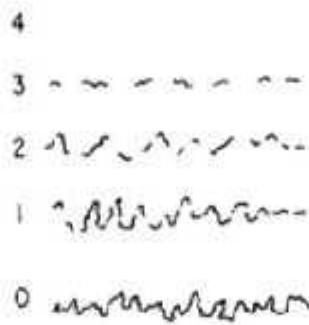
Deceased between 21-50 years of age.

Exclusion criteria:

- 1) All other age groups.
- 2) Cases with skull vault fractures.
- 3) Cases involving pathological conditions of bones.



Ectocranial sutures



Scoring system

KEY WORDS

S -SAGITTAL

C -CORONAL

L -LAMBDOID

R -RIGHT

L -LEFT

U- UPPER

L-LOWER

ENDO -ENDOCRANIAL

ECTO -ECTOCRANIAL

S1 -PARS BREGMATICA

S2 -PARS VERTICES

S3 -PARS OBELICA

C1- PARS BREGMATICA

C2- PARS COMPLICATA

L1- PARS LAMBDAICA

L2 -PARS INTERMEDIA

m -MALE

f -FEMALE

t-test -STUDENT'S T TEST

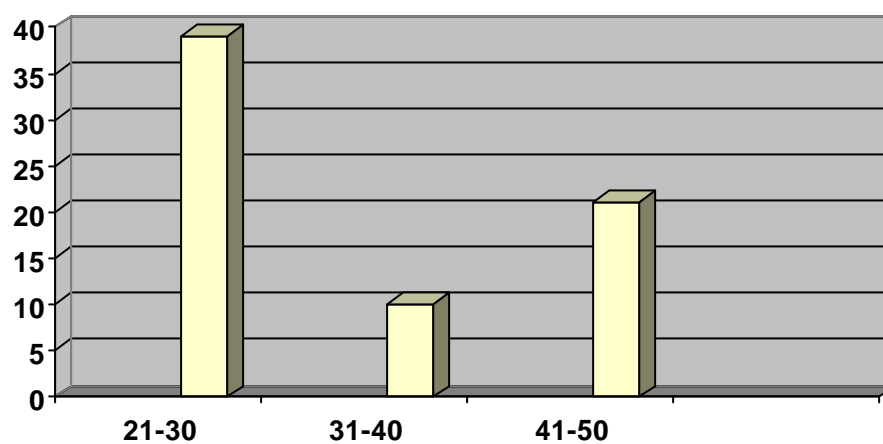
RESULTS

The study consisted of 70 cases brought to the mortuary of KLEs Prabhakar Kore Hospital and MRC, Belgaum. from Nov 2008 to Oct 2009.

TABLE-1**AGE AND SEX WISE DISTRIBUTION**

Age groups in years	No. of cases	Percentage
21-30	39	56
31-40	10	14
41-50	21	30
Total	70	100

The age of the victims varied from 20 to 50 years. Age groups were classified with 10 year of interval so as to compare with the previous studies. (Table-1, 2 & Graph-1)

GRAPH-1**DISTRIBUTION OF CASES –ACCORDING TO AGE GROUP**

Maximum numbers of cases (56%) are seen in 21-30 age groups, least in above 31-40 years age group.

TABLE-2

RANGE, MEAN, STANDARD DEVIATION, MEDIAN STANDARD AND ERROR OF MEAN OF THE CASES

N	Minimum	Maximum	Range	Mean	Std. Deviation	Median Std.	Error of Mean
70	20	50	30	32.88	11.11	28	1.33

TABLE-3

MALE AND FEMALE WISE DISTRIBUTION OF CASES

	Frequency	Percentage
Male	54	77
Female	16	23
Total	70	100

TABLE-4

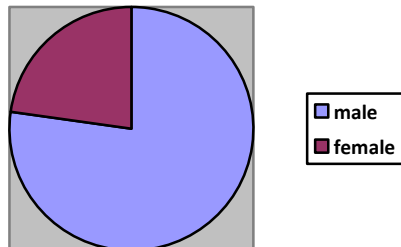
MALE AND FEMALE DISTRIBUTION OF CASES ACCORDING TO AGE

	Male		Female		Total	
	No.	%	No.	%	No.	%
21-30	31	57	8	50	39	56
31-40	6	11	4	25	10	14
41-50	17	32	4	25	21	30
Total	54	100	16	100	70	100

GRAPH-2

SEX WISE DISTRIBUTION OF CASES

In our study, out of 70 cases there were 16 females and 54 males.



GRAPH-3

SEX WISE DISTRIBUTION OF CASES

Male dominance was observed in all age groups.

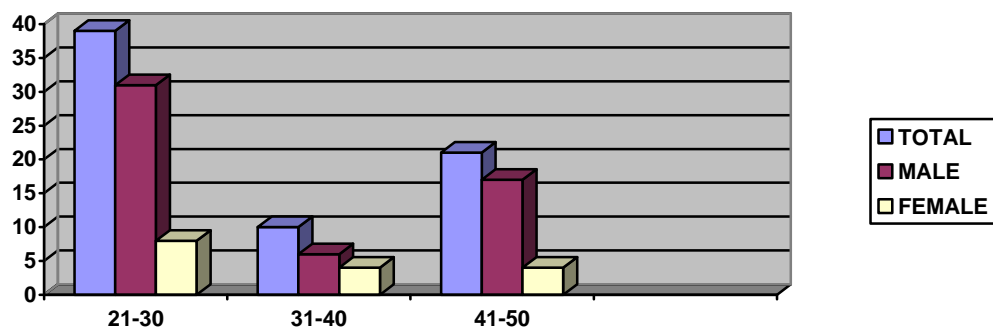


TABLE-5

ENDOCRANIAL SUTURE CLOSURE-SEXUAL VARIATION

Age group	N(m/f)		Mean(m/f)	
	m	f	m	f
21-30	31	8	2.76	7.04
31-40	6	4	7.33	7.5
41-50	17	4	6.33	7.28
Total	54	16	4.94	6.97

TABLE-6

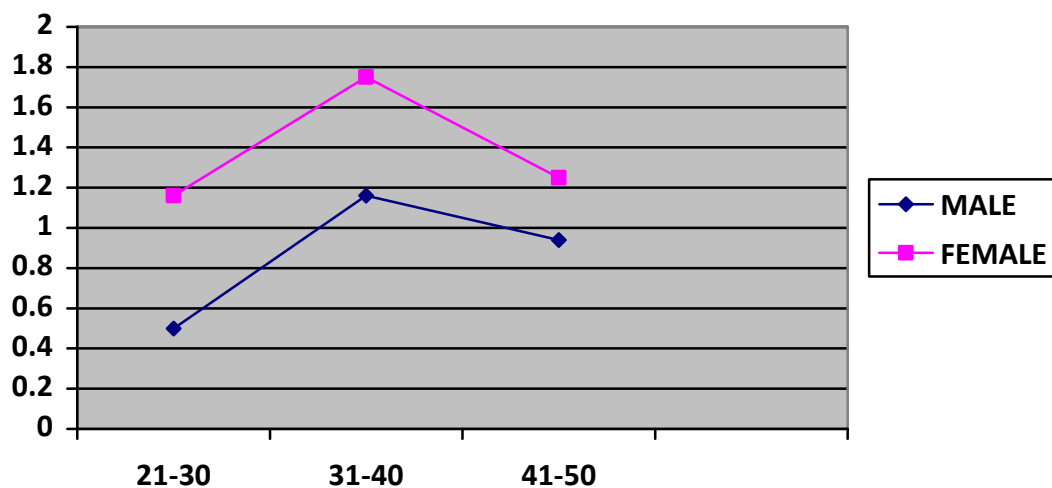
ECTOCRANIAL SUTURE CLOSURE-SEXUAL VARIATION

Age group	N(m/f)		Mean(m/f)	
21-30	31	8	2.01	4.791
31-40	6	4	3.66	6.62
41-50	17	4	3.51	5.37
Total	54	16	2.66	5.42

When comparison between male and female subjects were made, closure was earlier in females (Mean 6.97 vs. 4.94 in case of endocranial suture closure & 5.42 vs. 2.66 in case of ectocranial suture closure).

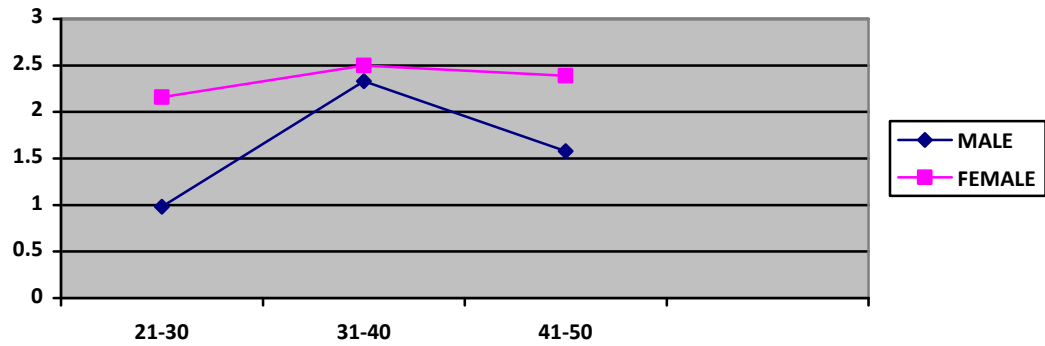
GRAPH-4

ECTOCRANIAL SAGITTAL SUTURE CLOSURE-SEXUAL VARIATION



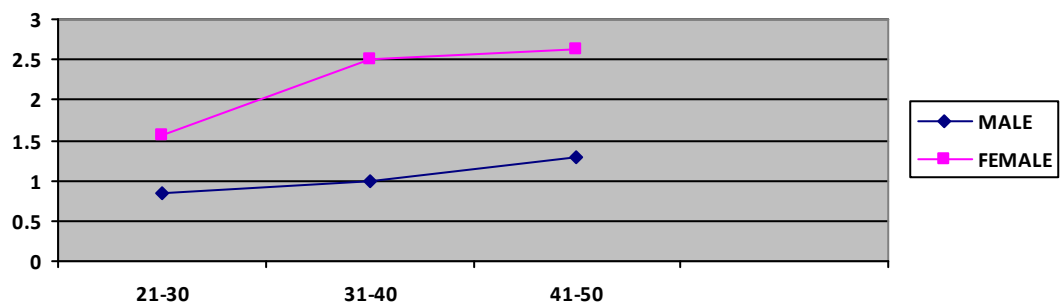
GRAPH-5

ENDOCRANIAL SAGITTAL SUTURE CLOSURE-SEXUAL VARIATION



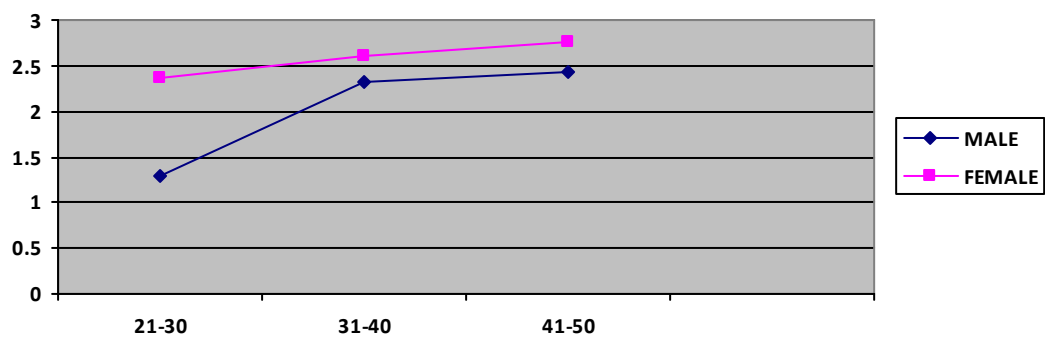
GRAPH-6

ECTOCRANIAL CORONAL SUTURE CLOSURE-SEXUAL VARIATION



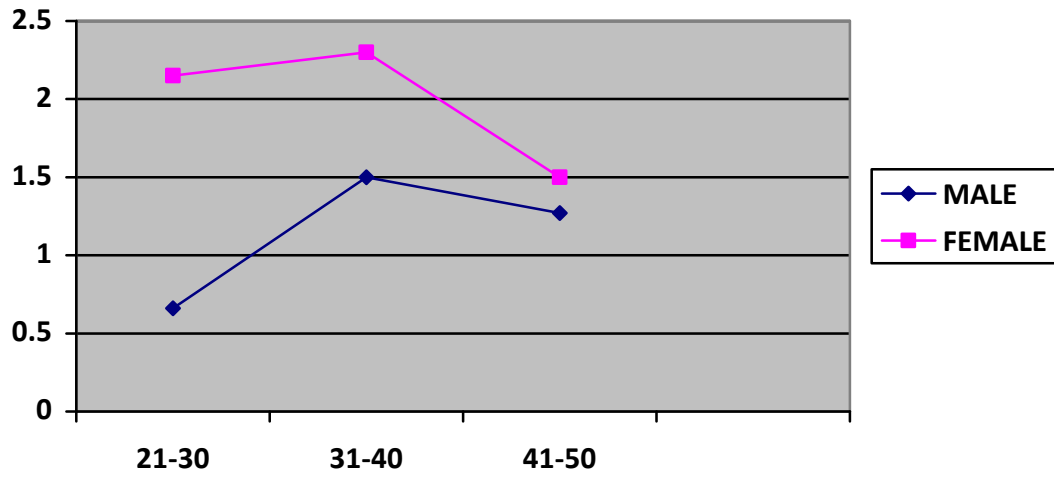
GRAPH-7

ENDOCRANIAL CORONAL SUTURE CLOSURE-SEXUAL VARIATION



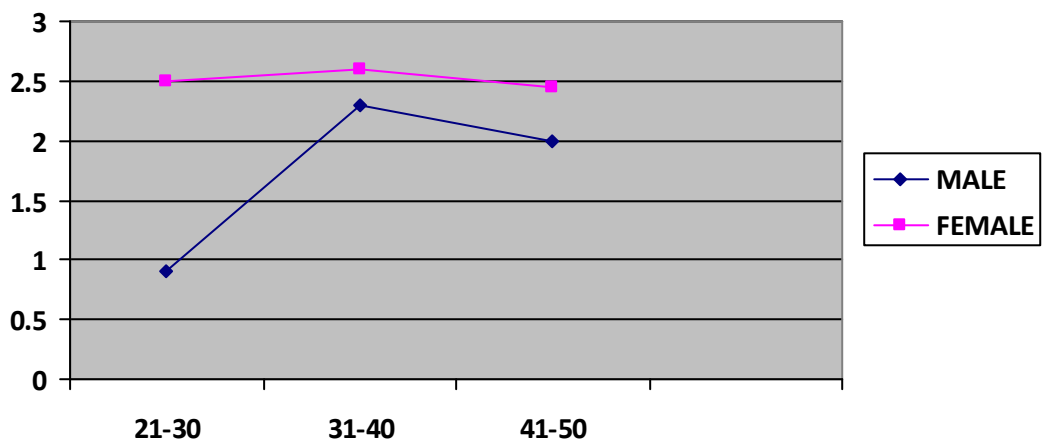
GRAPH-8

ECTOCRANIAL LAMDOID SUTURE CLOSURE-SEXUAL VARIATION



GRAPH-9

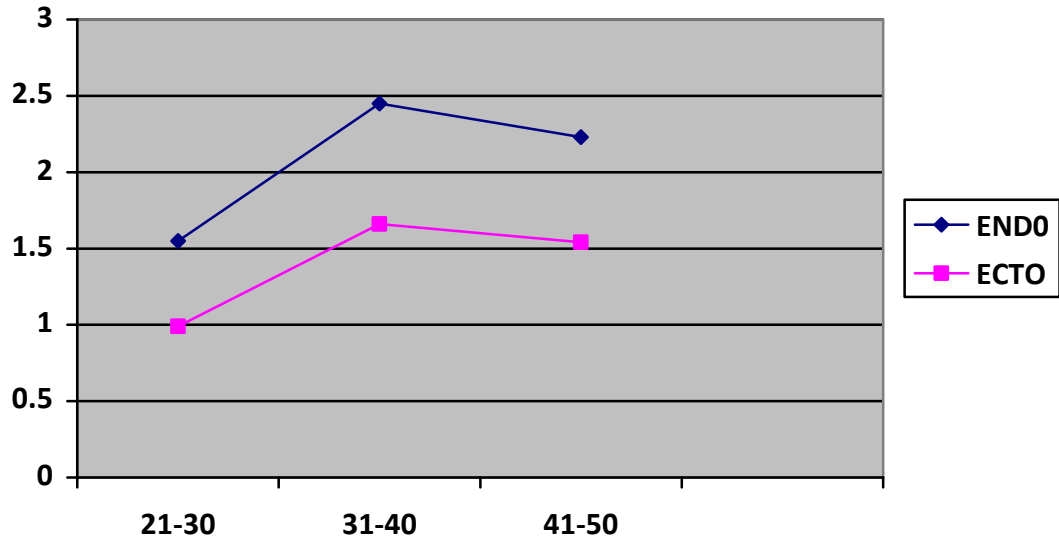
ENDOCRANIAL LAMDOID SUTURE CLOSURE-SEXUAL VARIATION



When males to female comparison were made, it shows that closure was earlier in females compare to male. (Graph 4, 5, 6, 7, 8, 9)

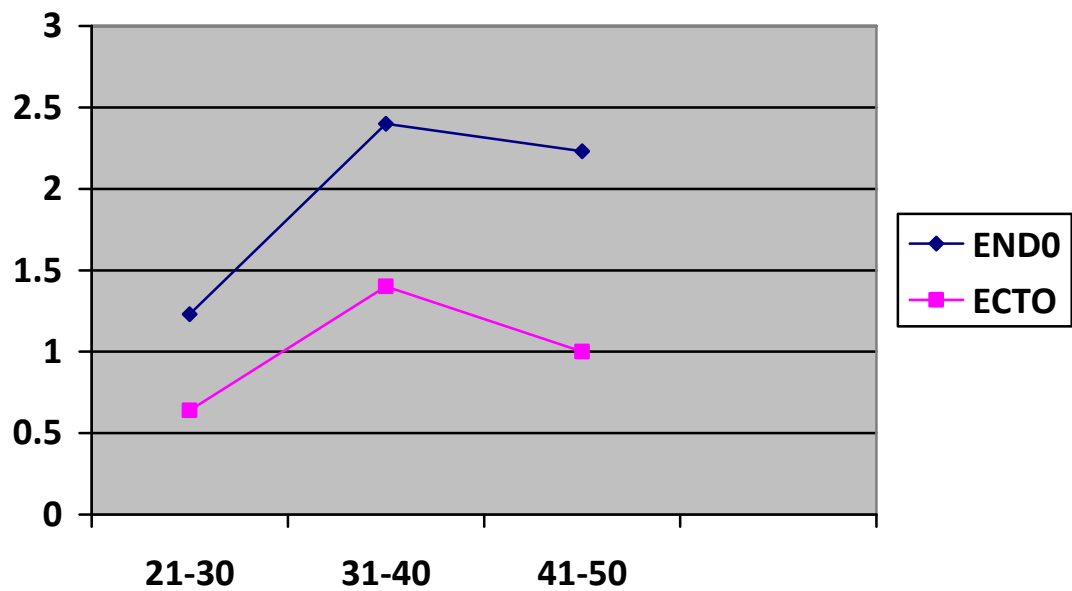
GRAPH-10

ECTOCRANIAL AND ENDOCRANIAL CLOSURE OF CORONAL SUTURE



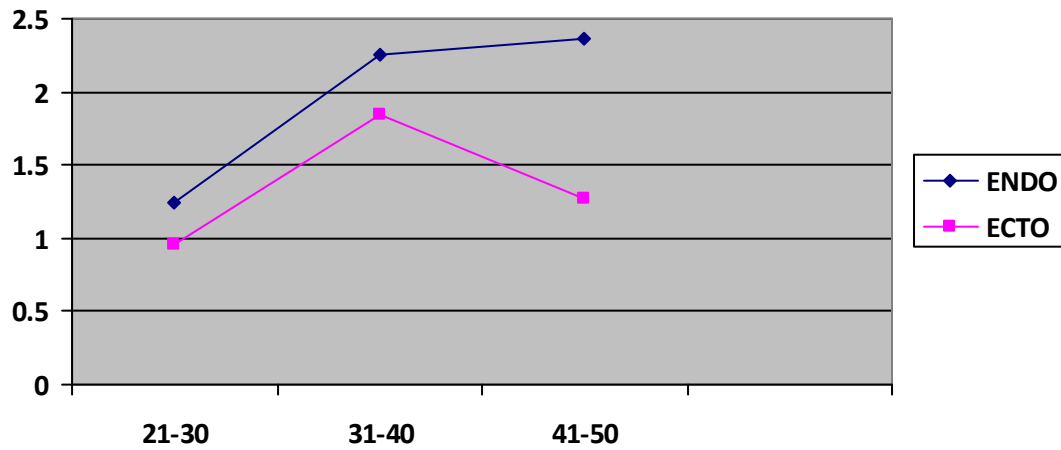
GRAPH-11

ECTOCRANIAL AND ENDOCRANIAL CLOSURE OF LAMBDOID SUTURE



GRAPH-12

ECTOCRANIAL AND ENDOCRANIAL CLOSURE OF SAGITTAL SUTURE



Ectocranial and endocranial suture components were compared through sagittal, right & left coronal and right & left lambdoid sutures. (Graph 10, 11 & 12)

This shows endocranial suture closure occurs early compared to ectocranial suture closure.

TABLE-7

MEAN VALUES OF SUTURES

SUTURES	MEAN
CORONAL	10.42
SAGITAL	9.93
LAMDOID	8.97

When comparison was made between sagittal, coronal and lambdoid suture, overall coronal suture closes early followed by sagittal and lambdoid respectively. (Table 7)

TABLE-8

ENDOCRANIAL AND ECTOCRANIAL CLOSURE OF SAGITAL SUTURE

Age group		Endo-S1	Ecto-S1	Endo-S2	Ecto-S2	Endo-S3	Ecto-S3
21-30	N	39	39	39	39	39	39
	mean	1.28	0.64	1.79	0.69	1.23	0.58
31-40	N	10	10	10	10	10	10
	mean	2.4	1.6	2.4	1.3	2.4	1.3
41-50	N	21	21	21	21	21	21
	mean	2.63	2.38	2	0.71	1.69	1.19
Total	N	70	70	70	70	70	70
	mean	1.75	0.8	1.71	0.9	1.62	0.87

When ectocranial suture closure was taken it is observed that S2 closure started early followed by S1 and S3 respectively (Mean in 21-30 decade---S2-0.69>S1-0.64>S3-0.58). Within the sagittal suture S1 appears to fuse much faster and S2 seems to close much slower (Mean in 41-50 decade---S1- 2.38>S3-1.19>S2-0.71).

When endocranial suture closure was taken it is observed that S2 closure started early followed by S1 and S3 respectively (Mean in 21-30 decade---S2-1.79>S1-1.28>S3-1.23). Within the sagittal suture S1 appears to fuse much faster and S3 seems to close much slower (Mean in 41-50 decade---S1- 2.63>S2-2>S3-1.69). (Table 8)

TABLE-9

ENDOCRANIAL AND ECTOCRANIAL CLOSURE OF CORONAL SUTURE

Age group		Endo-RU	Ecto-RU	Endo-RL	Ecto-RL	Endo-LU	Ecto-LU	Endo-LL	Ecto-LL
21-30	N	39	39	39	39	39	39	39	39
	mean	1.38	0.94	1.46	0.94	1.53	1.02	1.66	1.05
31-40	N	10	10	10	10	10	10	10	10
	mean	2.4	1.7	2.8	1.5	2.4	1.7	2.2	1.5
41-50	N	21	21	21	21	21	21	21	21
	mean	2.33	1.42	2.61	1.61	2.3	1.47	2.66	1.66
Total	N	70	70	70	70	70	70	70	70
	mean	1.81	1.2	2	1.22	1.91	1.25	2.04	1.3

In coronal suture there is no significant difference between right and left side. When ectocranial suture closure was taken it is observed that lower (L) coronal suture closure started early compared to upper (U) coronal suture (Mean in 21-30 decade---L- 1.05>U-1.02). Within the coronal suture, lower (L) coronal suture appears to fuse much faster compared to upper (U) coronal suture (Mean in 41-50 decade---L- 1.66>U-1.47).

When endocranial suture closure was taken it is observed that lower (L) coronal suture closure started early compared to upper (U) coronal suture (Mean in 21-30 decade---L- 1.66>U-1.53). Within the coronal suture, lower (L) coronal suture appears to fuse much faster compared to upper (U) coronal suture (Mean in 41-50 decade---L- 2.66>U-2.3).

TABLE-10

ENDOCRANIAL AND ECTOCRANIAL CLOSURE OF LAMDOID SUTURE

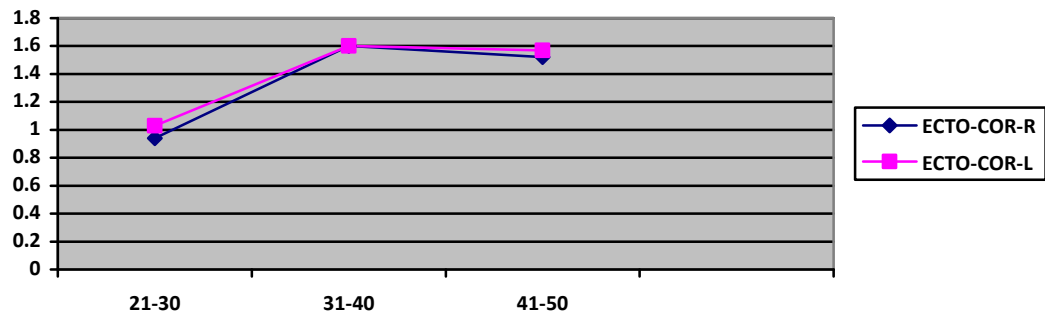
Age group		Endo-RU	Ecto-RU	Endo-RL	Ecto-RL	Endo-LU	Ecto-LU	Endo-LL	Ecto-LL
21-30	N	39	39	39	39	39	39	39	39
	mean	1.33	0.97	1.3	0.94	1.23	0.97	1.2	0.94
31-40	N	10	10	10	10	10	10	10	10
	mean	2.5	1.8	2.5	1.8	2.6	1.9	2.6	1.9
41-50	N	21	21	21	21	21	21	21	21
	mean	2.43	1.23	2.33	1.23	2.42	1.48	2.47	1.38
Total	N	70	70	70	70	70	70	70	70
	mean	1.71	1.17	1.78	1.15	1.78	1.24	1.78	1.21

In lamdoid suture there is no significant difference between right and left side.

When **ectocranial** suture closure was taken it is observed that upper (U) lamdoid suture closure started early compared to lower (L) lamdoid suture (Mean in 21-30 decade---U-0.97>L-0.94). Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture (Mean in 41-50 decade---U- 1.4>L-1.3). When **endocranial** suture closure was taken it is observed that upper (U) lamdoid suture closure started early compared to lower (L) lamdoid suture (Mean in 21-30 decade---U-1.3>L-1.2). Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture (Mean in 41-50 decade---U- 2.5>L-2.4).

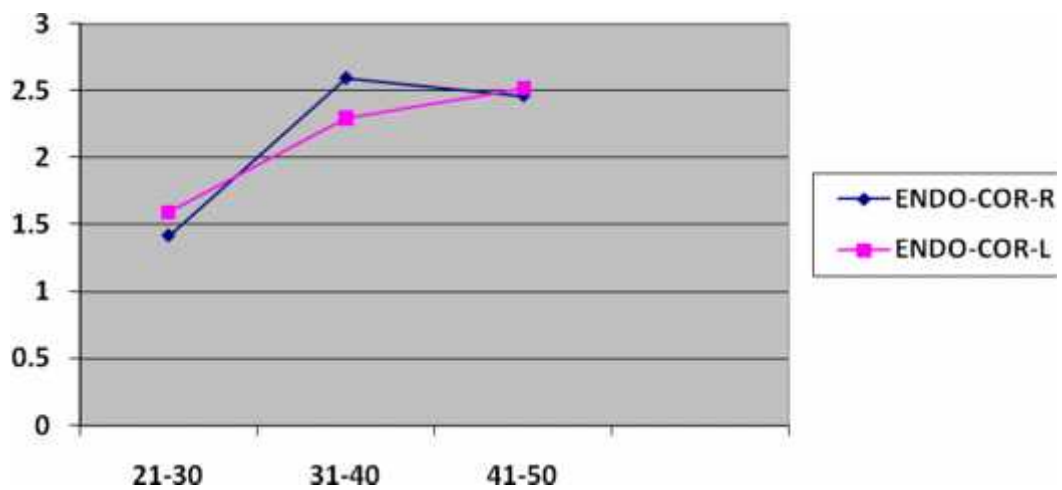
GRAPH-13

BILATERAL VARIATION IN ECTO-CORONAL SUTURE



GRAPH-14

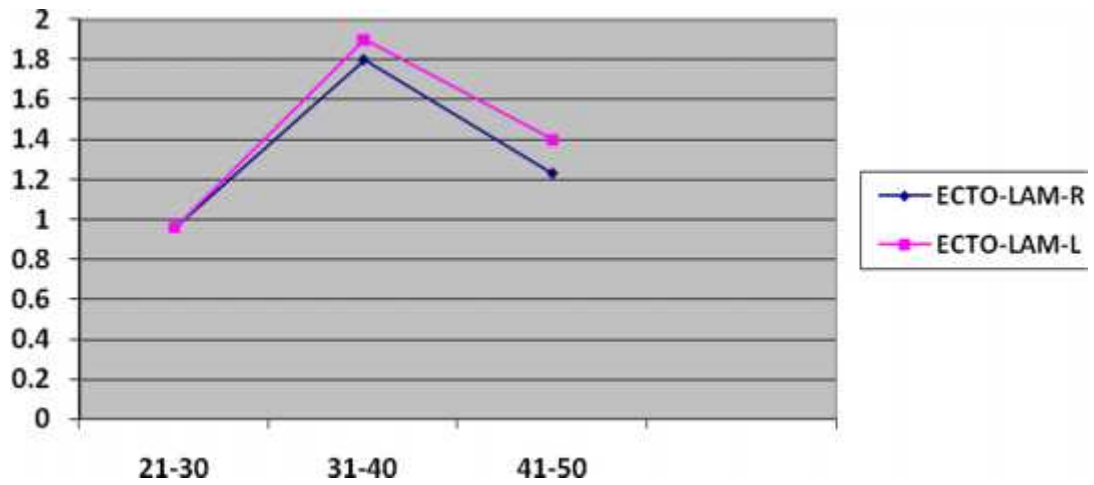
BILATERAL VARIATION IN ENDO-CORONAL SUTURE



In coronal suture right and left side were compared and no significant difference was found. When males and females were considered separately there were no significant difference between right and left side of coronal suture.

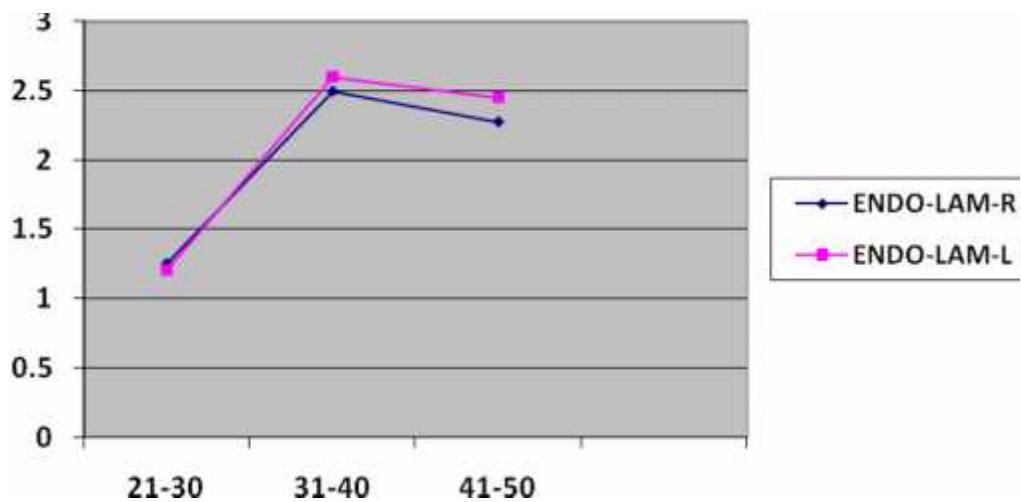
GRAPH-15

BILATERAL VARIATION IN ECTO-LAMDOID SUTURE



GRAPH-16

BILATERAL VARIATION IN ENDO-LAMDOID SUTURE



Right and left side of coronal and lambda suture were compared both ectocranially and endocranially, there were no significant difference after applying student 't' test (P value > 0.05). It implies that there is no bilateral variation in ectocranial and endocranial suture closure. (Graph 13, 14, 15, 16)

Coronal suture

In our study endocranial fusion of coronal suture was observed as early as 20-29 years. Other workers like Pommerol (1869), Topinard (1885), Ribbe (1885) reported closure between 40-50 years. However their study did not indicate whether it was ectocranial or endocranial or it was commencement or termination. In coronal suture, youngest age at which complete union was seen at 20 years endocranially and 28 years ectocranially. There is no significant variation in suture closure of right and left sides of coronal sutures; both ectocranially and endocranially. In coronal suture lower (L) coronal suture closure started early compared to upper (U) coronal suture. Within the coronal suture lower (L) coronal suture appears to fuse much faster compared to upper (U) coronal suture.⁵

Sagittal Suture

In our study we have found that the sagittal suture, endocranially, starts fusing at the end of 20-29 years and this observation confirms to that reported by Todd and Lyon (1924), while it is in contrast to the observation reported by Pommerol (1869) and Topinard (1885), who indicated endocranial commencement of sagittal suture at a much later age at about 40 years. In sagittal sutures S2 closure started early followed by S1 and S3 respectively. Within the sagittal suture S1 appears to fuse much faster and S2 seems to close much slower.³

Lambdoid suture

Lambdoid endocranially, starts fusing at the age of 20-29 years in the present context which shows that it is a year earlier than that reported by Todd and Lyon (1924). The other workers have not reported on lambdoid suture. Our Indian data compares well with those of the male whites (Todd and Lyon 1925). Negro skulls however show an earlier date of commencement and closure. Form the present study

it is clearly evident that endocranial union is a far better parameter for age determination than is the ectocranial union as also has been established by Todd and Lyon (1924 and 1925) and Dwight. All the previous works was done in France, Germany and United States of America under different climatic conditions and in diverse racial groups. In our country the obliteration of the skull sutures in females is some what earlier than that of males. There is no significant variation in suture closure of right and left sides of lambdoid sutures; both ectocranially and endocranially. In lamdoid suture, upper (U) lamdoid suture closure started early compared to lower (L) lamdoid suture. Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture.^{3, 7, 8, 9}

Mckern and Stewart examined 369 skulls from the skeletal remains of the American soldiers between the ages of 17 and 50 years who were killed in North Korean war. They observed that in the youngest age group of 17-18 years containing 55 skulls the incidence of complete or partial obliteration of sutures was sagittal 25%, coronal 1% and lambdoid 8%.²⁵

In the present material all the three main sutures of the skull started closing earlier in the females than in the males. Some workers in USA and India have shown the epiphyses of the long bones fused with the metaphyses earlier in females than in males.²⁶

Todd and Lyon and Hrdlicka have shown that skull sutures closed earlier on the endocranial surface than the ectocranial. They also found the former to be quite often more reliable as the outer sutures had "lapsed union". Neither did they find any gender difference in closure of suture on the two surfaces. Present observations reveal that there is specific difference in the time of closure of sutures on the two surfaces.²⁷

According to Hrdlicka the estimated age from the skull sutures is within 10 years, one or the other from the real age.²⁷

Topinard made some specific observations regarding estimation of age from the extent of obliteration of skull sutures. According to him, if all the sutures were open, the age of the skull was 35 years or less; if the posterior part of the sagittal suture started closing, the age would be about 40 years and if the coronal suture near bregma started closing, the age should be 50 years or more. His observations were contradicted by Dwight and Parsons and Box who showed that suture closure commenced much earlier.²⁸

Dwight examined 100 skulls of Paupers whose ages had been recorded. According to him the sutures start closing under 30 years; closing of sutures almost invariably began on the endocranial surface earlier than ectocranial and variability in suture closure was the rule. He, however, dismissed the suggestion that sutures were worthless in indicating the age of a given skull. Todd and Lyon undertook extensive studies on the time of closure of the skull sutures. They examined male skulls of 307 whites and Negroes and found that in the former, on the outer surface, the sagittal sutures started to close at the age of 22 years and got completely closed at 35 years. The obliteration of the coronal suture commenced at 26 years and got completed by 42 years. The lambdoid suture showed commencement of closure at 26 years and was completely closed at 42 years. Almost similar results were obtained in case of Negro skulls. They excluded from their study 40 white and 41 black skulls as in those specimens suture closure did not fit a definite trend of progress. Their principal of rejecting "irregular" specimens was criticized by Cobb as this rejection was responsible for the subsequent workers not being able to endorse the observation of Todd and Lyon.²⁹

Perizonius studied the time of suture closure in 174 male and 82 female skulls of non-Jewish inhabitants of Amsterdam whose ages were between 20 and 99 years. He examined the sutures endocranially by introducing a small lamp through the foramen magnum. He did not find any difference in the time of closure of the sutures in both the sexes or on both the surfaces. According to him, the obliteration of sutures was related to age in the age group of 20-49 years but not thereafter. Validity of his observations is questionable as it is not possible to observe the lateral parts of the lambdoid sutures endocranially by the procedure followed by him.³⁰

Obliteration of skull sutures in late age, practically when all the teeth have erupted and epiphysis have fused i.e. after 21 years of age, is one of the methods to determine age but the results are only in decades. Many authors have pointed to discrepancies and some have consequently doubted the reliability of suture closure as an age indicator. However, none of these critics abandoned the starting point that if any correlation with age at death existed, it had to be a positive one. This is even more noteworthy because in several publications, the phenomenon of extremely old individuals with many open sutures is discussed. There are, for example, the crania of four Dutchmen, aged over hundred years, but with open sutures, described by J.B. Davis, and many others like Powers & Bolk. The above results suggest that these aged individuals with open sutures may become thinner, but sutures once closed, do not open again. The question forces itself whether selection does occur? Do individuals with open sutures have more chance to grow old? And if so, to what extent do similar selective mechanisms occur in relation to other age indicators?³³

CONCLUSION

In the present study we tried the possibilities for suture closure to contribute to one of the essential foundations of Paleodemography: age estimation. It is evident that, before several age indicators are combined into complex methods, as much information as possible about the separate age indicators has to be accumulated. This information can be obtained only by investigating skeletal material of known age as done in our study.

- 1) Suture obliteration starts earlier on endocranial surface than on the ectocranial surface.
- 2) There is significant variation in suture closure in male and female (Females showed earlier union than males).
- 3) There is no significant variation in suture closure of right and left sides of coronal and lambdoid sutures, both ectocranially and endocranially.
- 4) Endocranially and Ectocranially- coronal suture closes earlier followed by sagittal and lambdoid.
- 5) Ectocranially sagittal suture S2 closure started early followed by S1 and S3 respectively. Within the sagittal suture S1 appears to fuse much faster, S2 seems to close much slower. In coronal suture, lower (L) coronal suture closure started early compared to upper (U) coronal suture. Within the coronal suture, lower (L) coronal suture appears to fuse completely much faster compared to upper (U) coronal suture.
- 6) Endocranially sagittal suture S2 closure started early followed by S1 and S3 respectively. Within the sagittal suture S1 appears to fuse much faster, S3 seems to close much slower. In coronal suture lower (L) coronal suture closure started early compared to upper (U) coronal suture. Within the coronal suture lower (L) coronal suture appears to fuse completely much faster compared to upper (U) coronal suture.
- 7) In lamdoid suture, upper (U) lamdoid suture closure started early compared to

CONCLUSION

lower (L) lamdoid suture. Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture.

8) Metopism was observed in 1% of cases.

Our analyses strengthen the view that, there is a significant relationship between suture closure and age. But whatever the underlying biological factors are for suture closure and even if there in the future it should be better understood. It is still important to refine the methods of quantifying these structures, in order to render the methods of quantification as unbiased as possible.

In this study, all the cases brought for post-mortem examination at mortuary of KLEs PRABHAKAR KORE HOSPITAL AND MRC, BELGAUM between 1st November 2008 to 31st October 2009 has been studied.

- 1) Suture obliteration starts earlier on endocranial surface than on the ectocranial surface.
- 2) Females showed earlier union than males.
- 3) There is no significant variation in suture closure of right and left sides of coronal and lambdoid sutures, both ectocranially and endocranially.
- 4) Endocranially and Ectocranially- coronal suture closes earlier followed by sagittal and lambdoid.
- 5) Ectocranially sagittal suture S2 closure started early followed by S1 and S3 respectively. Within the sagittal suture S1 appears to fuse much faster, S2 seems to close much slower. In coronal suture, lower (L) coronal suture closure started early compared to upper (U) coronal suture. Within the coronal suture, lower (L) coronal suture appears to fuse completely much faster compared to upper (U) coronal suture.
- 6) Endocranially sagittal suture S2 closure started early followed by S1 and S3 respectively. Within the sagittal suture S1 appears to fuse much faster, S3 seems to close much slower. In coronal suture lower (L) coronal suture closure started early compared to upper (U) coronal suture. Within the coronal suture lower (L) coronal suture appears to fuse completely much faster compared to upper (U) coronal suture.
- 7) In lamdoid suture, upper (U) lamdoid suture closure started early compared to lower (L) lamdoid suture. Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture.
- 8) Metopism was observed in 1% of cases.

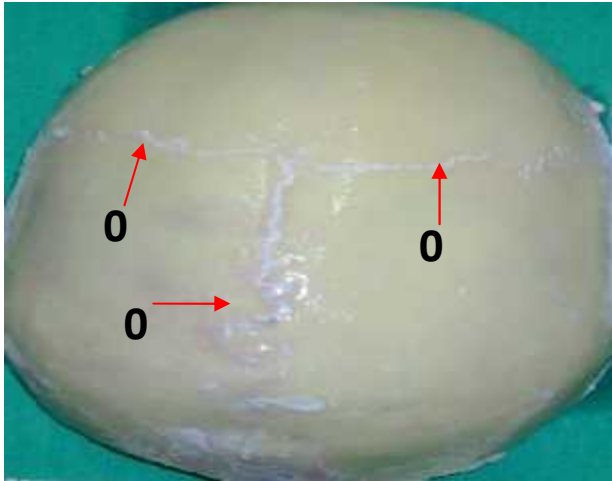
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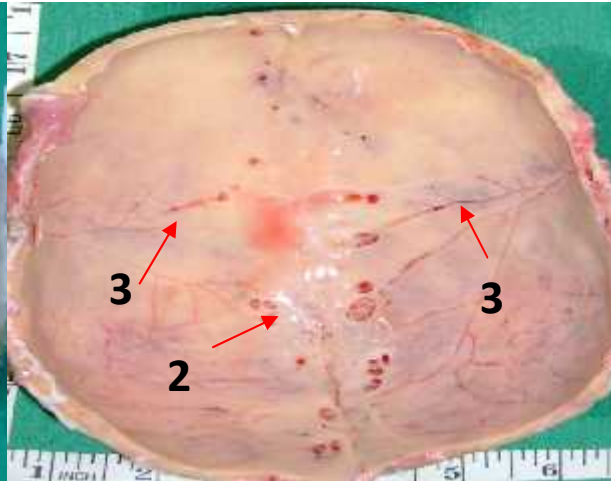
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CASE-1



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

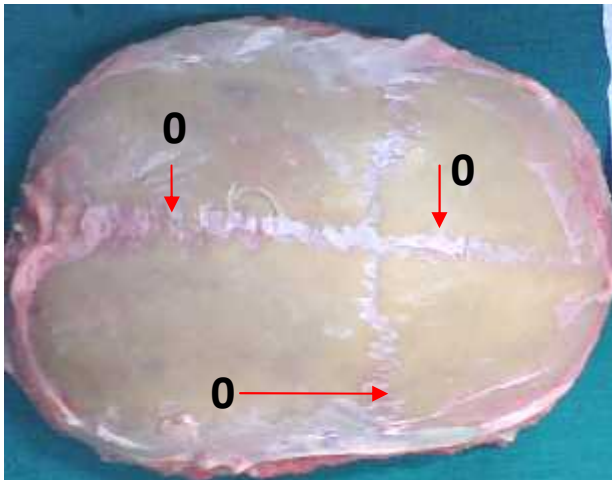


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

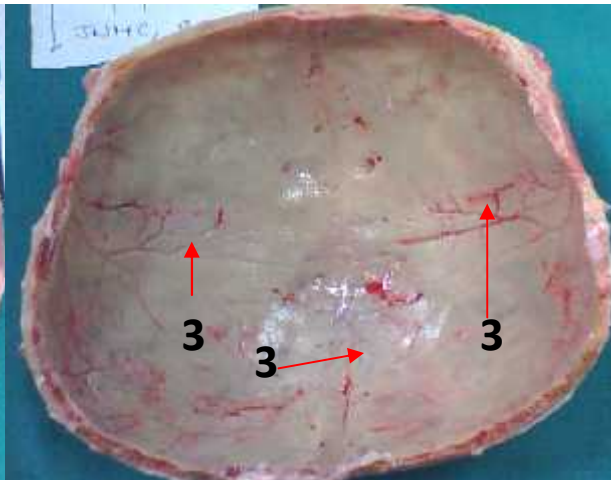


LAMDOID SUTURES (ENDOCRANIAL)

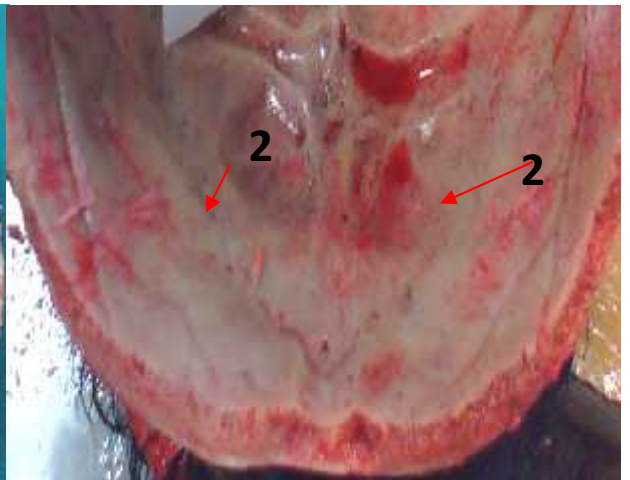
CASE-2



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



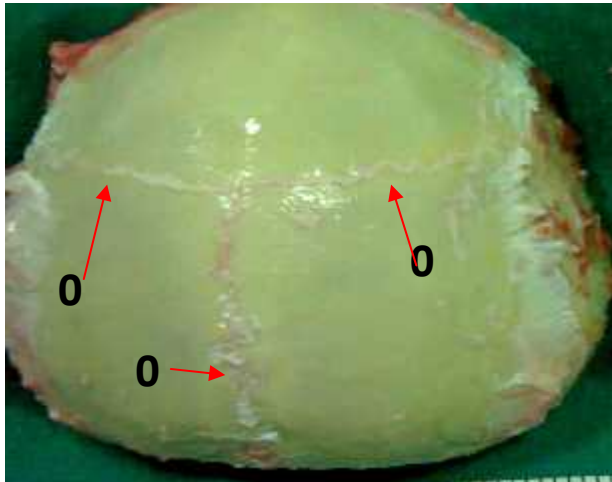
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



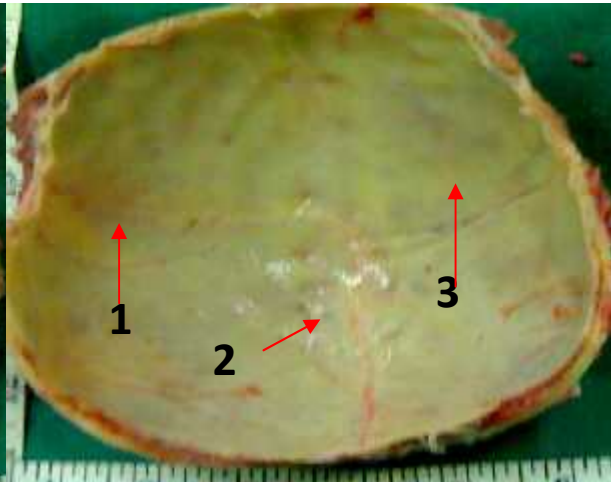
LAMDOID SUTURES (ENDOCRANIAL)

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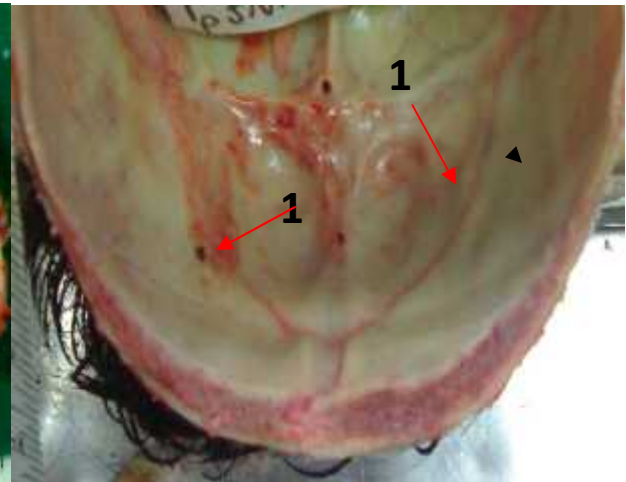
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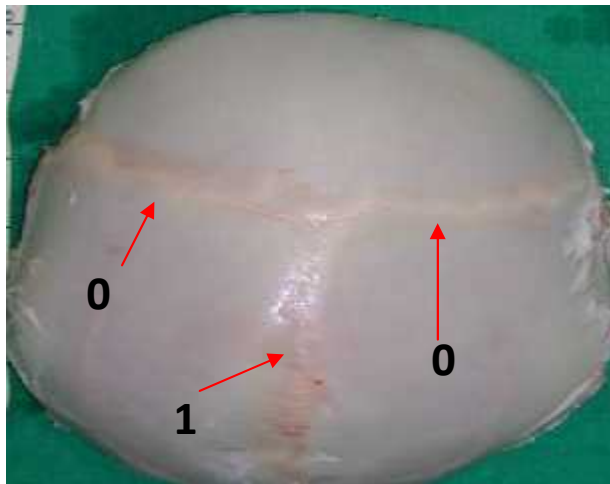


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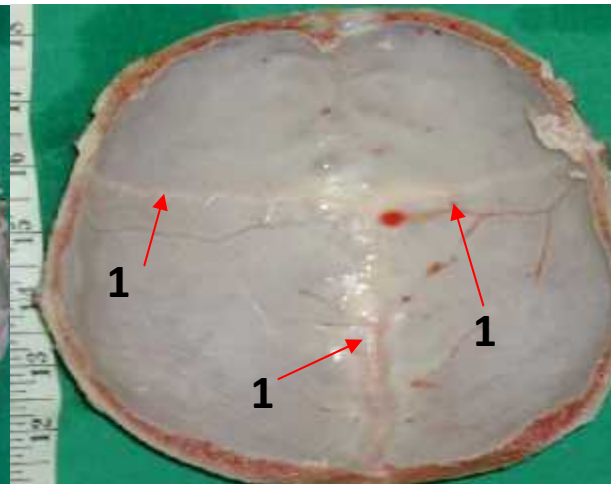


LAMDOID SUTURES (ENDOCRANIAL)

CASE-4



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



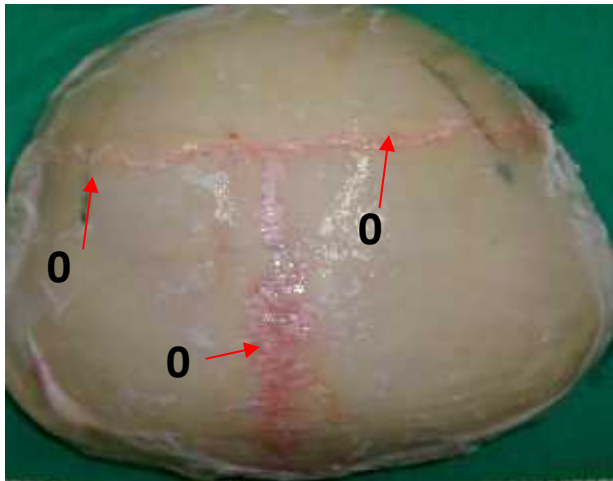
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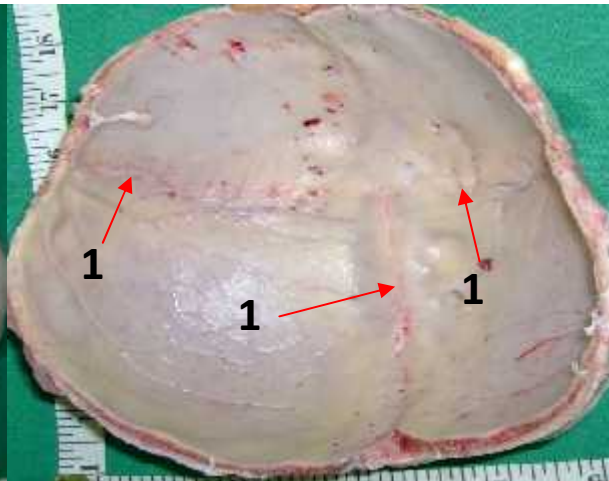
LAMDOID SUTURES (ENDOCRANIAL)

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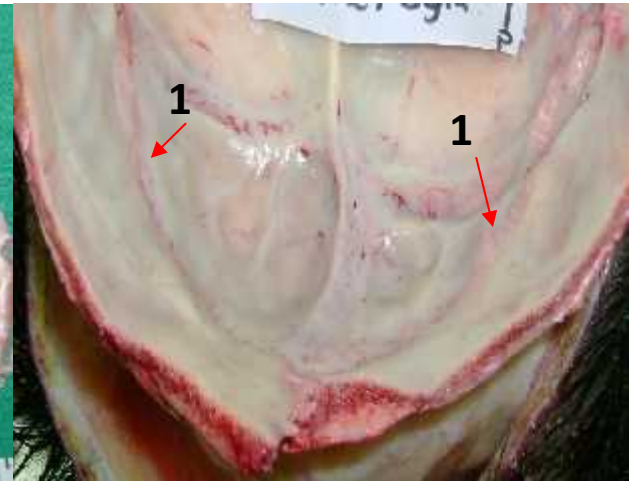
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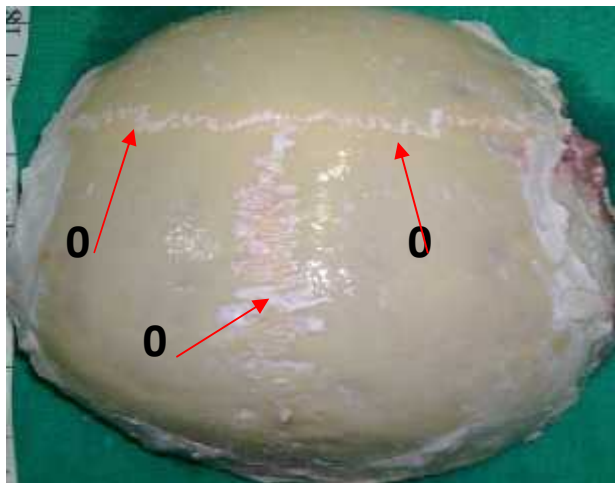


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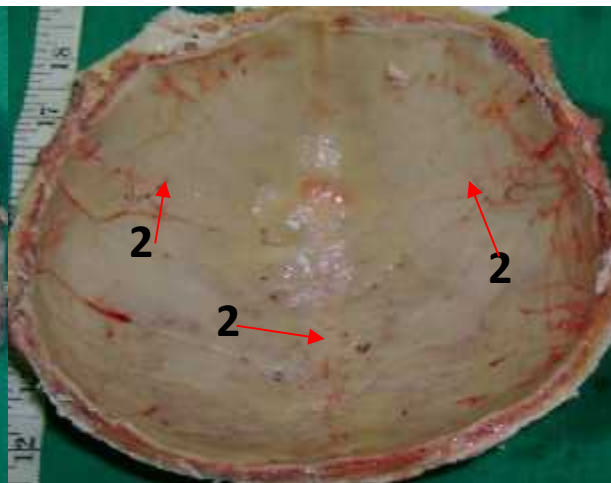


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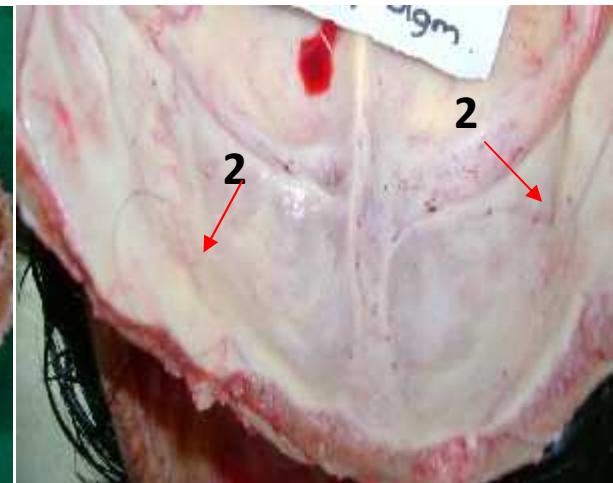
CASE-6



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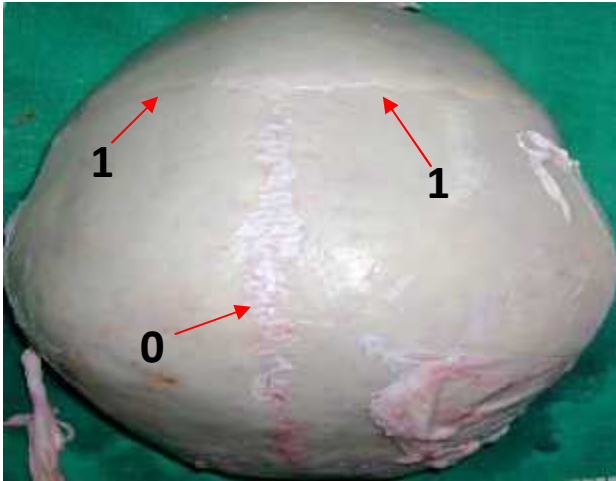
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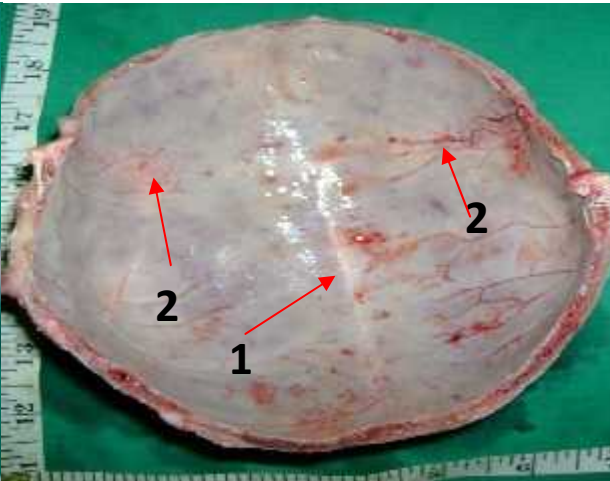
LAMDROID SUTURES (ENDOCRANIAL)

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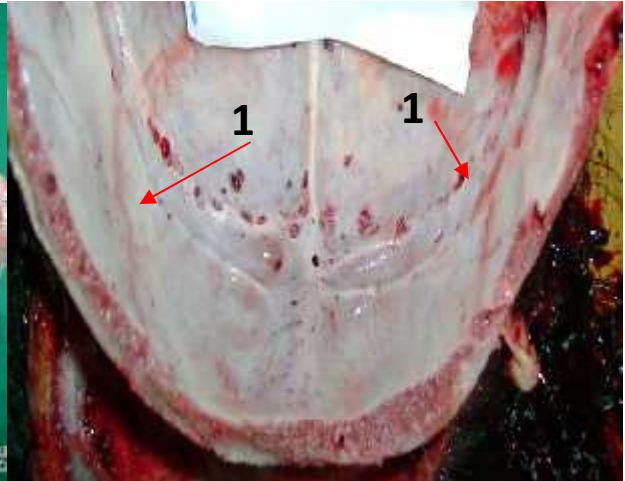
CASE-7



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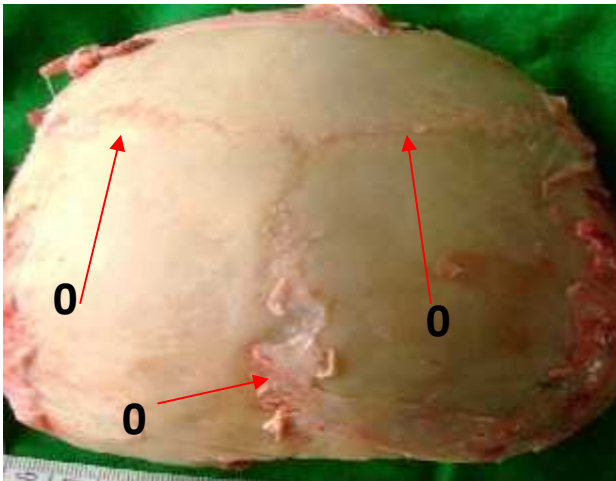


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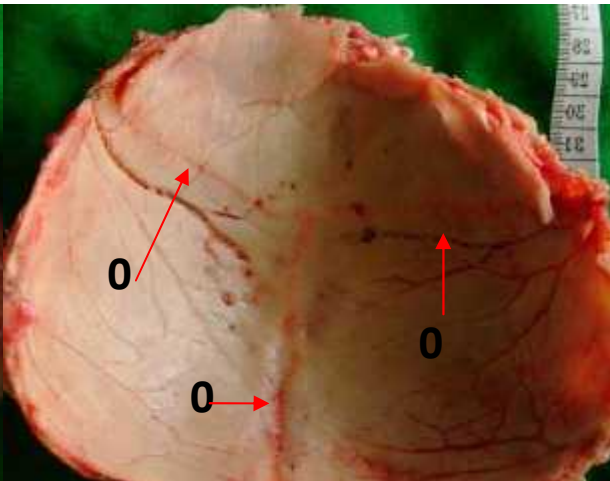


LAMDROID SUTURES (ENDOCRANIAL)

CASE-8



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



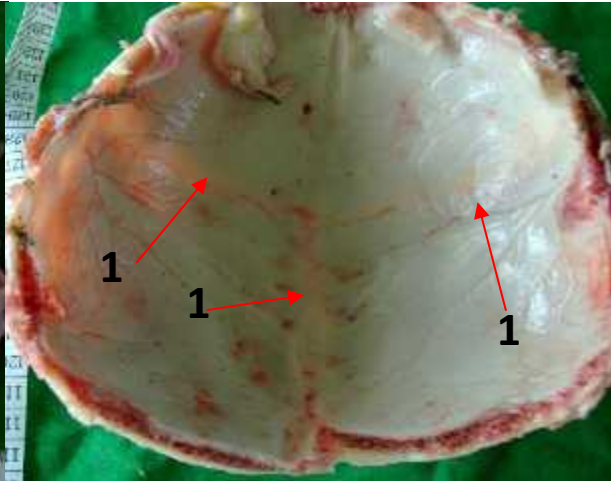
LAMDROID SUTURES (ENDOCRANIAL)

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CASE-9



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

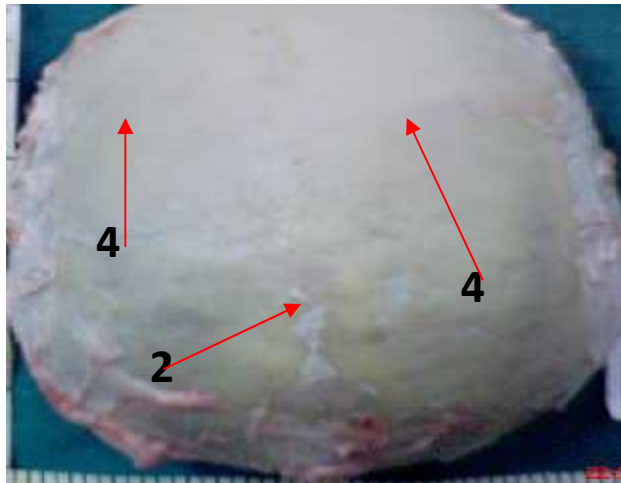


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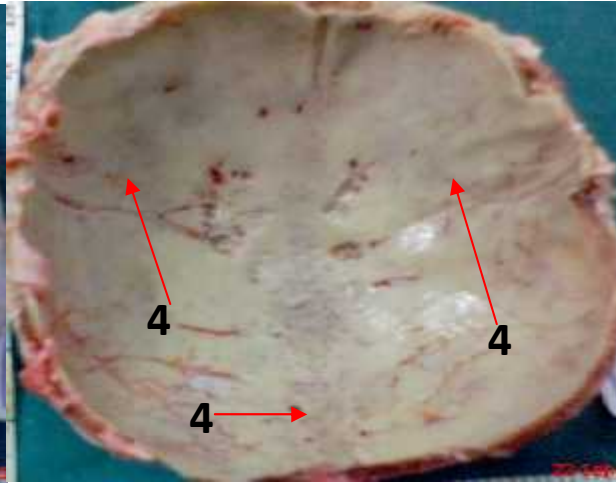


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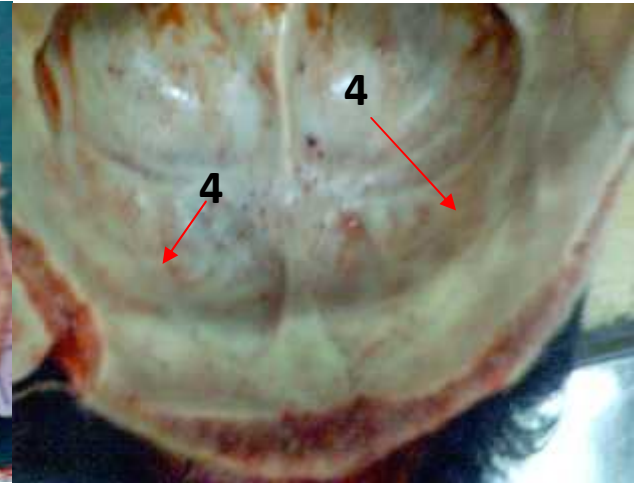
CASE-10



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



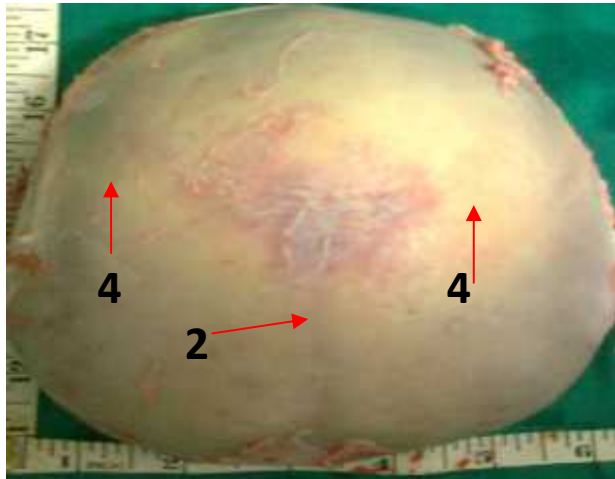
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



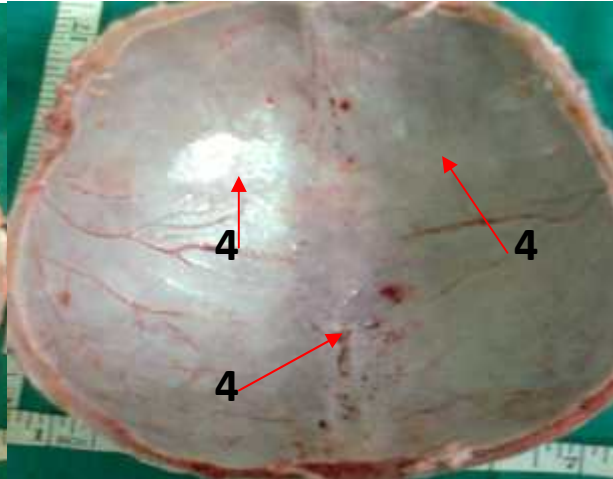
LAMDROID SUTURES (ENDOCRANIAL)

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CASE-11



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

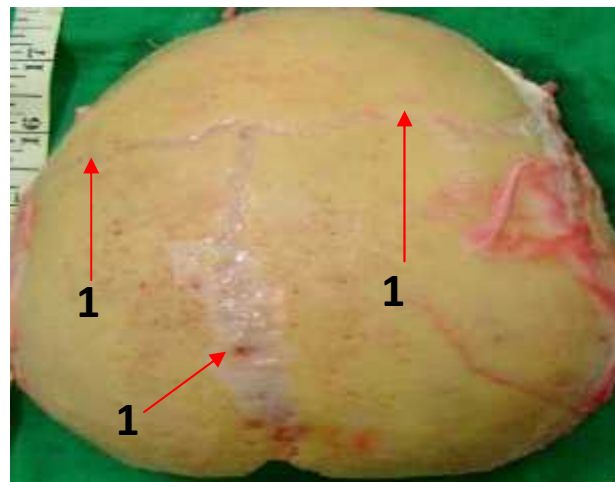


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

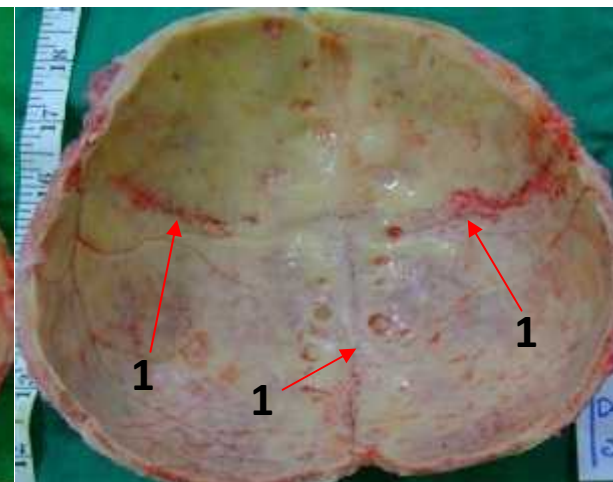


LAMDOID SUTURES (ENDOCRANIAL)

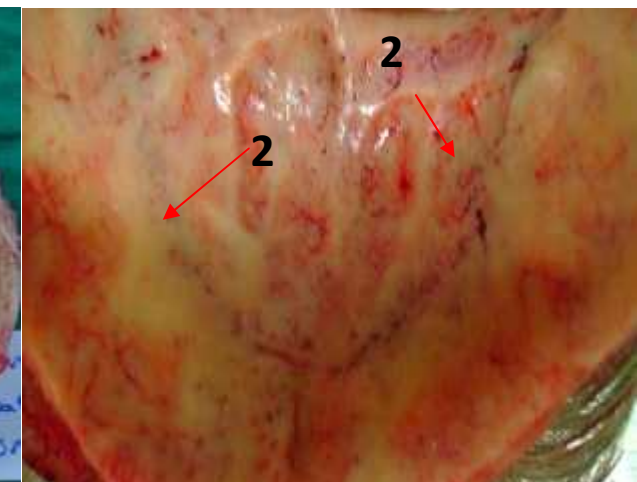
CASE-12



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



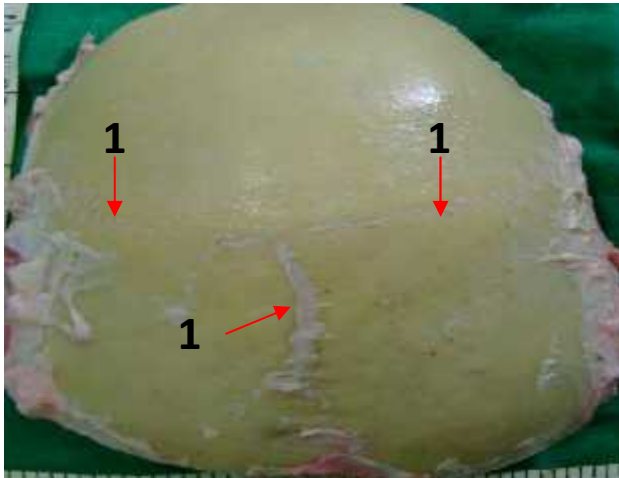
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



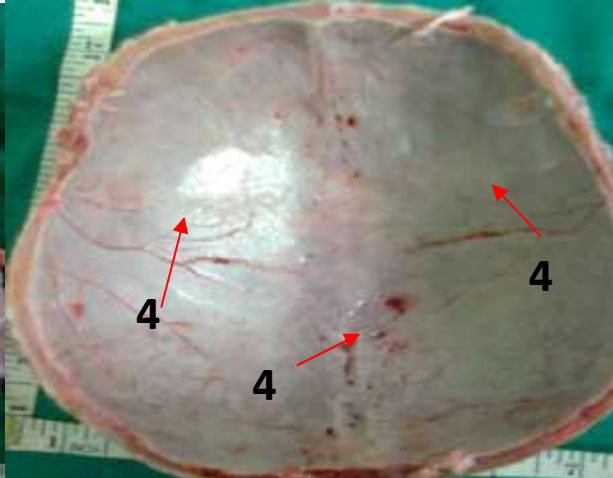
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

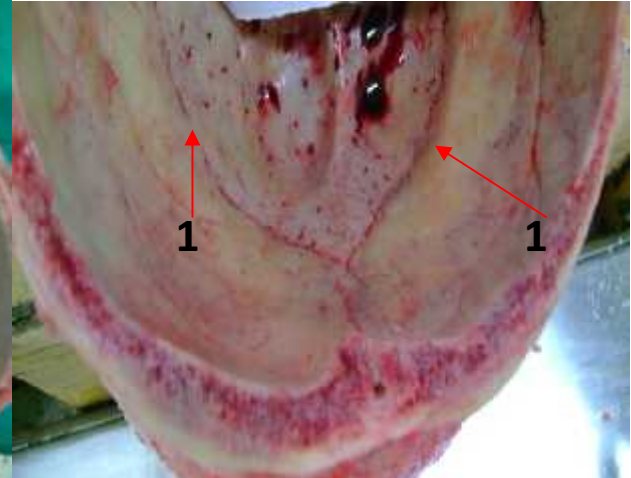
CASE-13



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

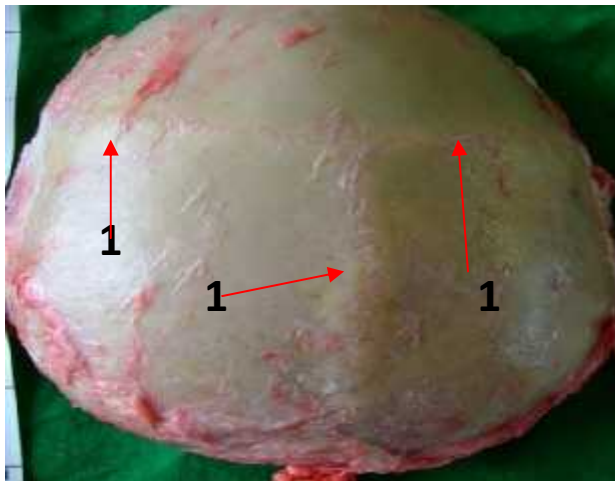


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

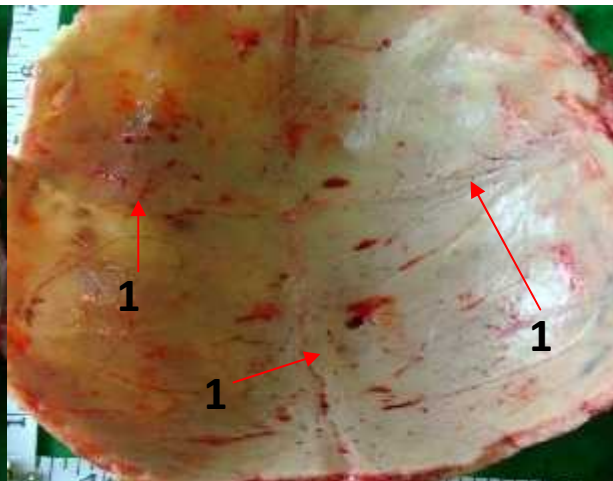


LAMDROID SUTURES (ENDOCRANIAL)

CASE-14



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



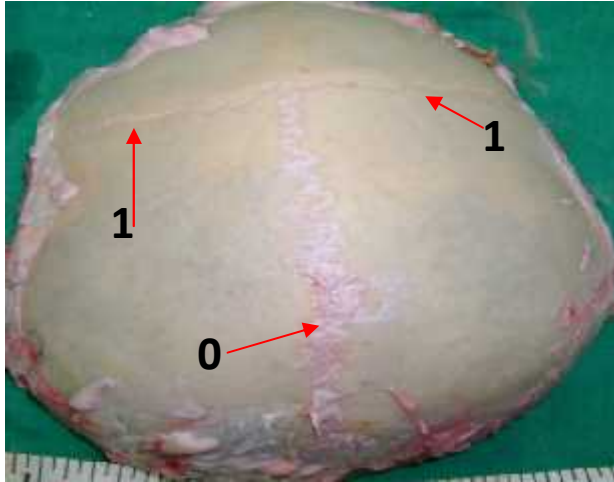
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



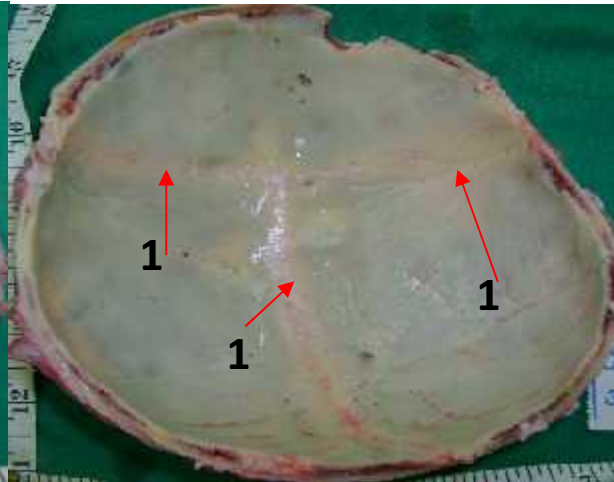
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

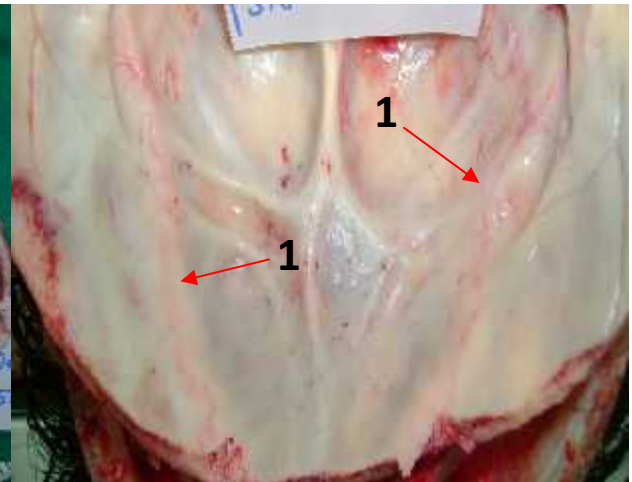
CASE-15



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

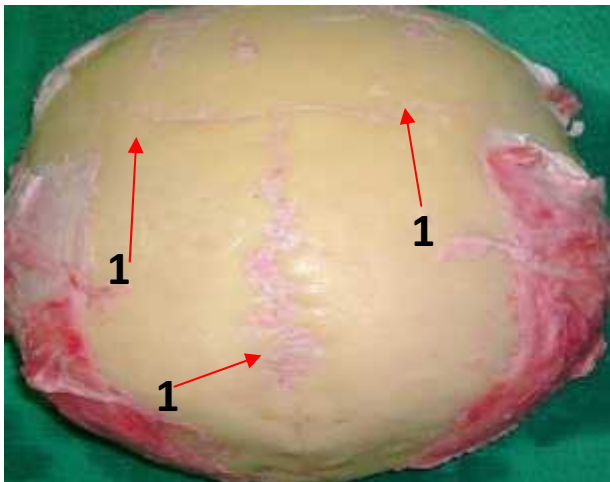


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

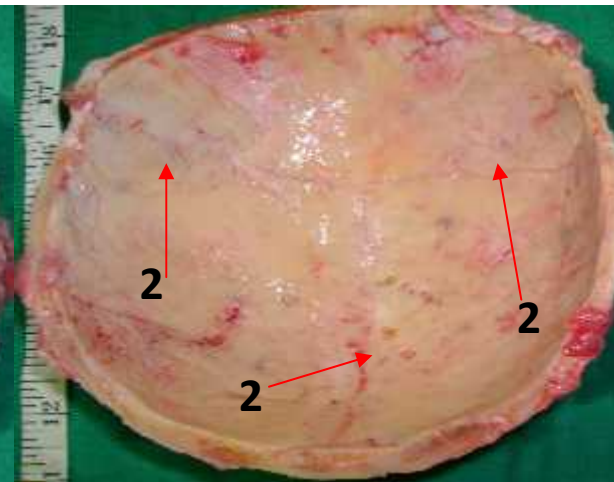


LAMDROID SUTURES (ENDOCRANIAL)

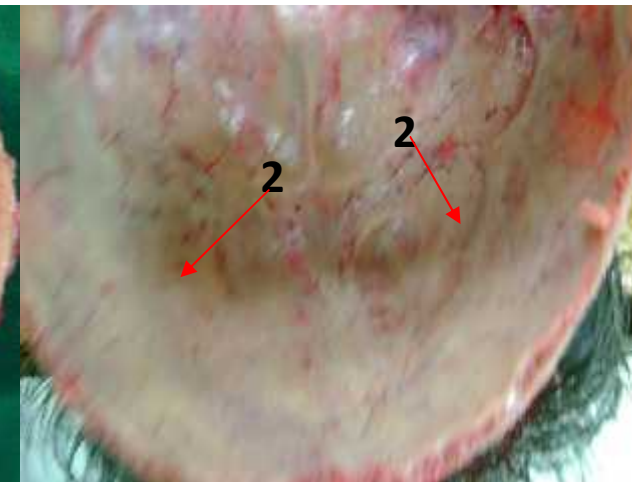
CASE-16



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



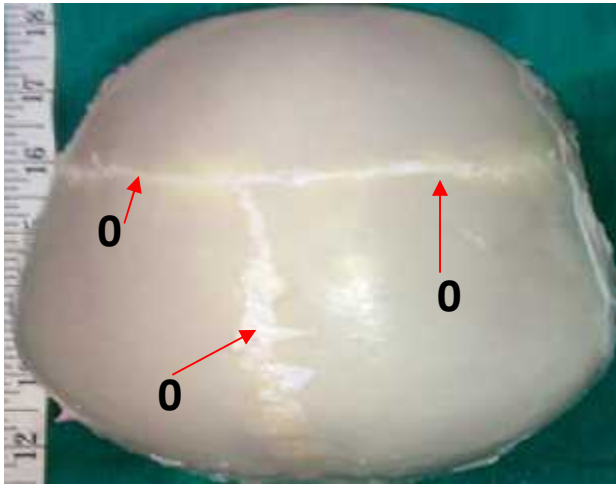
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



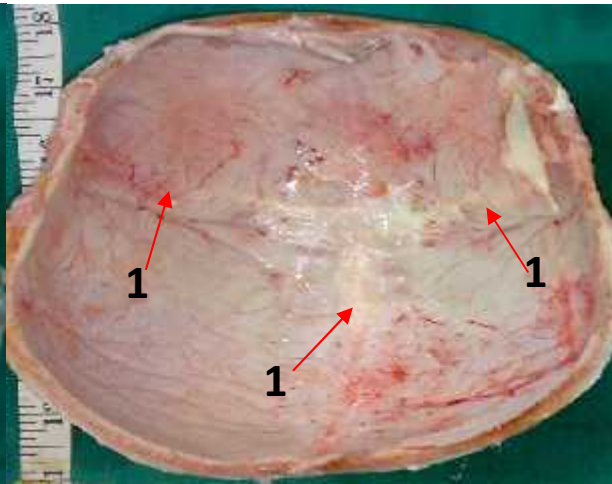
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

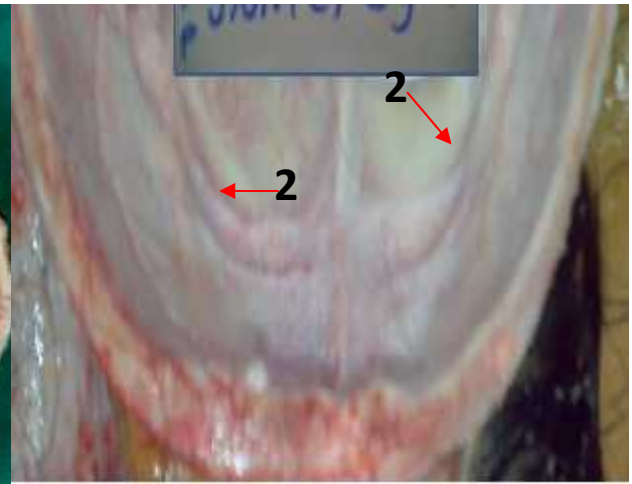
CASE-17



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

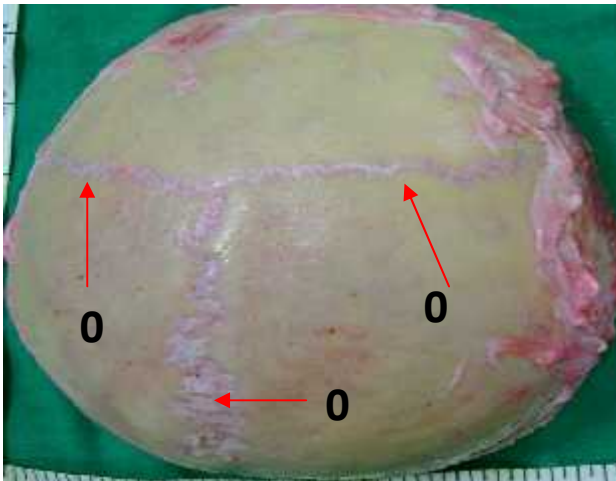


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

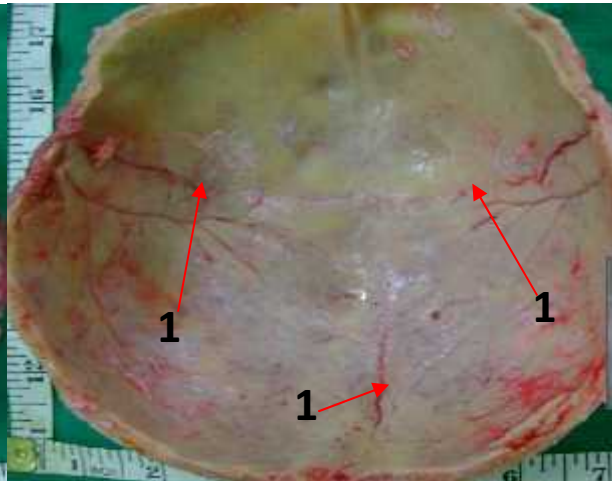


LAMDROID SUTURES (ENDOCRANIAL)

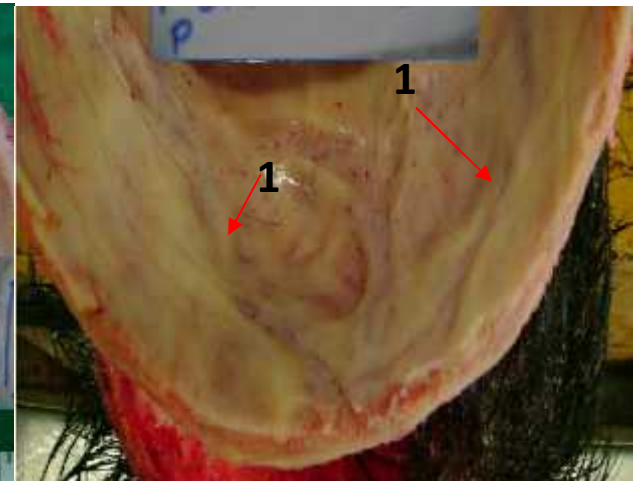
CASE-18



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



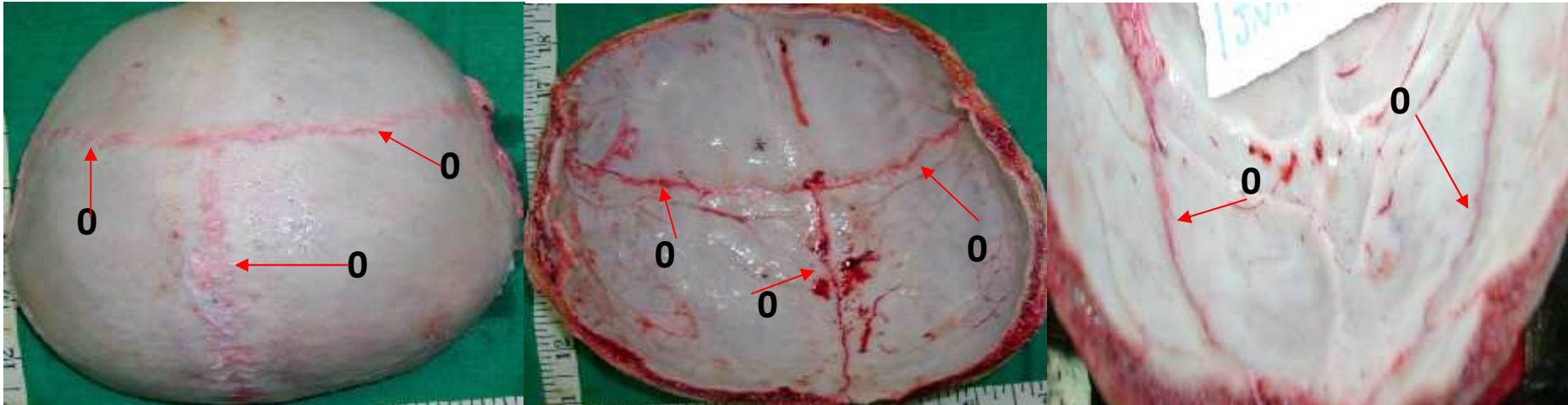
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-19

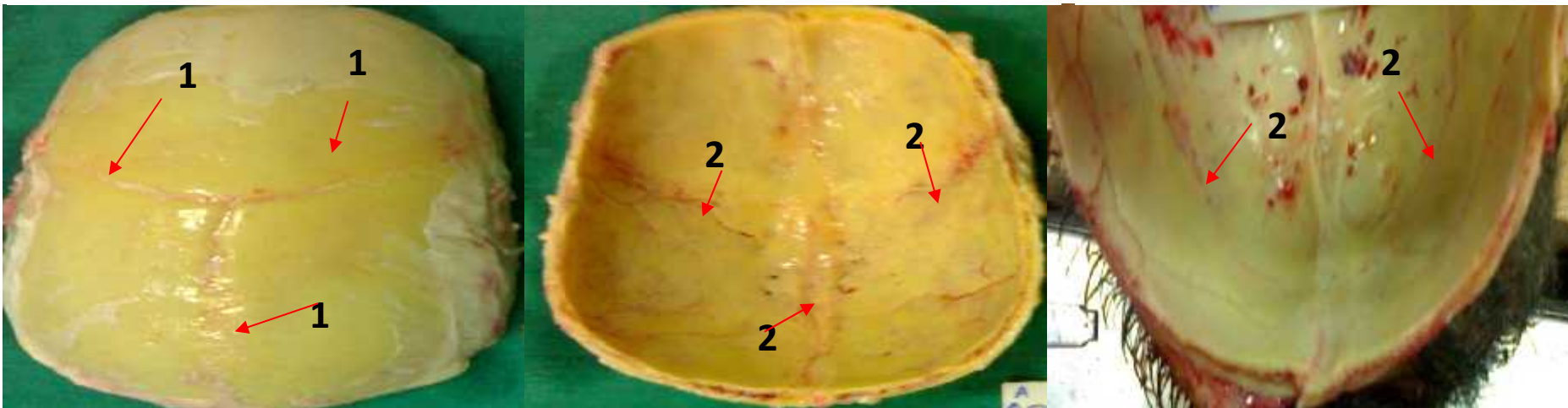


CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

LAMDROID SUTURES (ENDOCRANIAL)

CASE-20



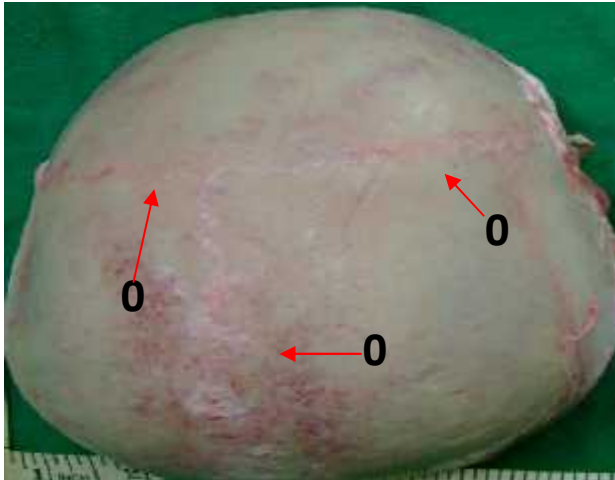
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

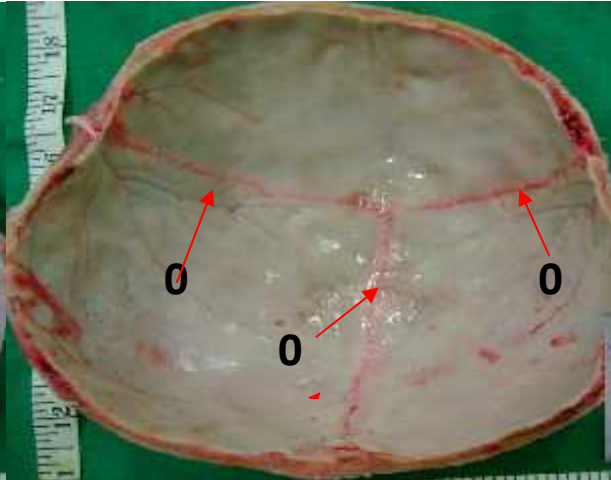
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

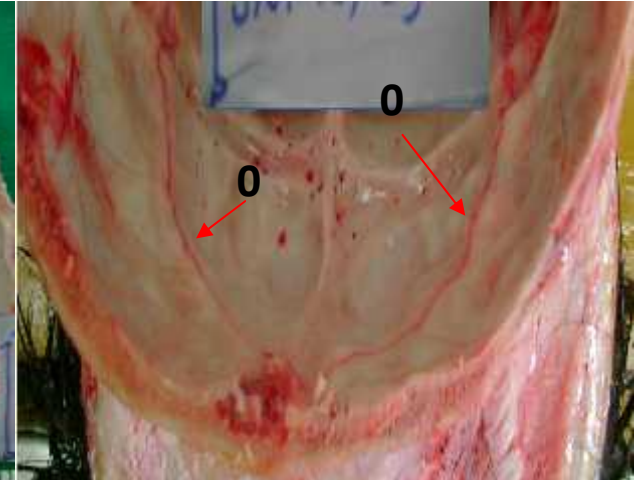
CASE-21



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

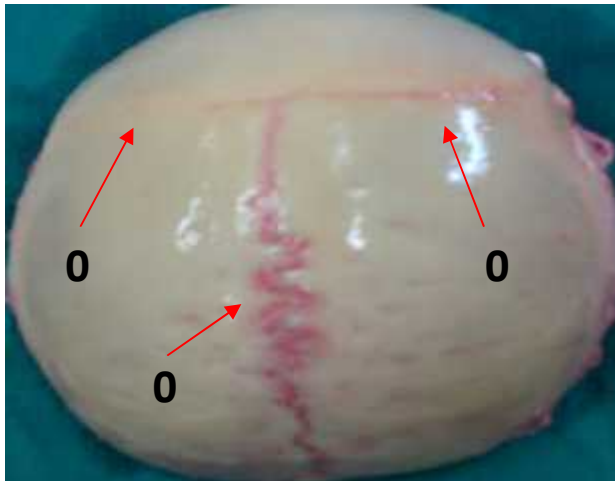


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

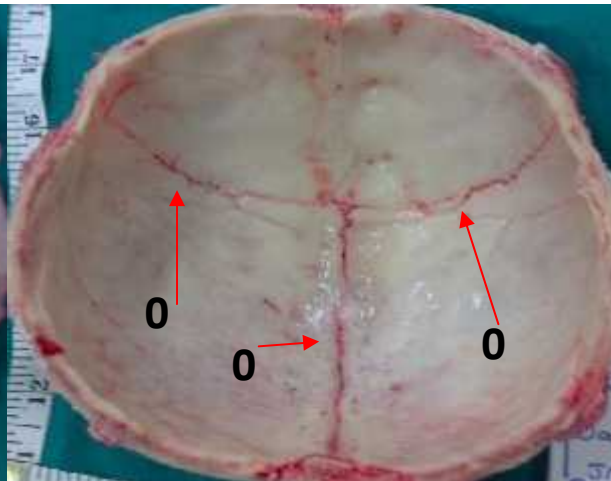


LAMDROID SUTURES (ENDOCRANIAL)

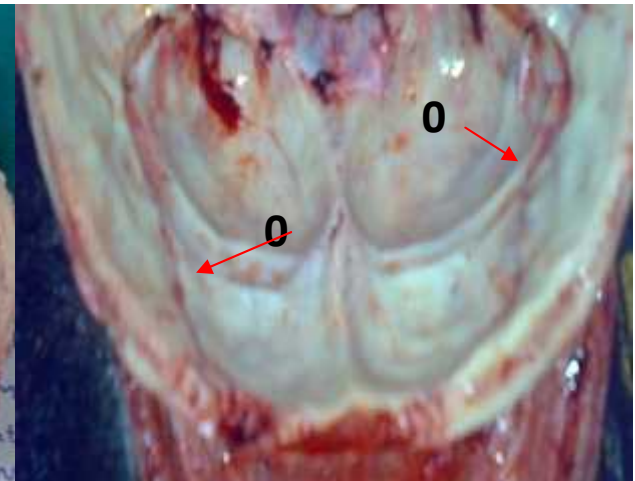
CASE-22



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



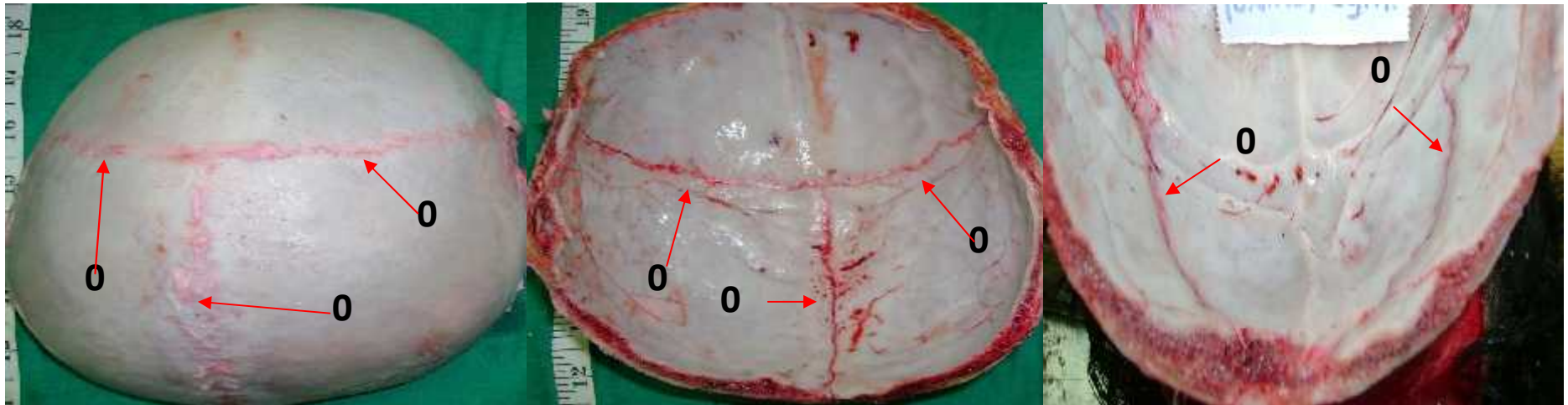
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-23

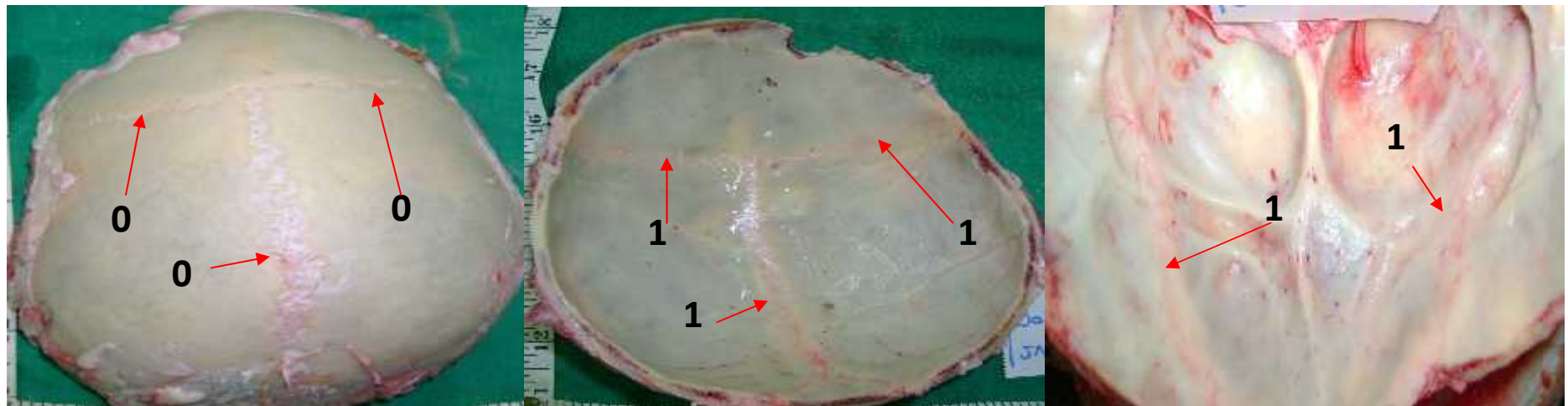


CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

LAMDOID SUTURES (ENDOCRANIAL)

CASE-24



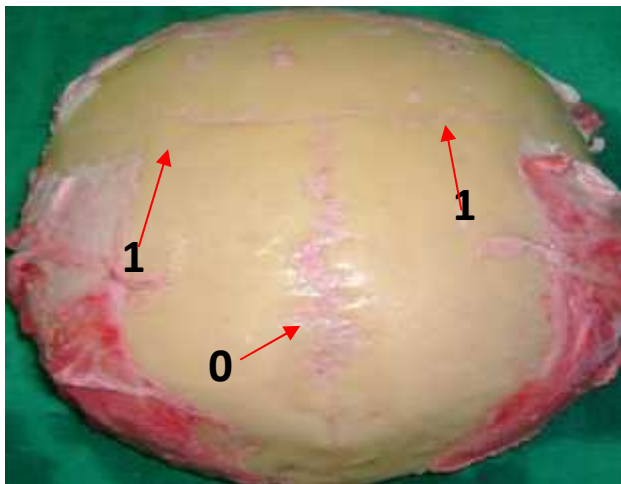
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

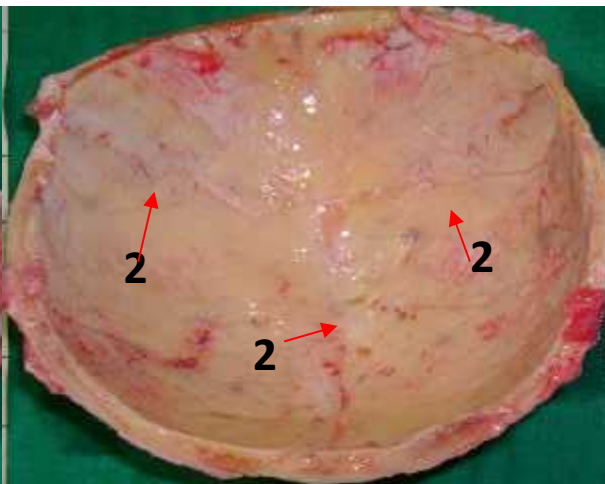
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

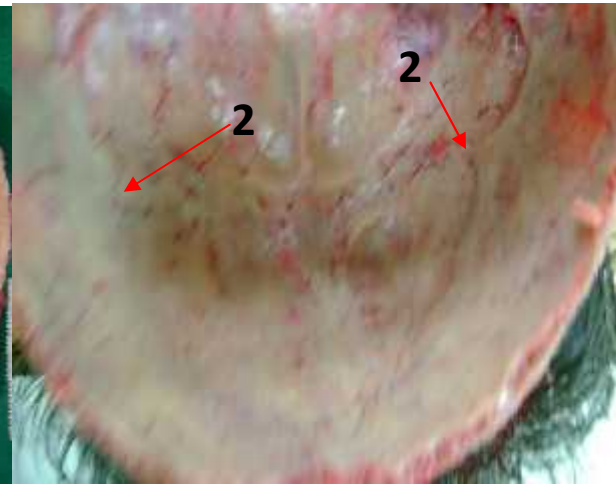
CASE-25



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

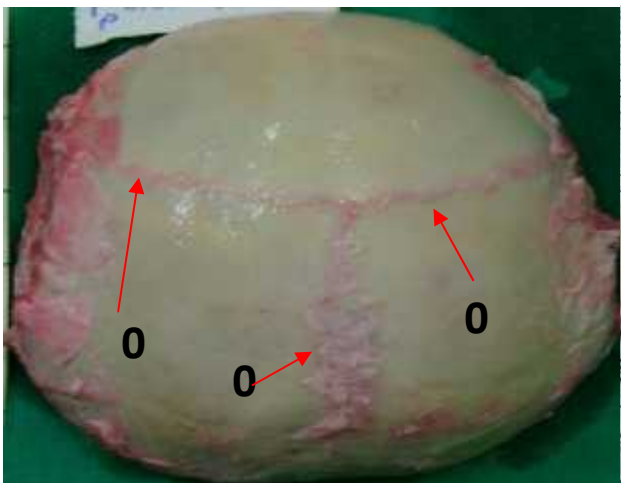


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

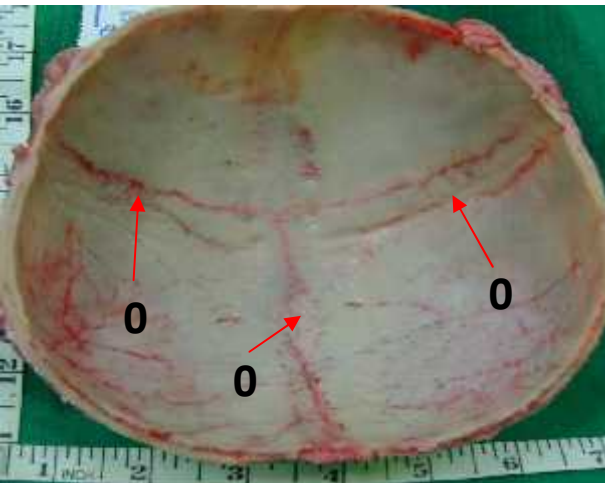


LAMDOID SUTURES (ENDOCRANIAL)

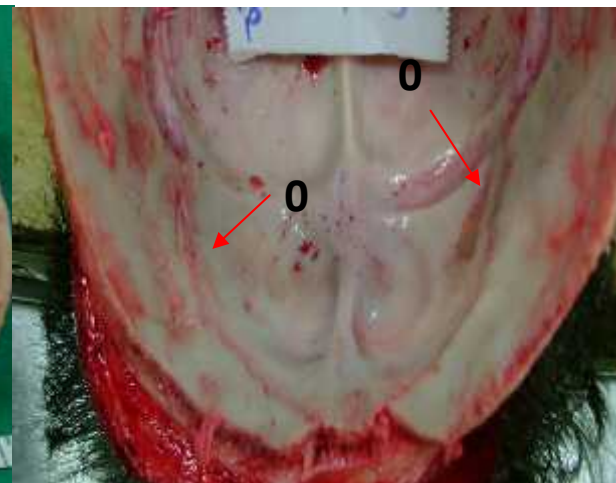
CASE-26



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



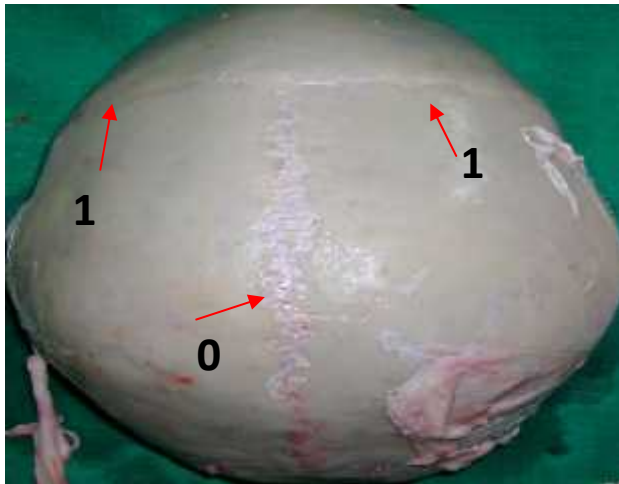
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



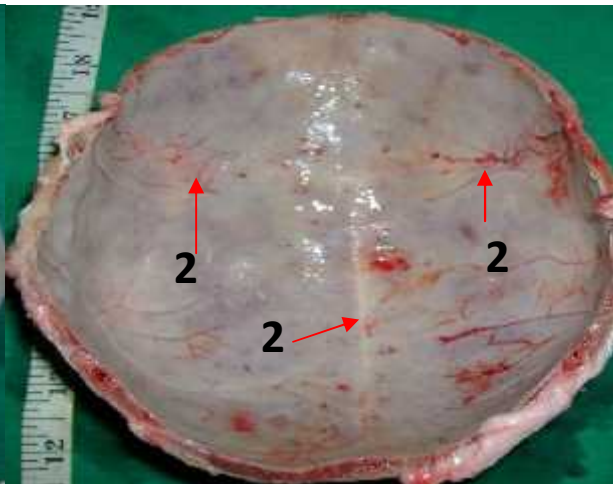
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

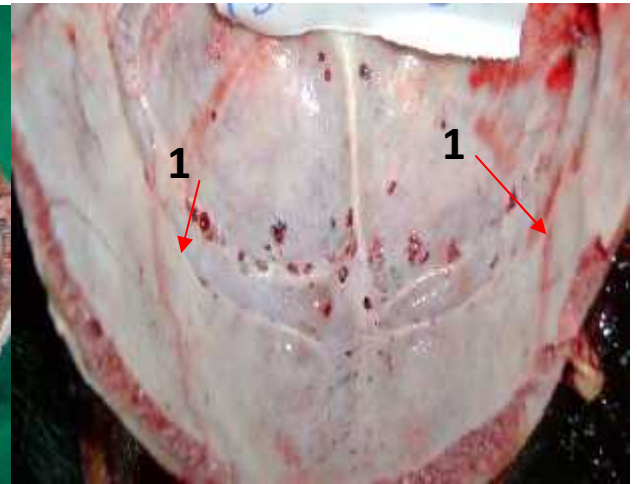
CASE-27



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

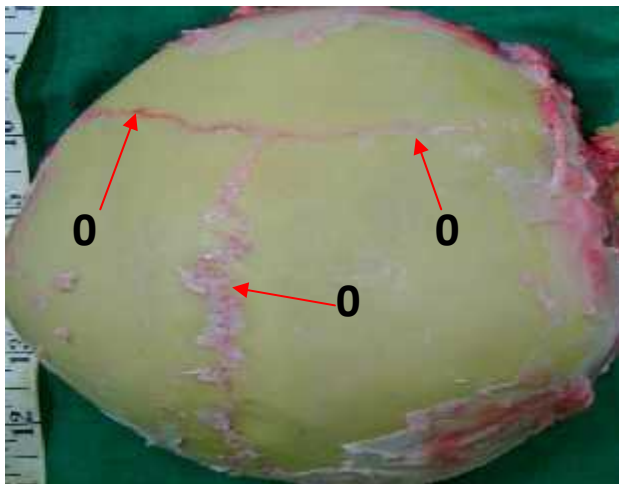


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

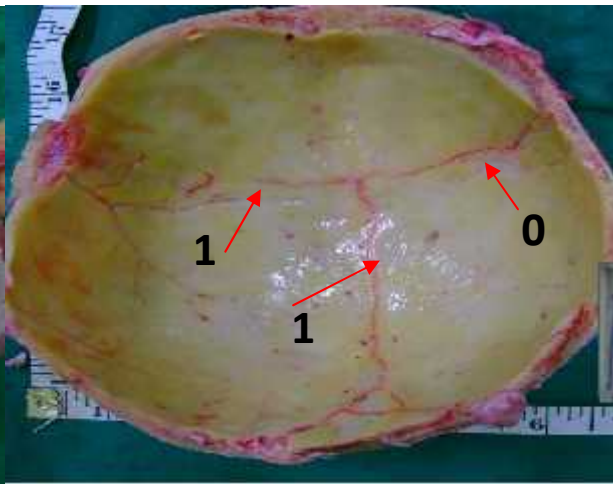


LAMDROID SUTURES (ENDOCRANIAL)

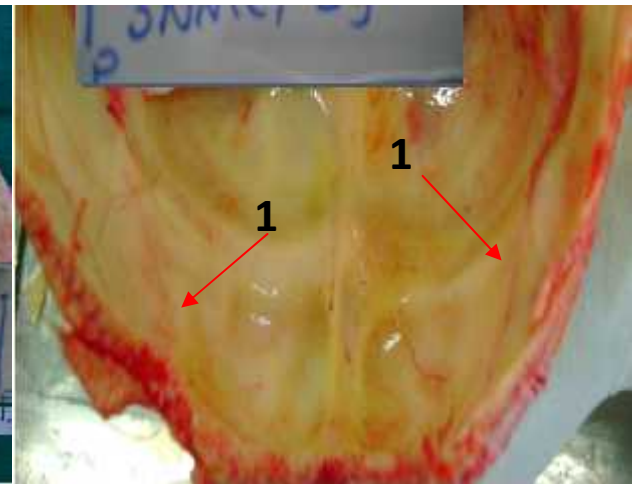
CASE-28



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



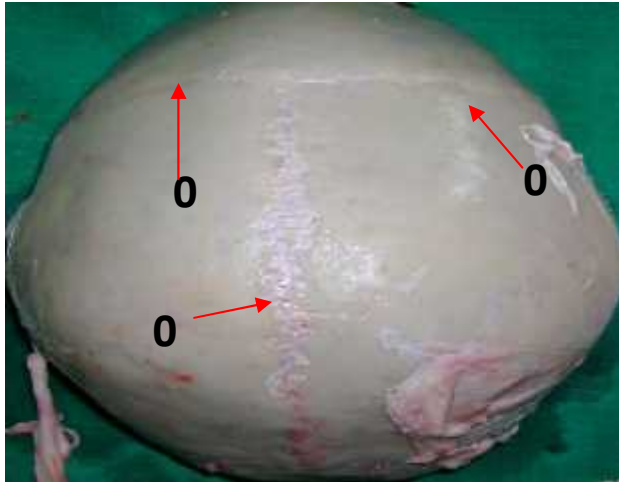
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



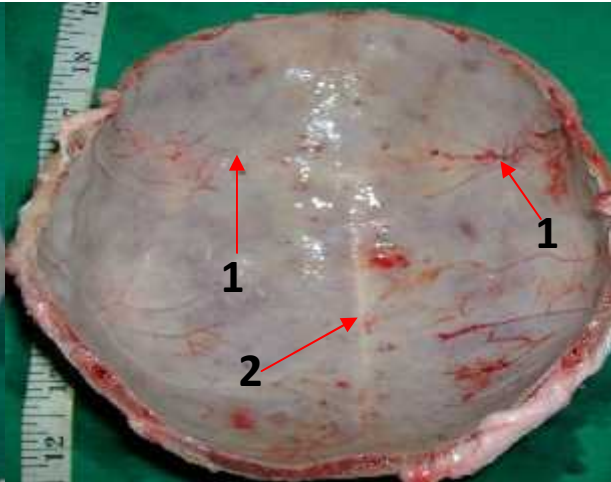
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

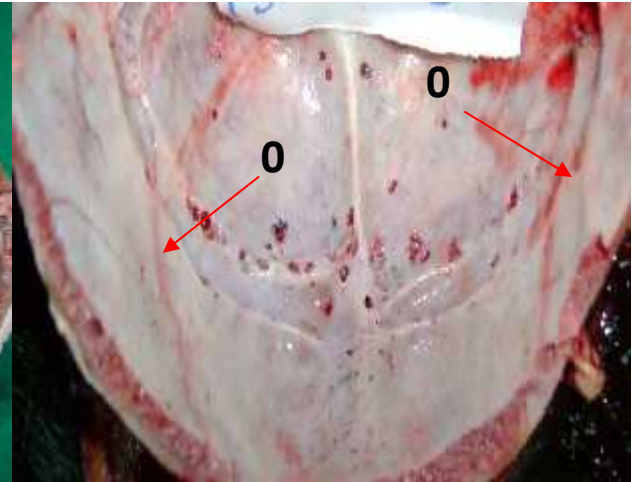
CASE-29



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

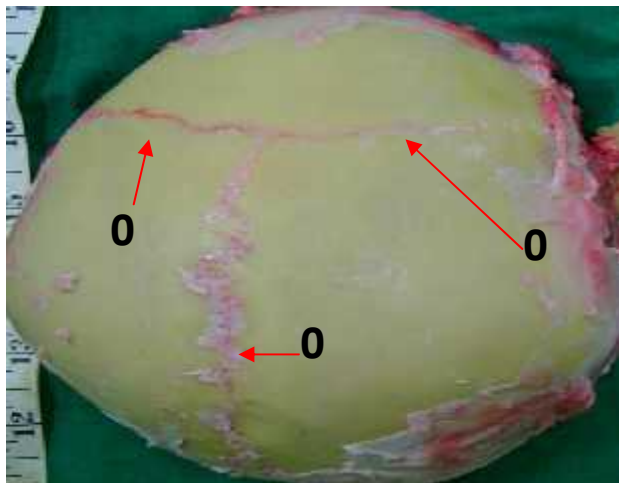


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

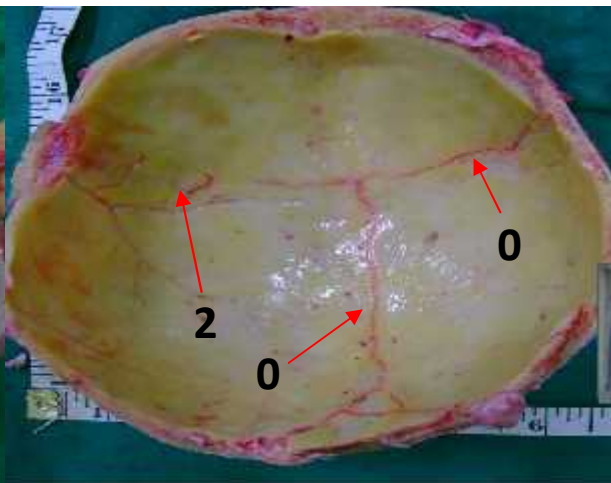


LAMDOID SUTURES (ENDOCRANIAL)

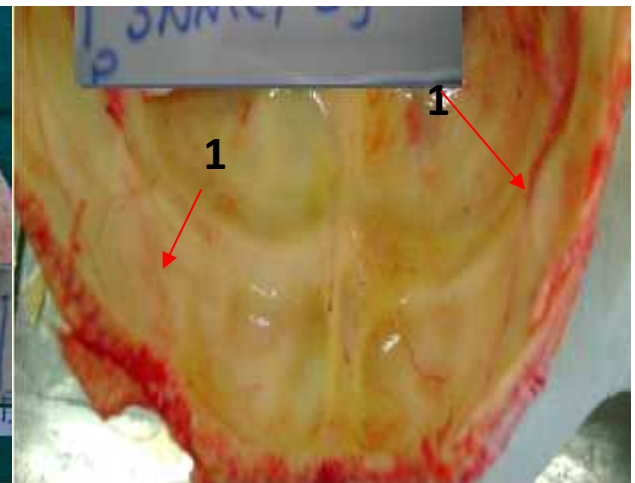
CASE-30



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



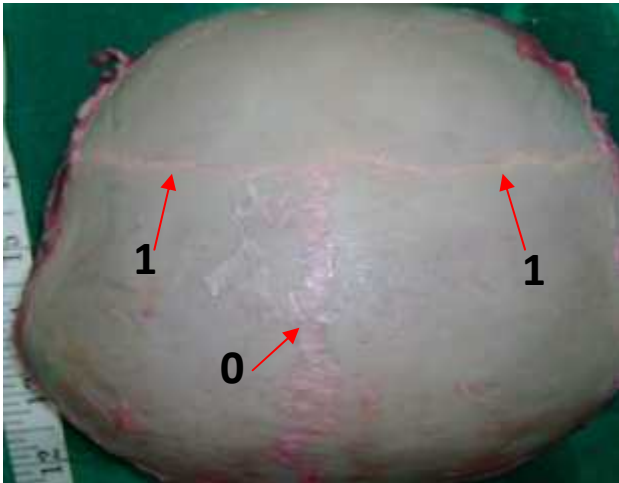
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



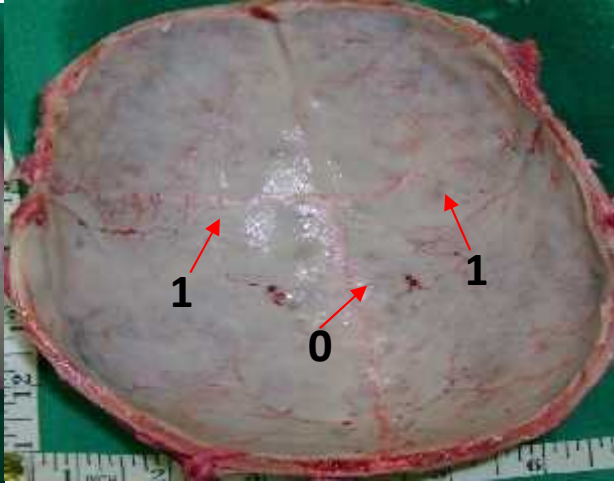
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

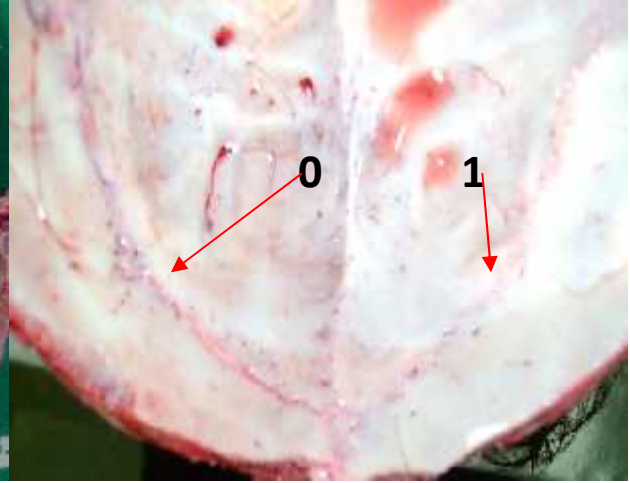
CASE-31



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

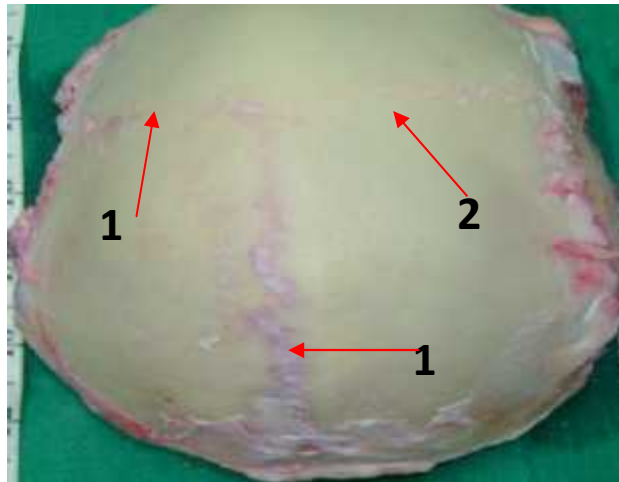


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

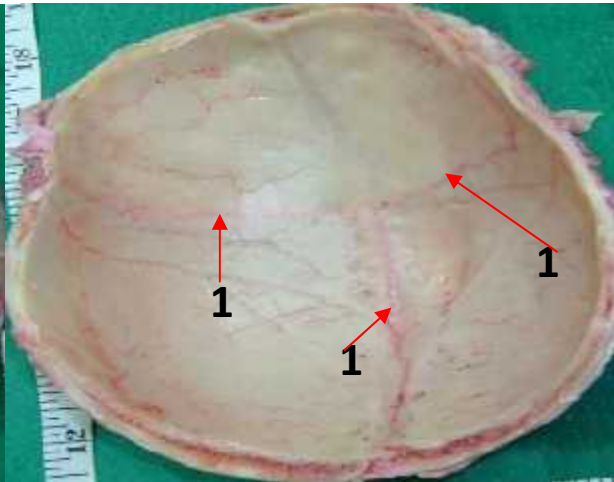


LAMDOID SUTURES (ENDOCRANIAL)

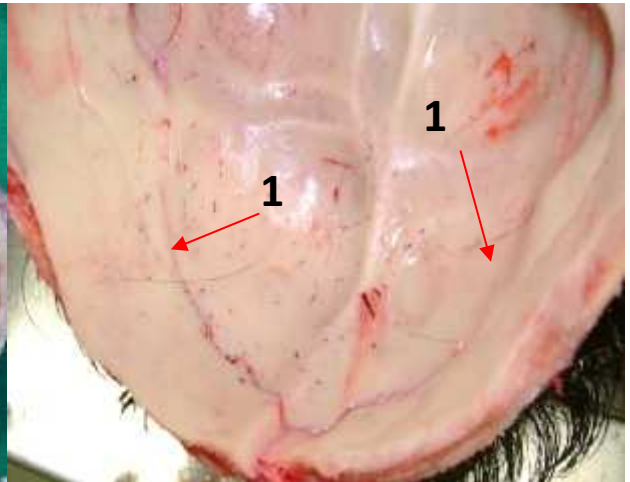
CASE-32



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



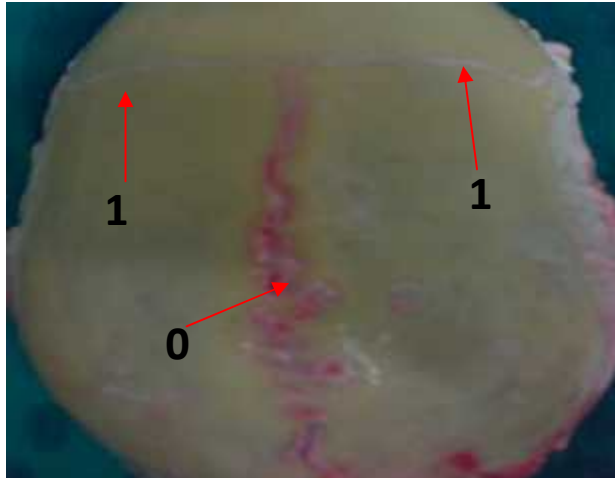
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



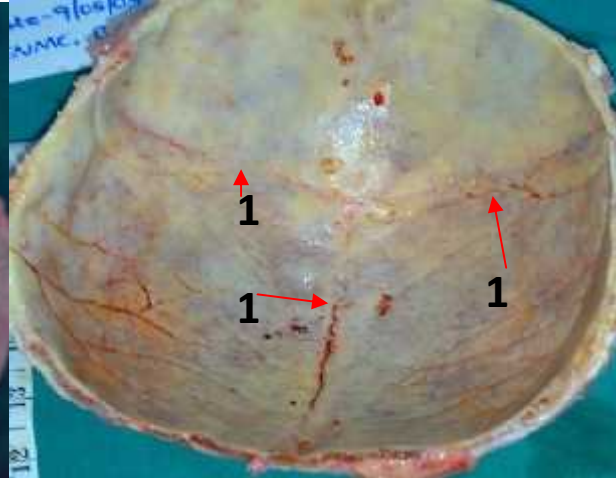
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

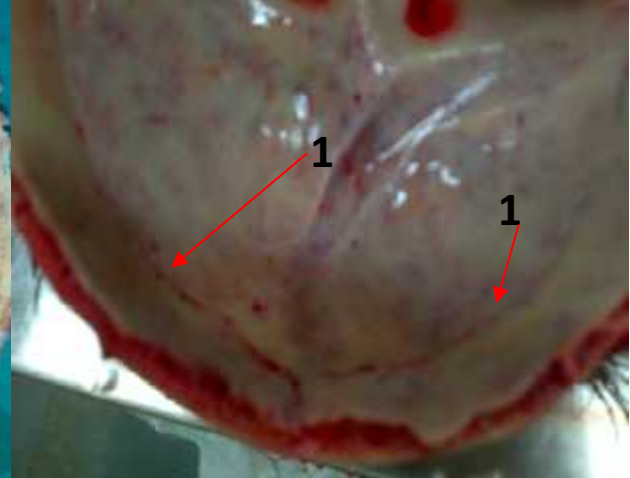
CASE-33



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

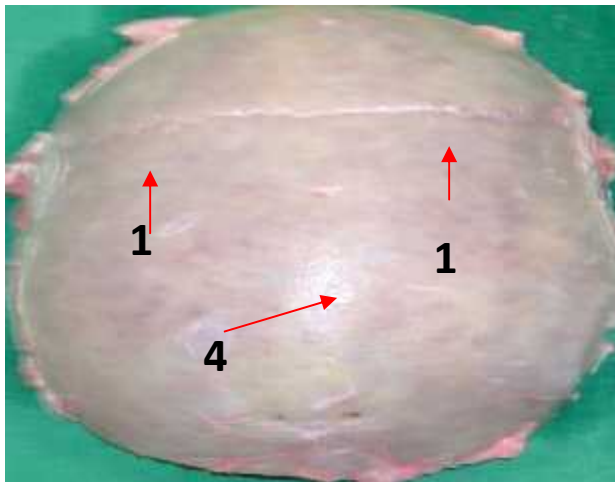


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

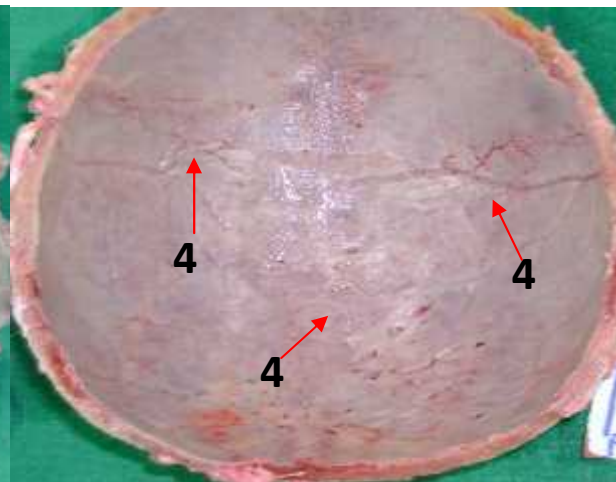


LAMDROID SUTURES (ENDOCRANIAL)

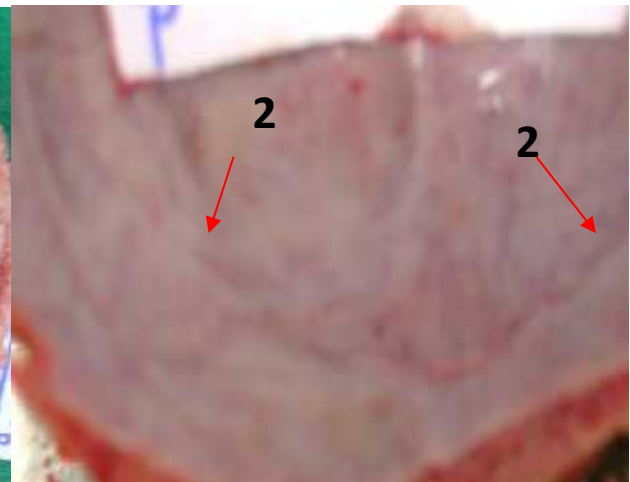
CASE-34



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



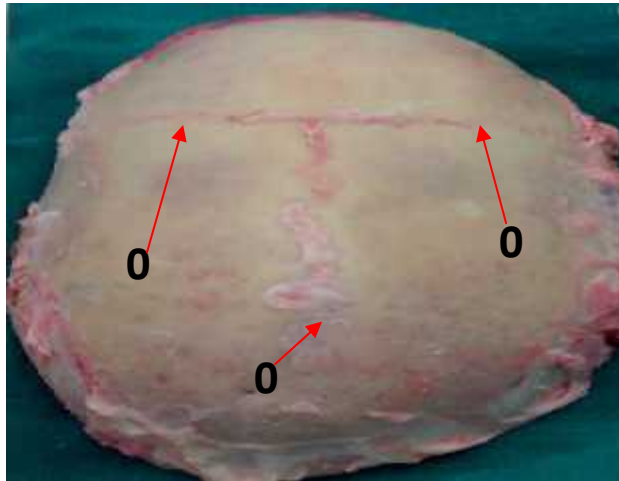
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



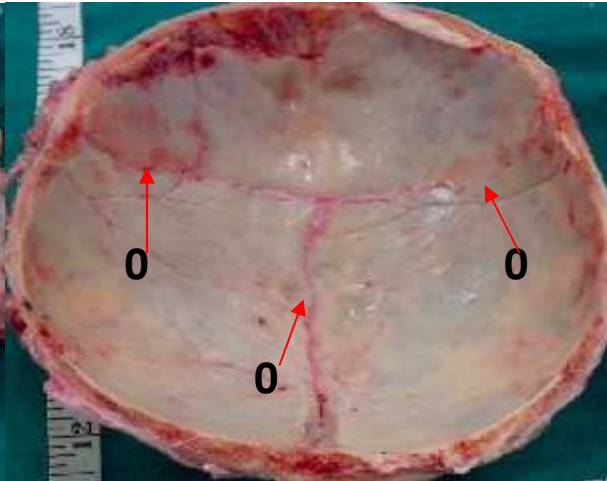
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-35



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

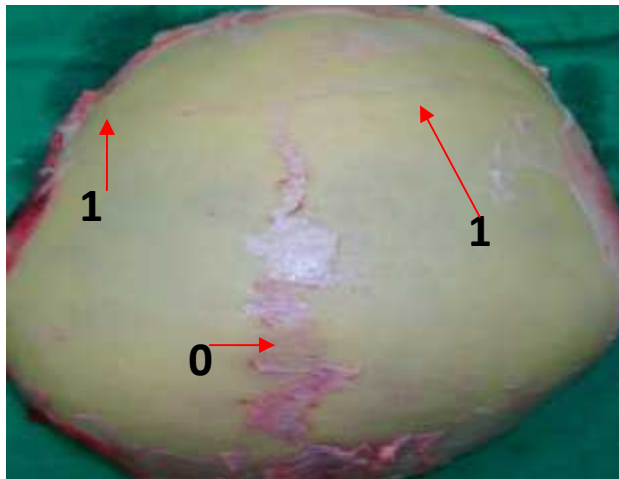


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

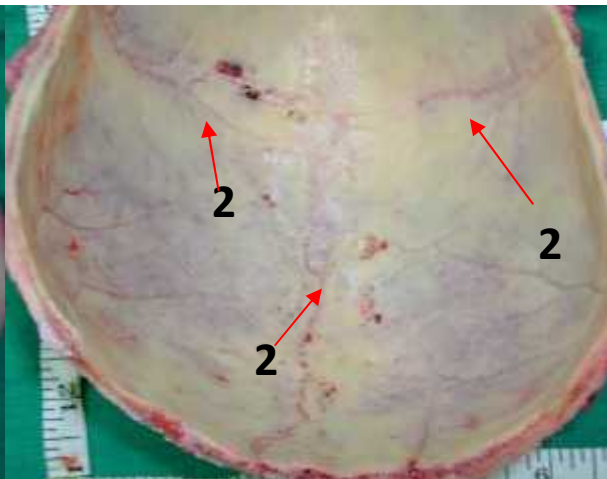


LAMDOID SUTURES (ENDOCRANIAL)

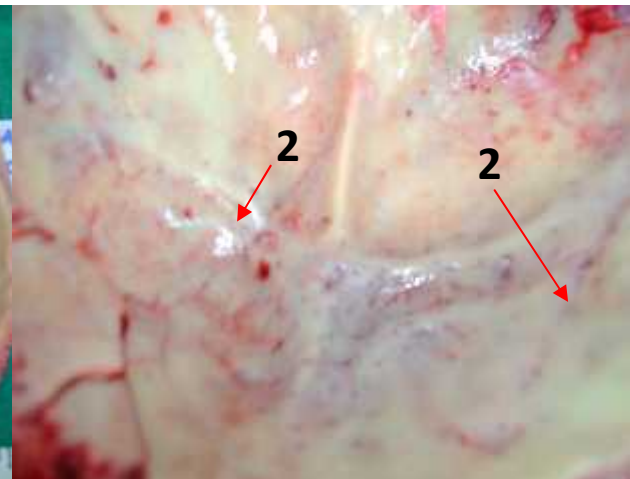
CASE-36



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



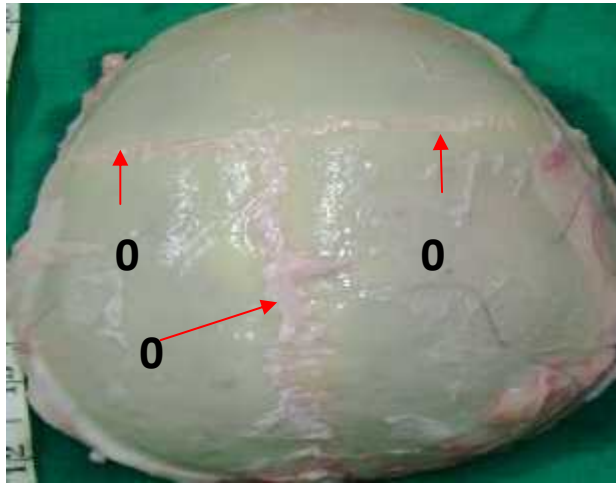
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



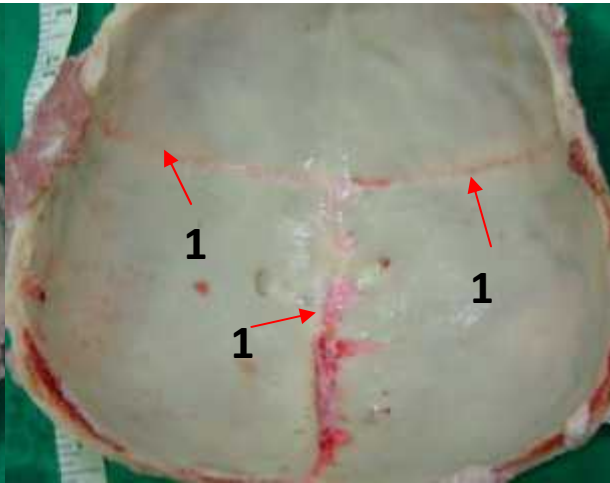
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

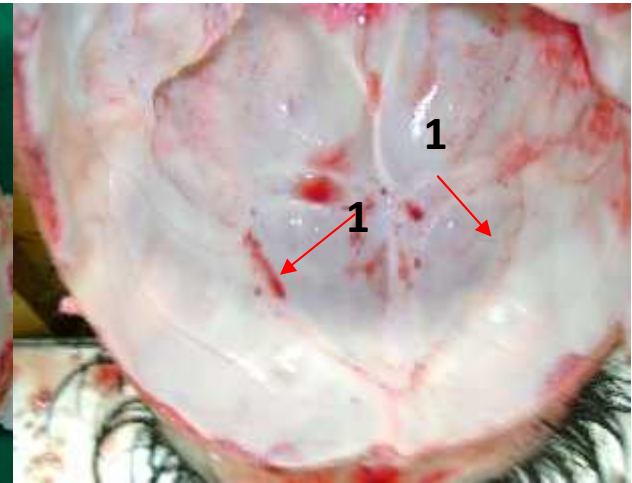
CASE-37



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

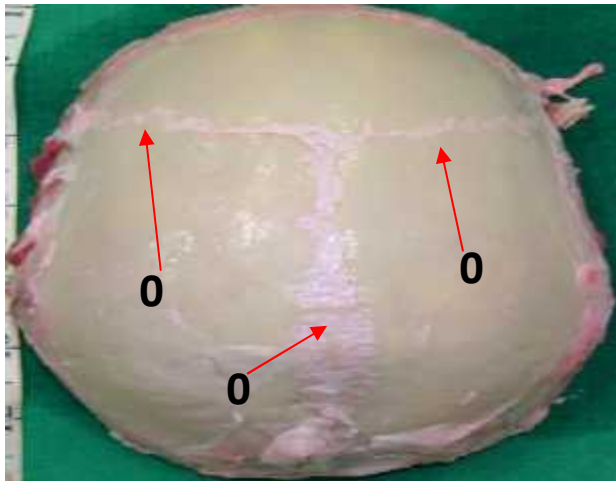


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

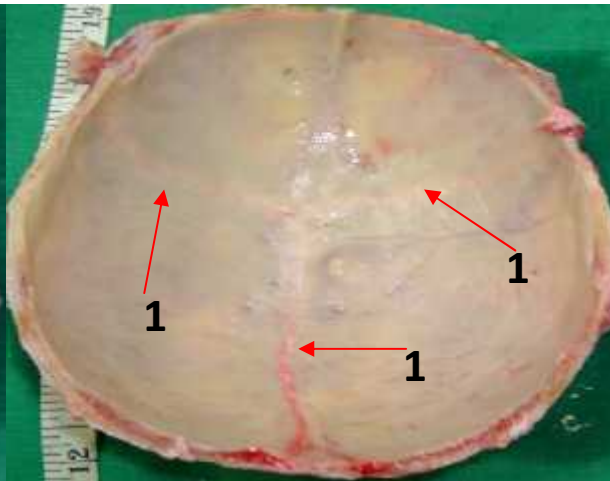


LAMDOID SUTURES (ENDOCRANIAL)

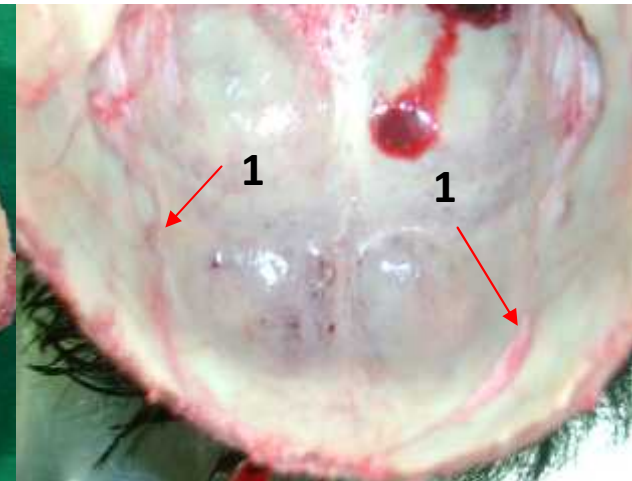
CASE-38



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



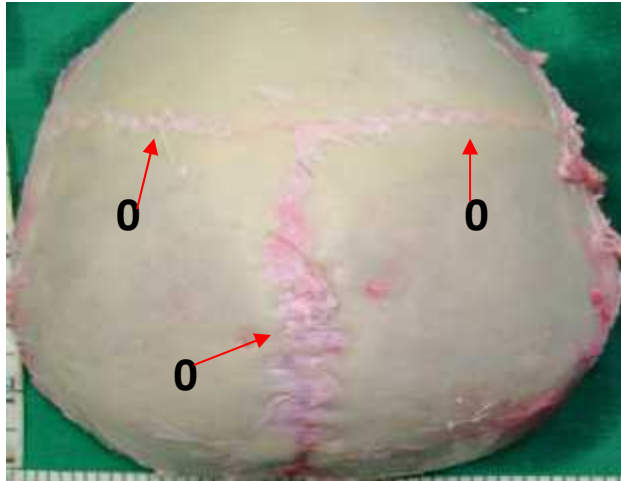
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



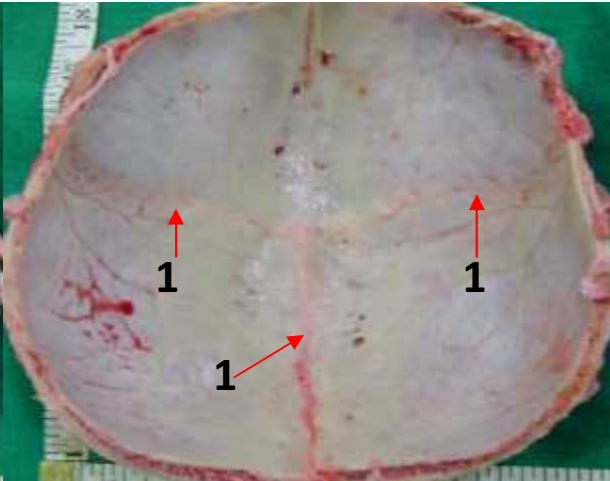
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-39



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

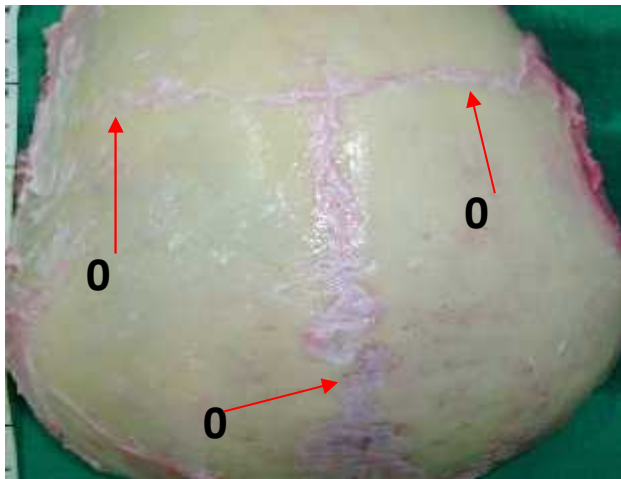


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

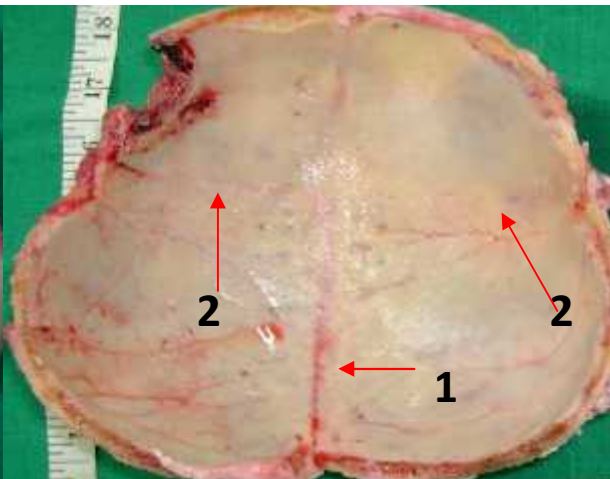


LAMDOID SUTURES (ENDOCRANIAL)

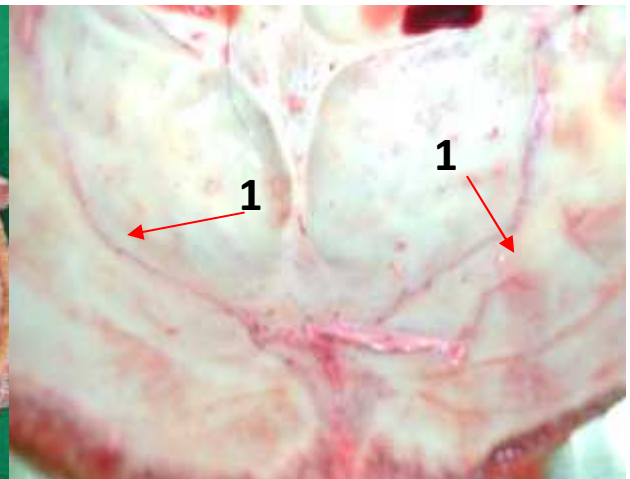
CASE-40



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



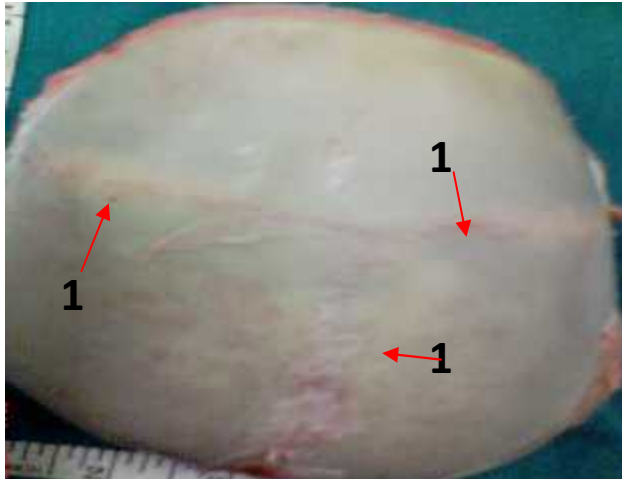
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



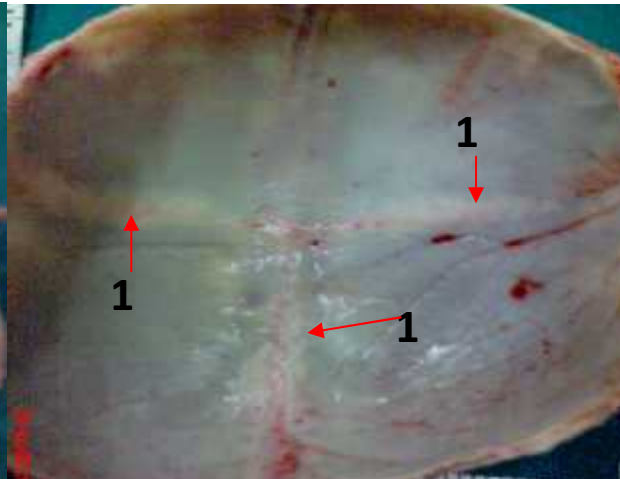
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

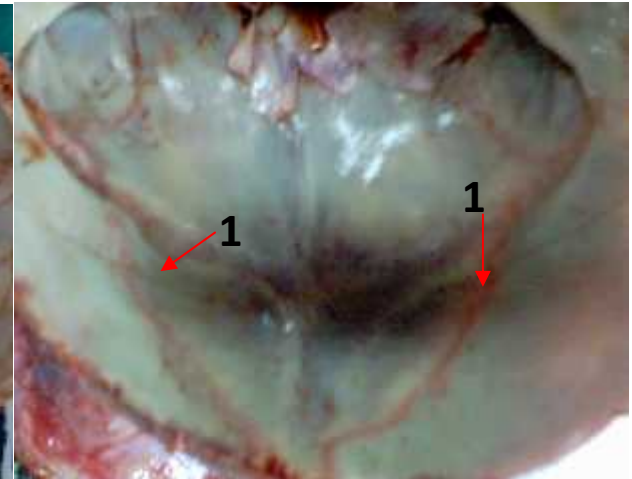
CASE-41



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

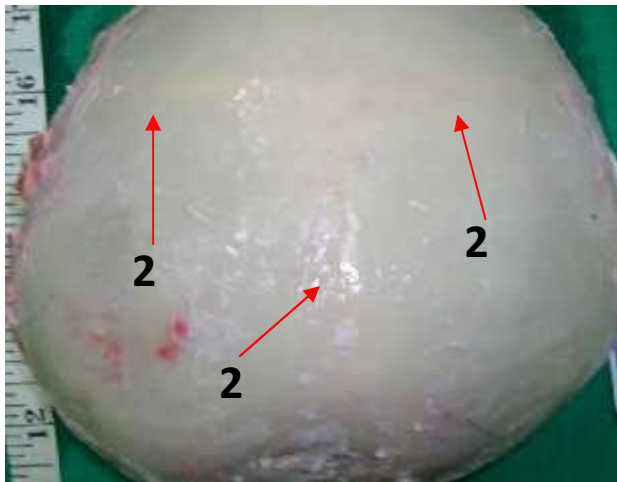


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

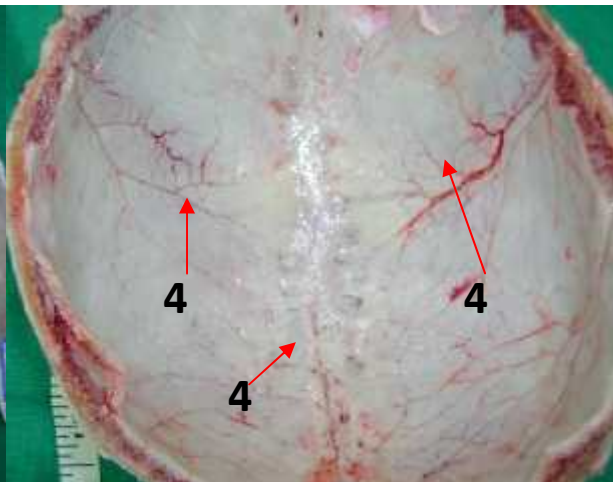


LAMDROID SUTURES (ENDOCRANIAL)

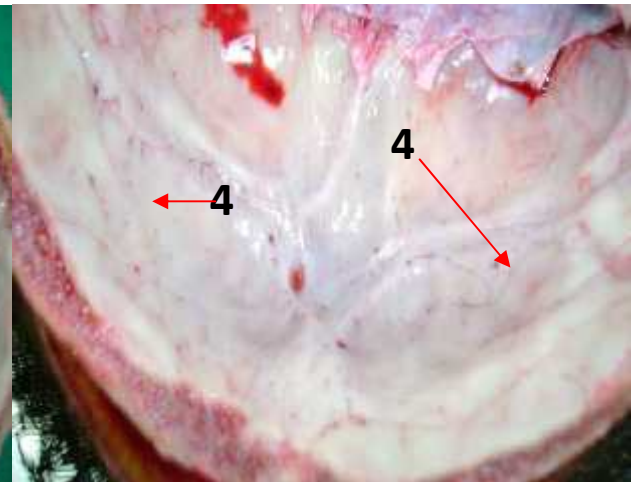
CASE-42



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



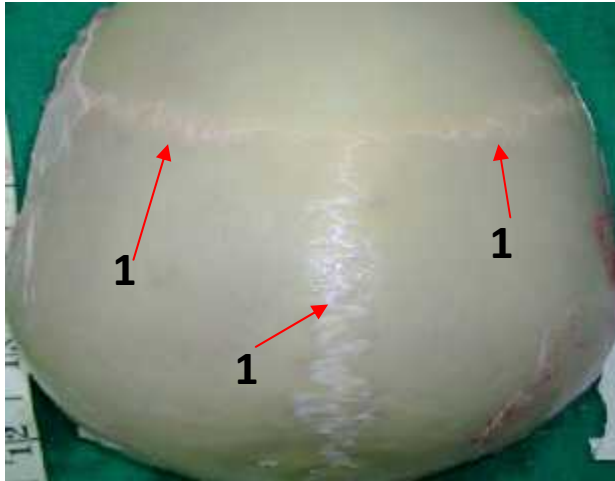
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



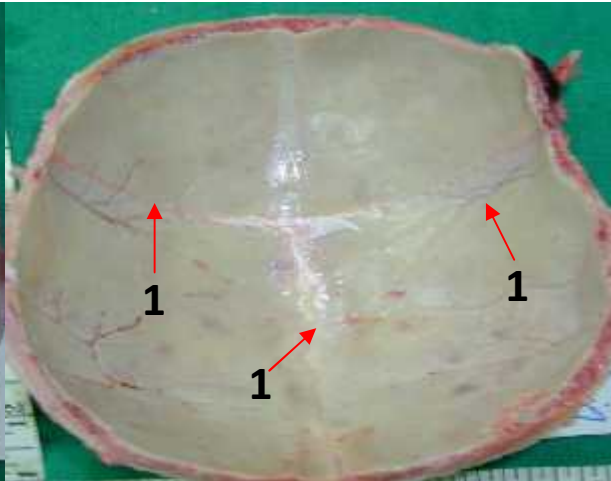
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

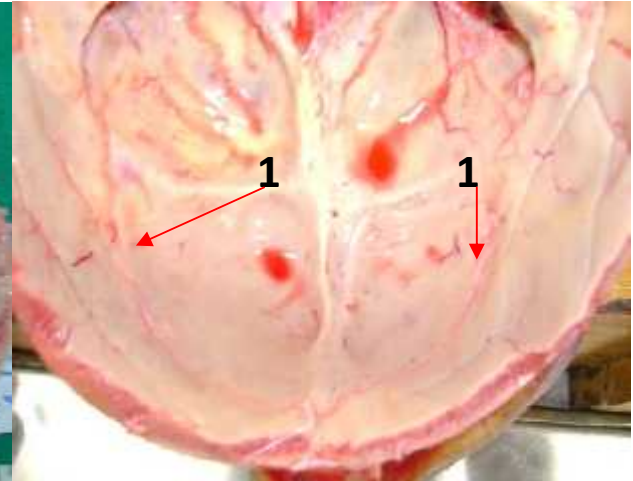
CASE-43



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

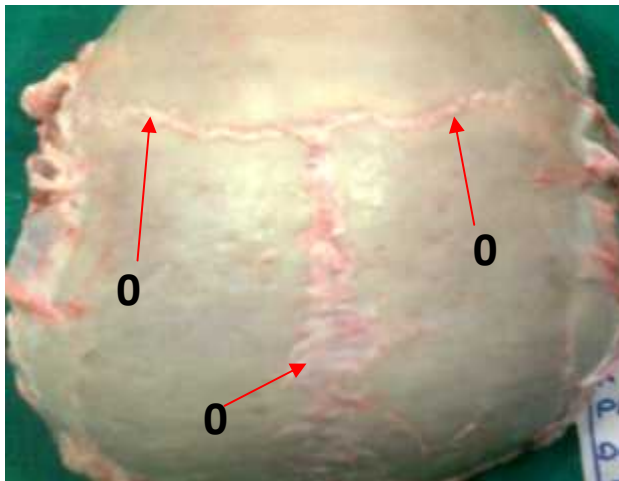


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

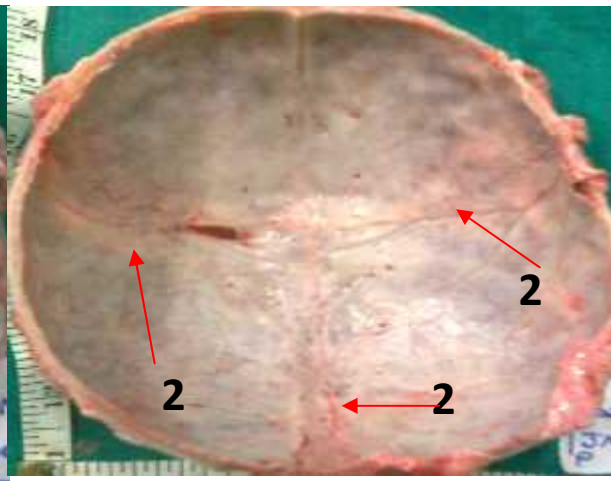


LAMDOID SUTURES (ENDOCRANIAL)

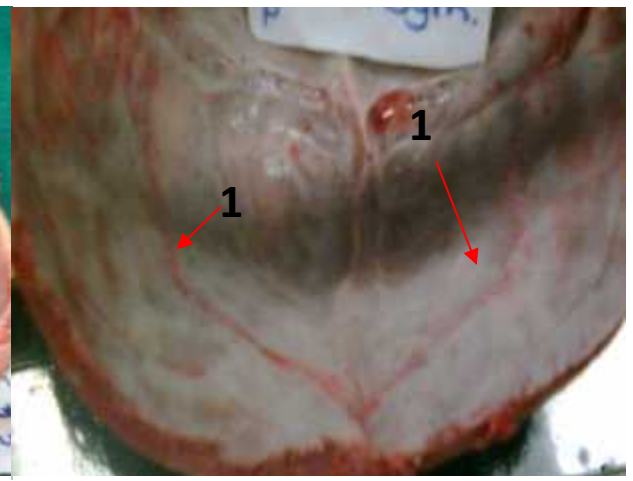
CASE-44



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



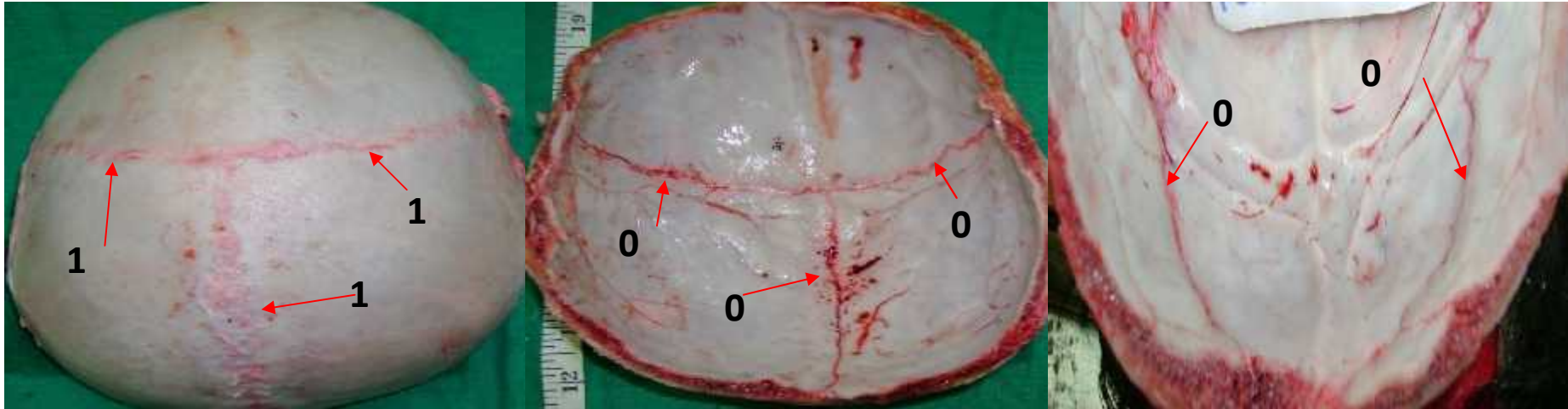
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-45

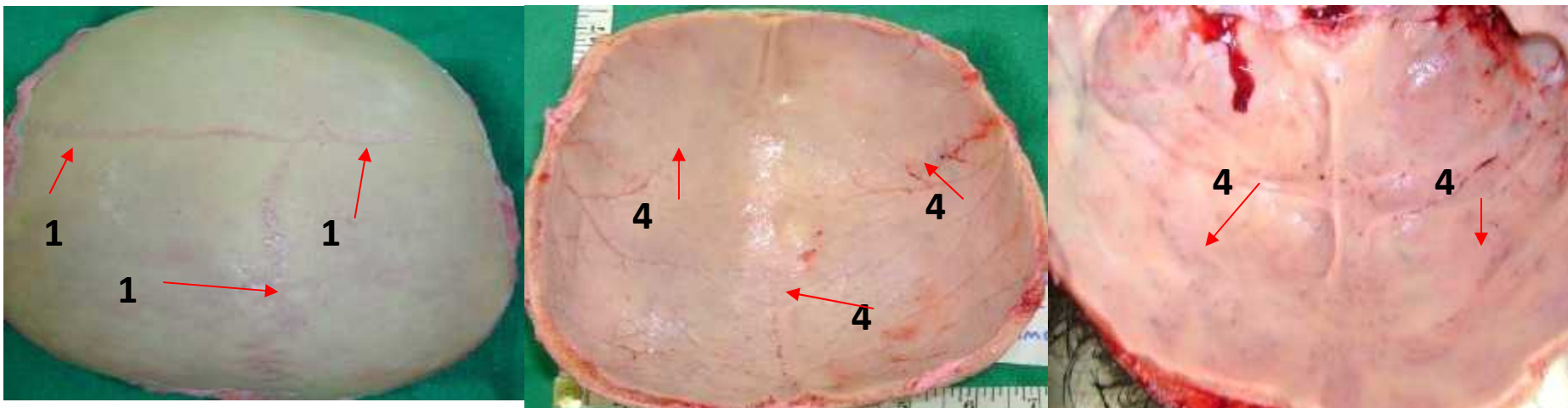


CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

LAMDOID SUTURES (ENDOCRANIAL)

CASE-46



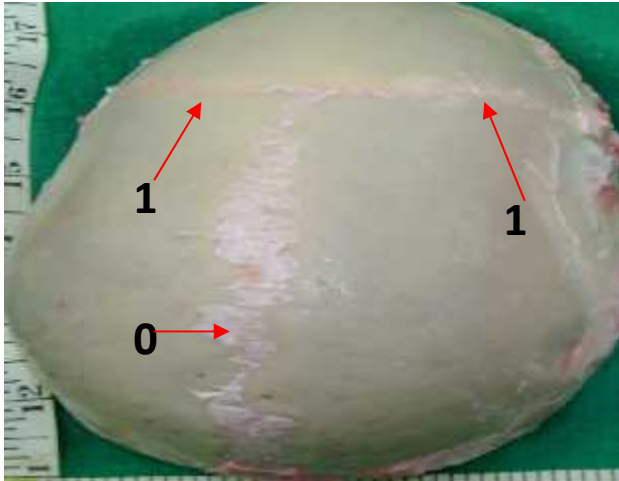
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

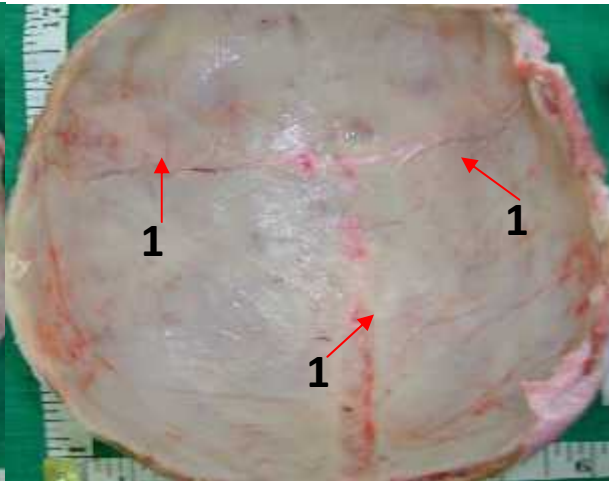
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

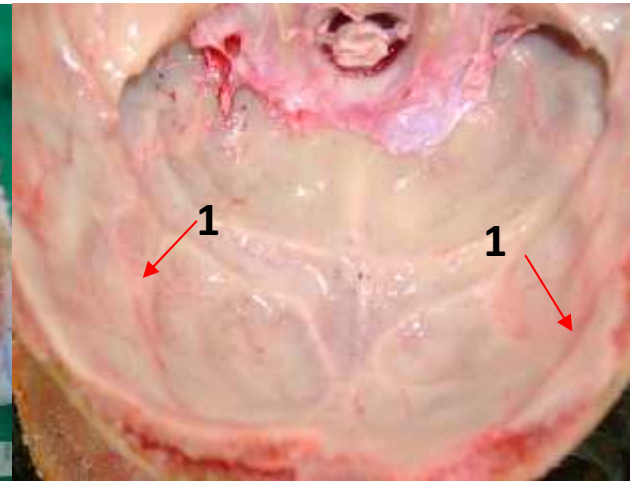
CASE-47



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

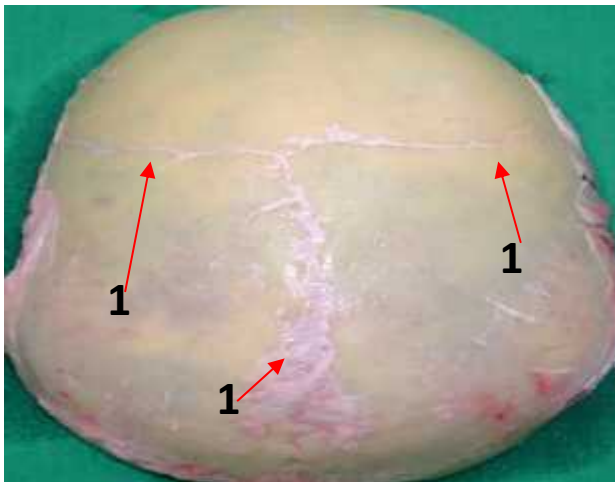


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

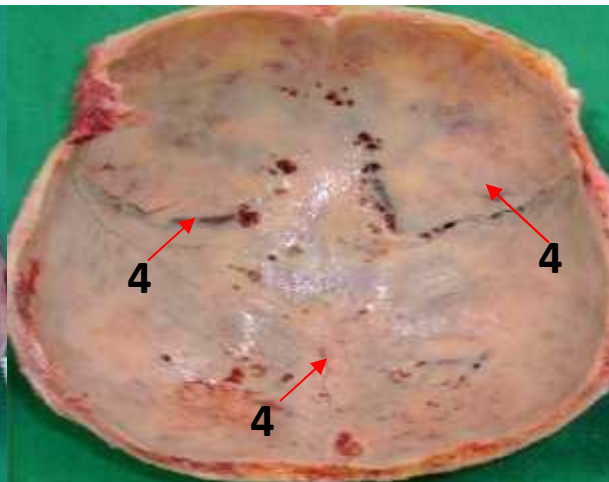


LAMDROID SUTURES (ENDOCRANIAL)

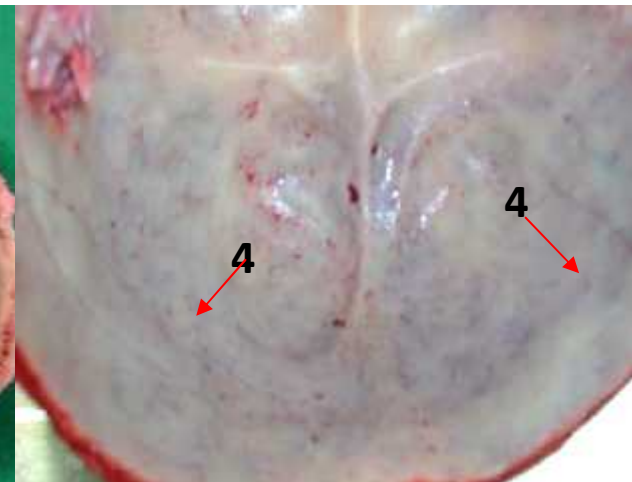
CASE-48



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



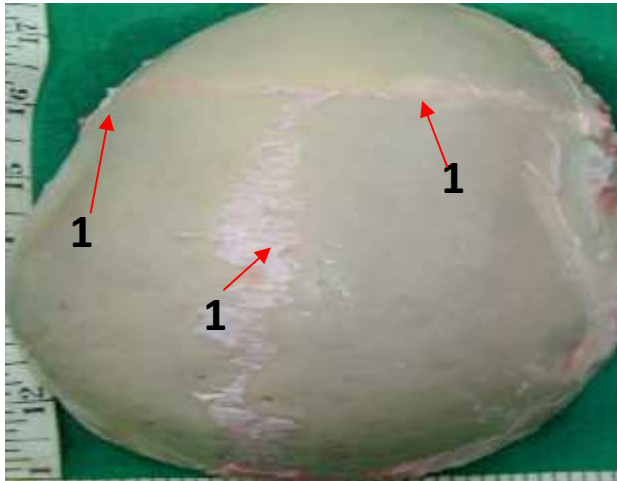
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



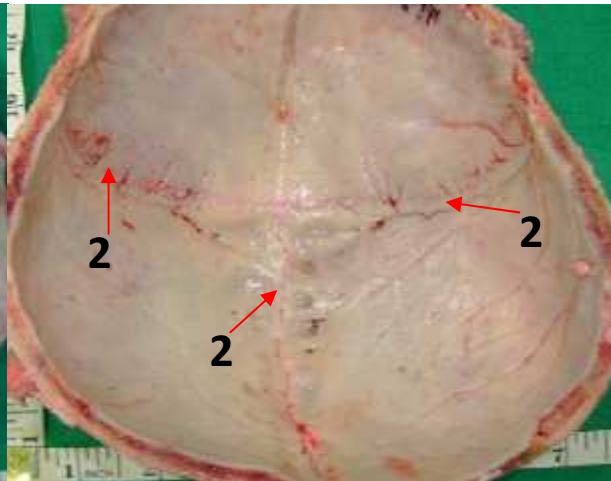
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

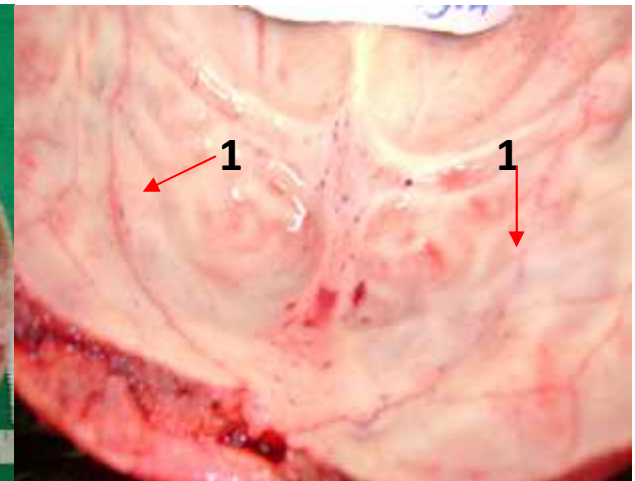
CASE-49



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

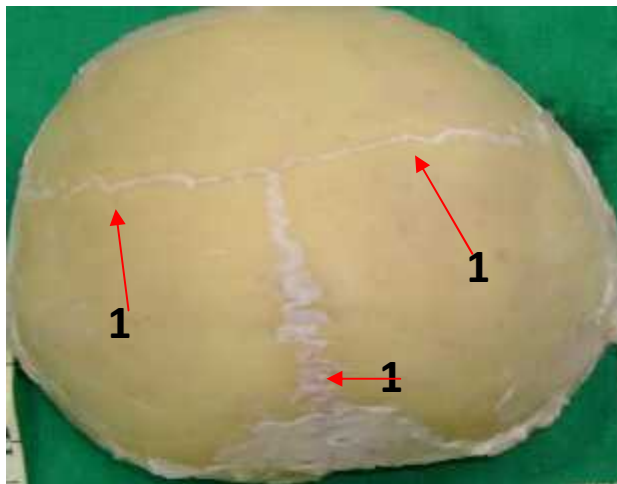


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

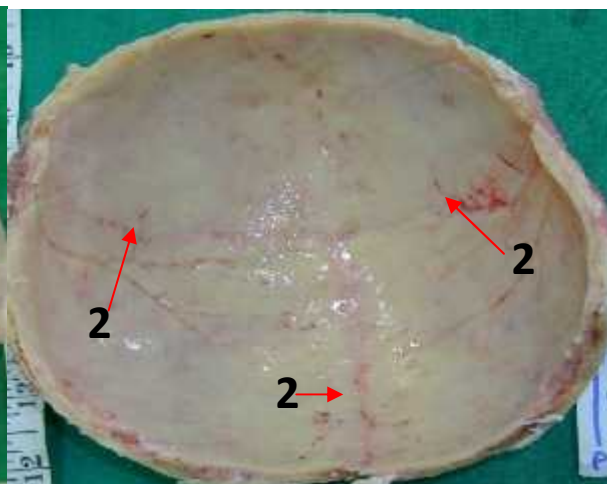


LAMDROID SUTURES (ENDOCRANIAL)

CASE-50



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



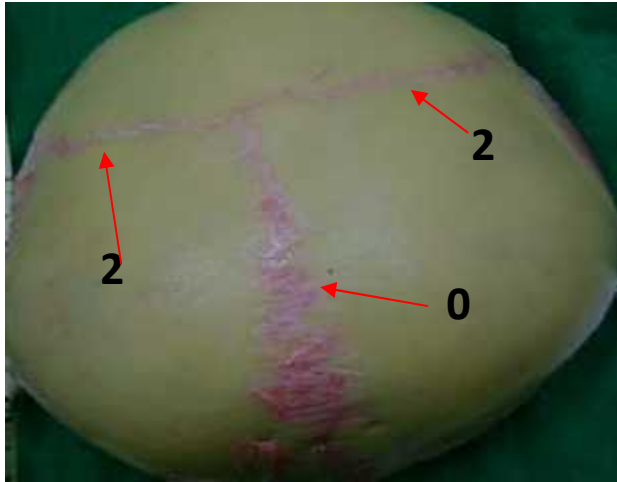
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



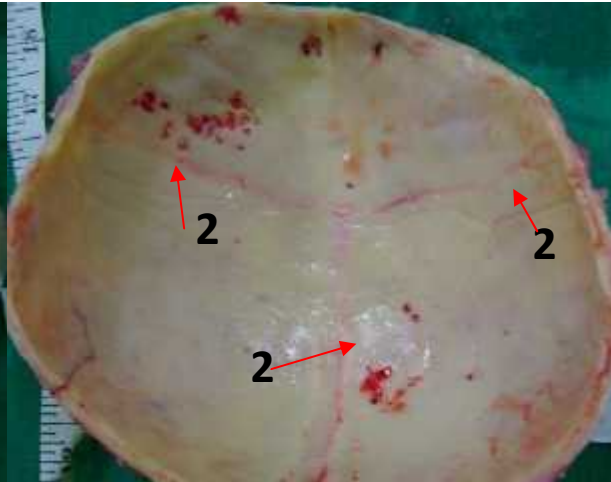
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-51



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

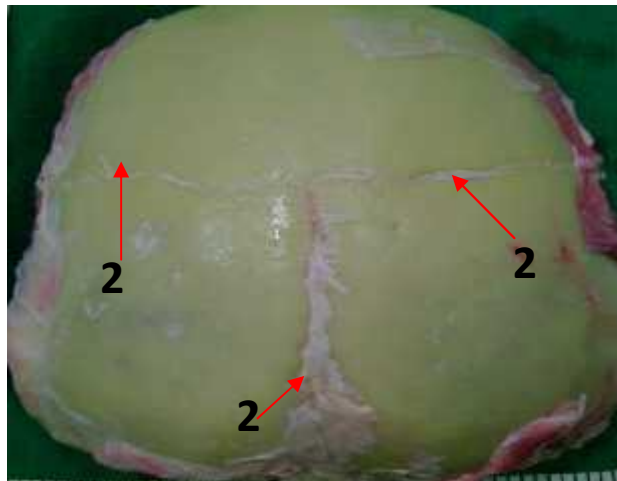


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

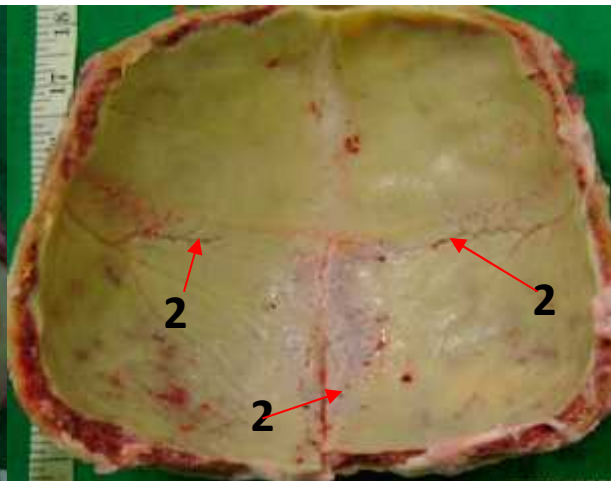


LAMDOID SUTURES (ENDOCRANIAL)

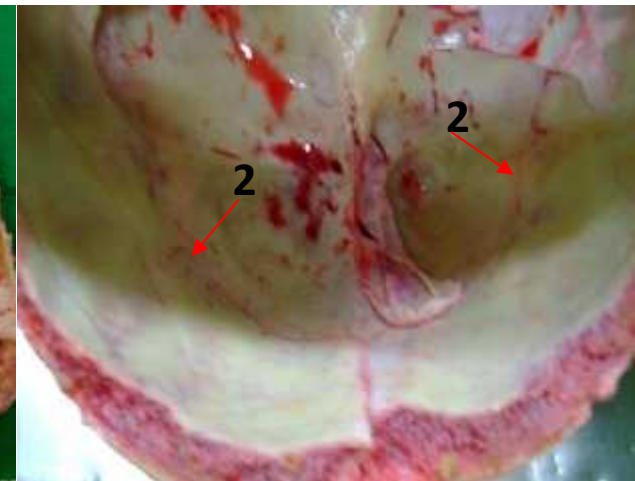
CASE-52



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



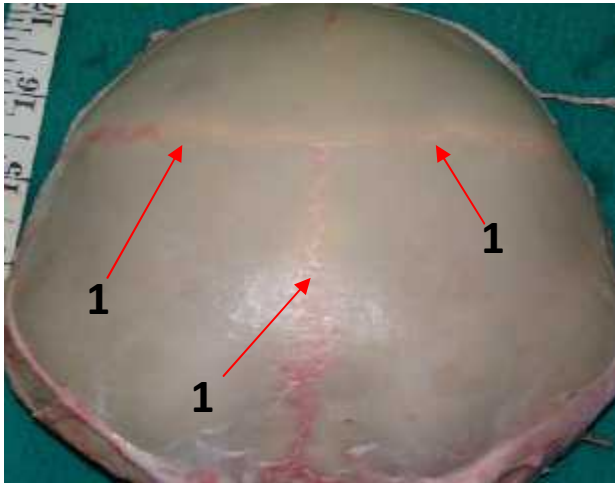
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



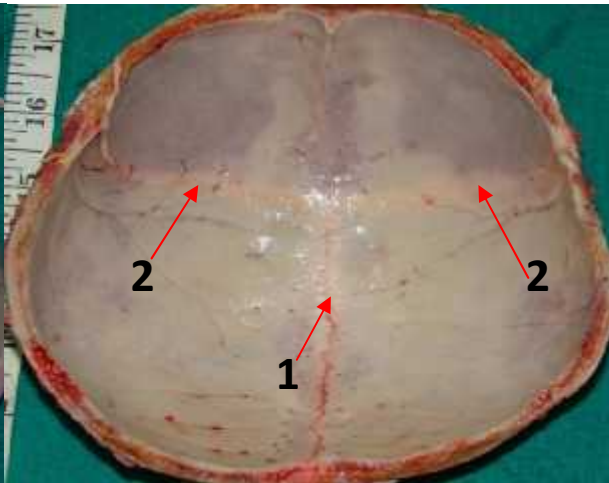
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

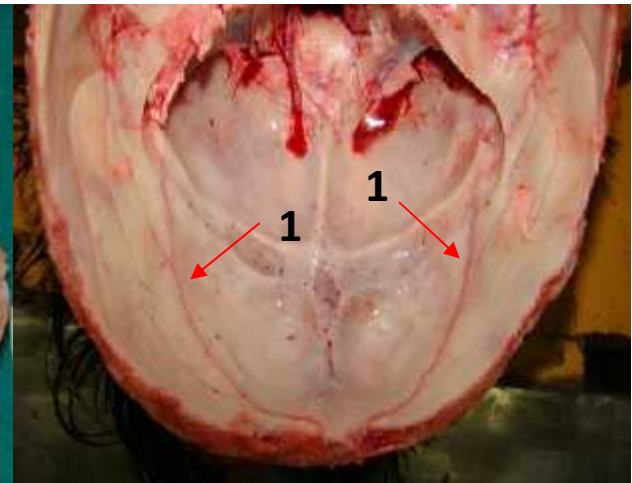
CASE-53



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

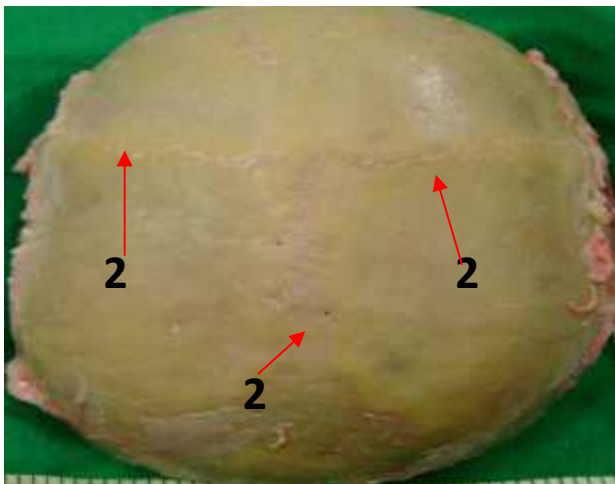


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

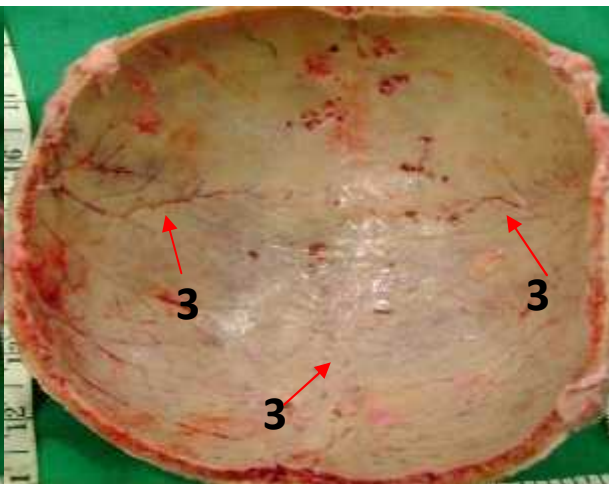


LAMDROID SUTURES (ENDOCRANIAL)

CASE-54



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



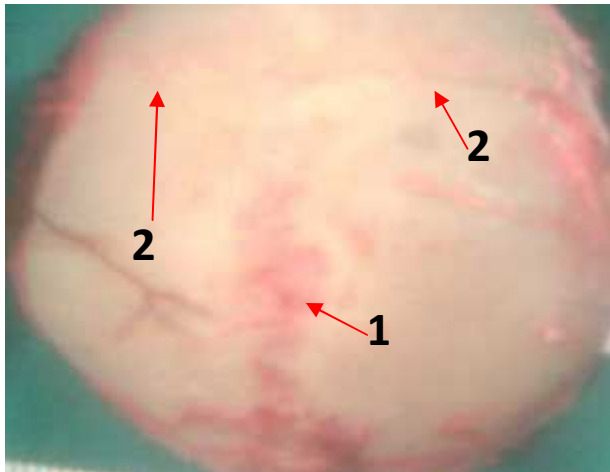
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



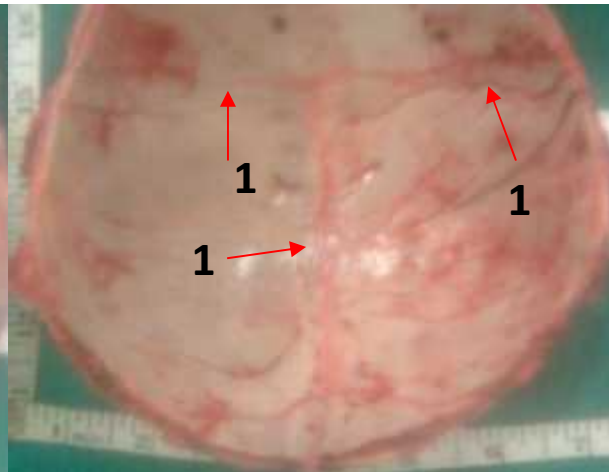
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

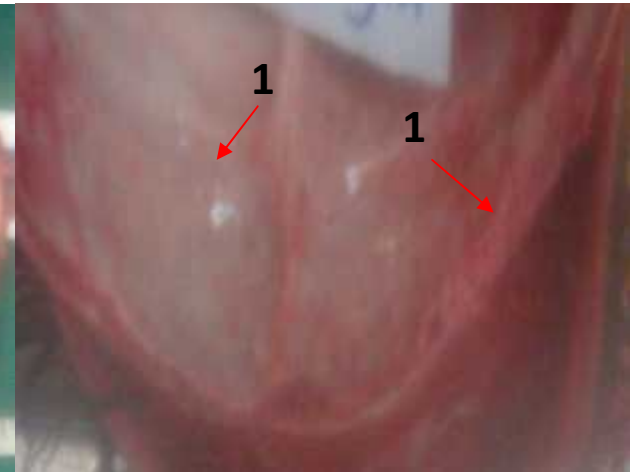
CASE-55



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

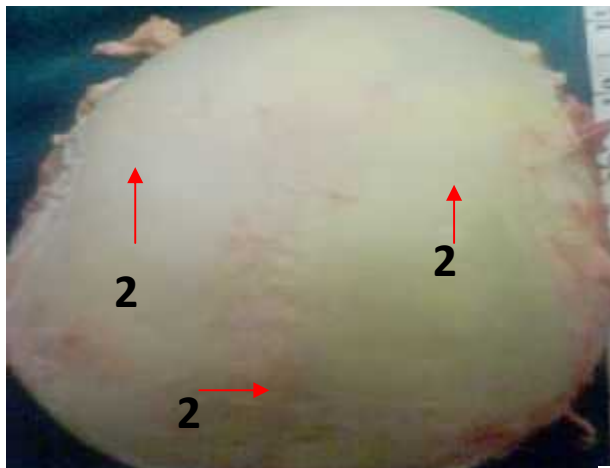


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

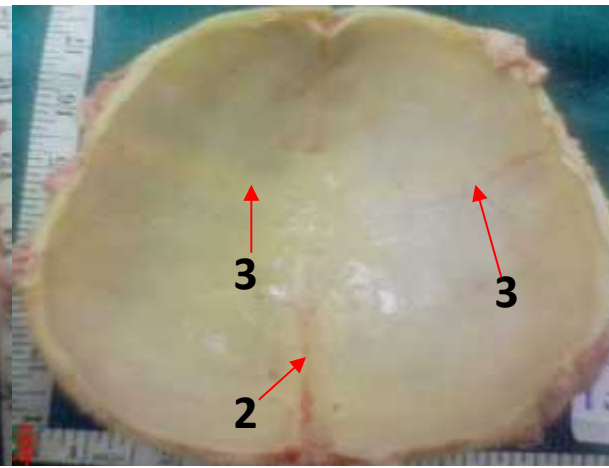


LAMDOID SUTURES (ENDOCRANIAL)

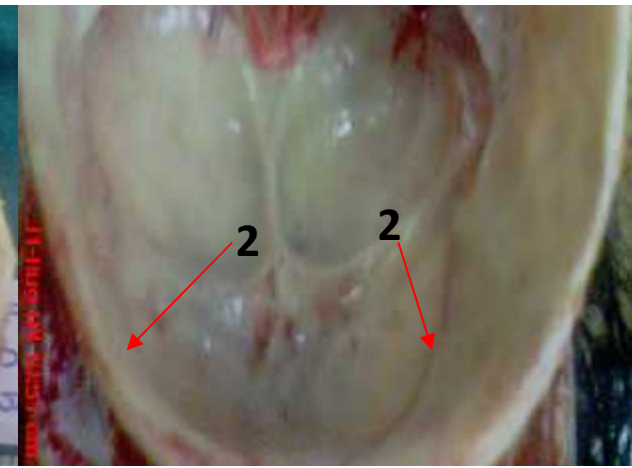
CASE-56



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



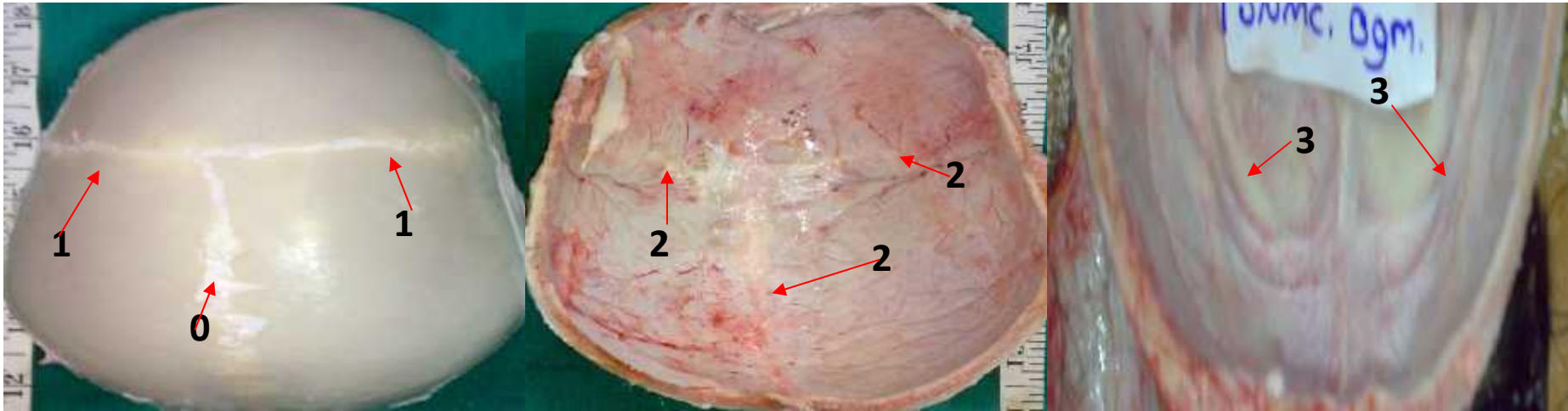
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-57

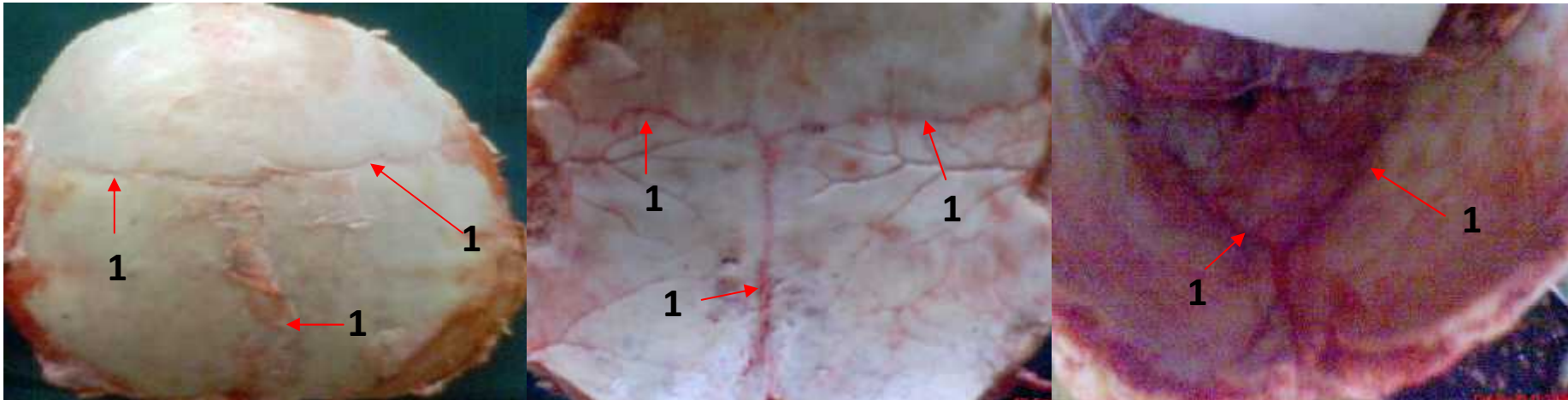


CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

LAMDOID SUTURES (ENDOCRANIAL)

CASE-58



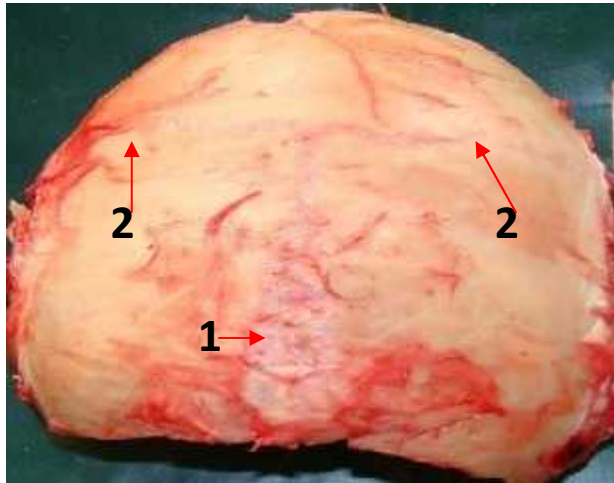
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

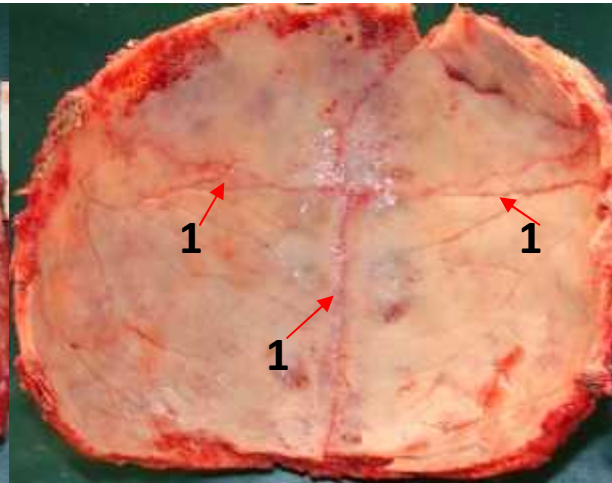
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

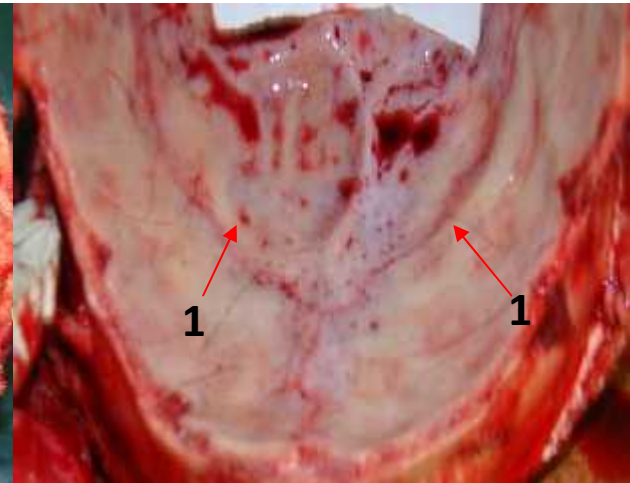
CASE-59



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

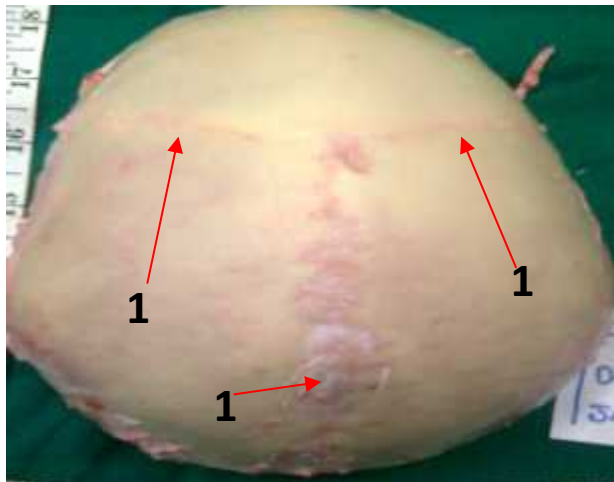


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

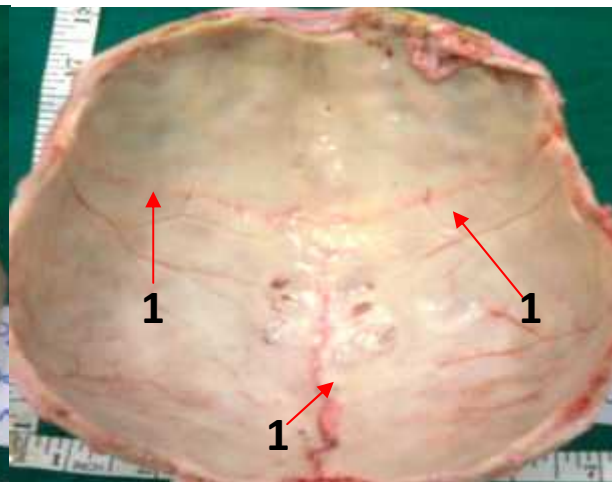


LAMDOID SUTURES (ENDOCRANIAL)

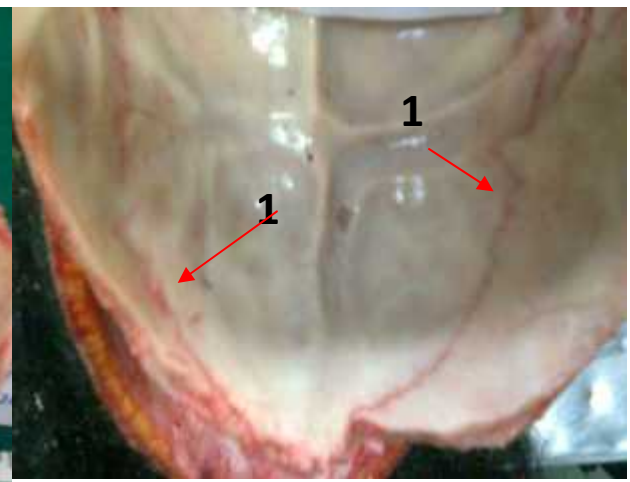
CASE-60



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



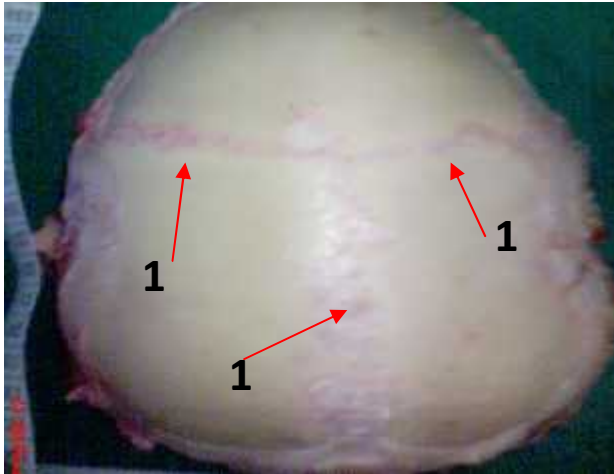
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



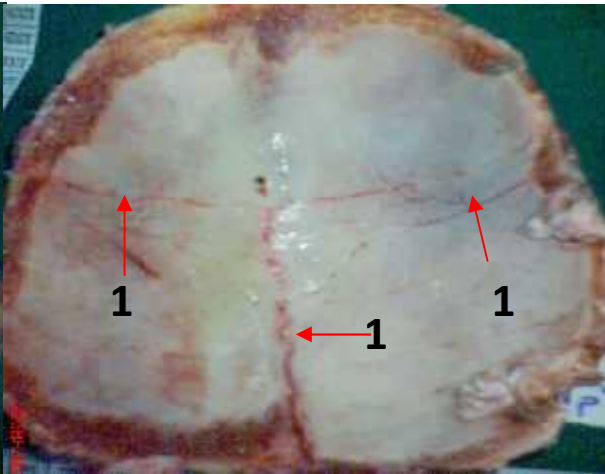
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

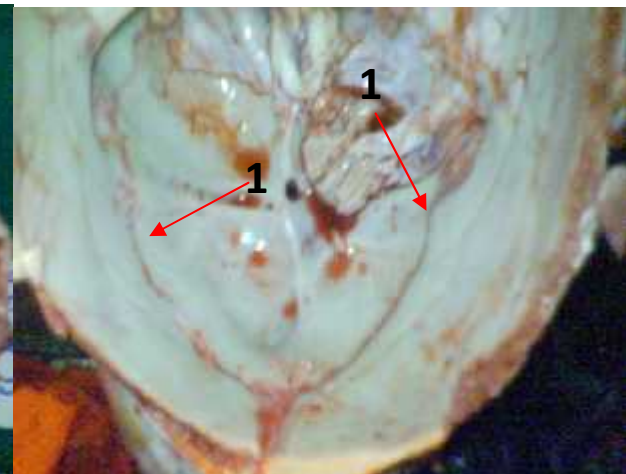
CASE-61



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

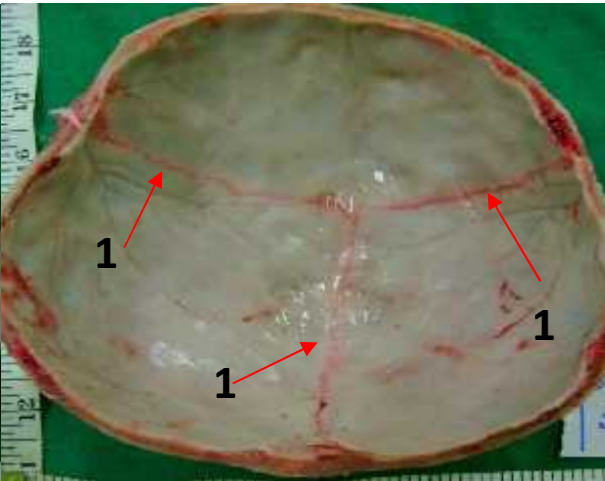


LAMDROID SUTURES (ENDOCRANIAL)

CASE-62



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



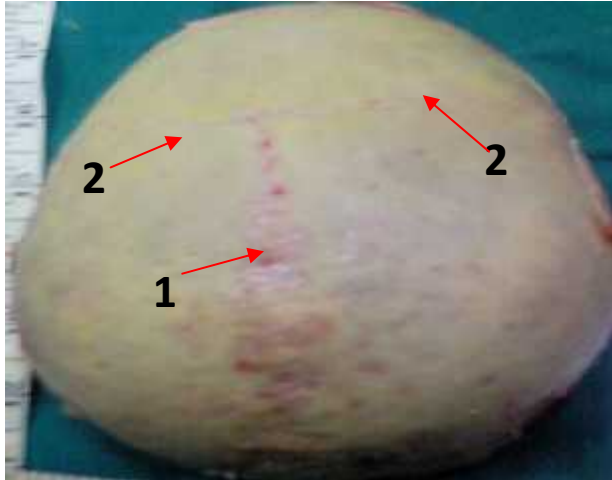
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



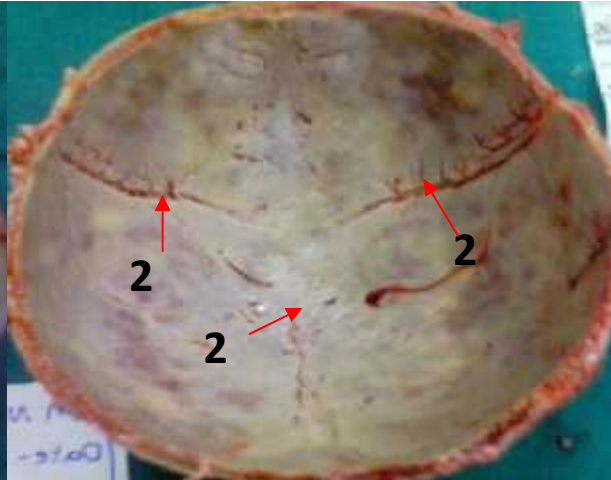
LAMDROID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

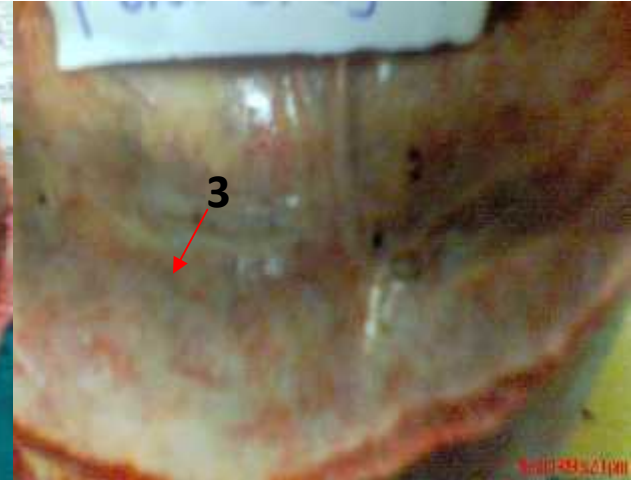
CASE-63



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

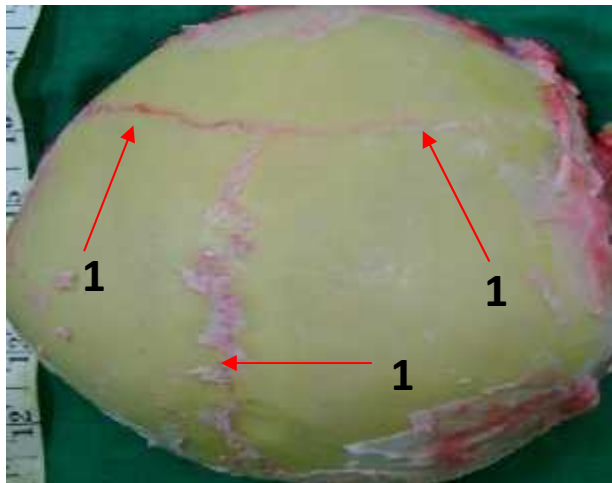


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

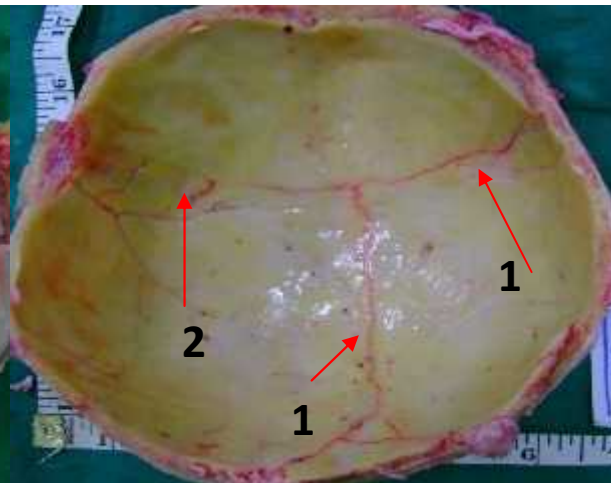


LAMDOID SUTURES (ENDOCRANIAL)

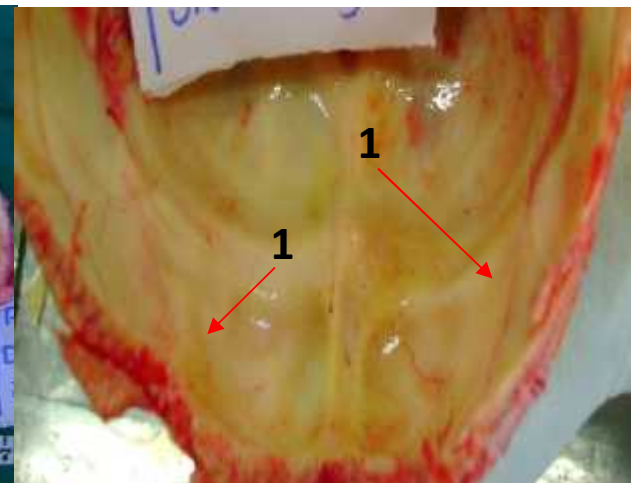
CASE-64



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



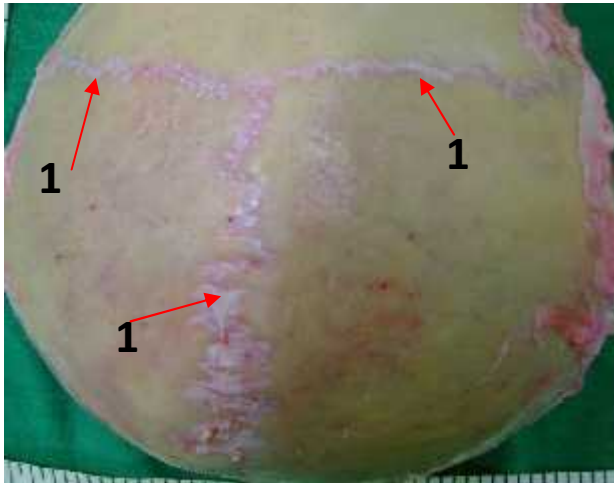
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



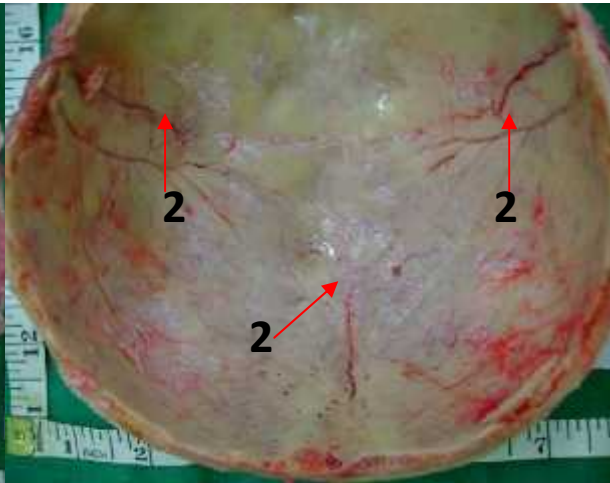
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

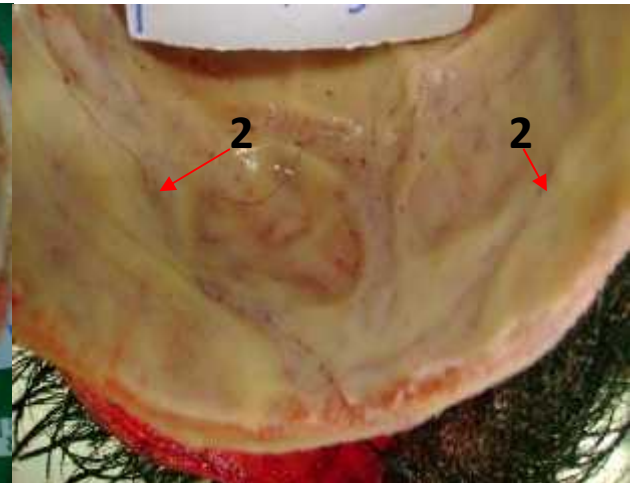
CASE-65



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

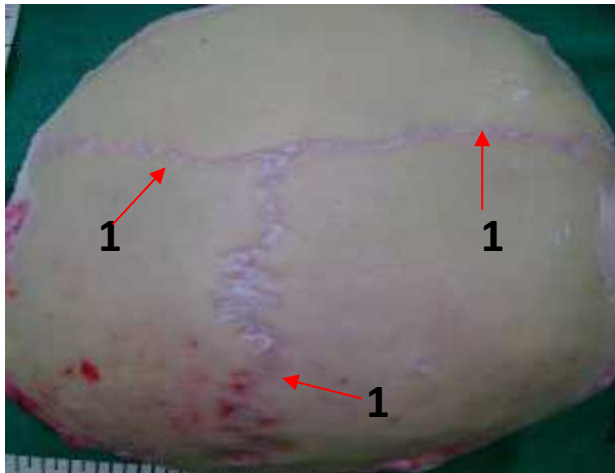


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

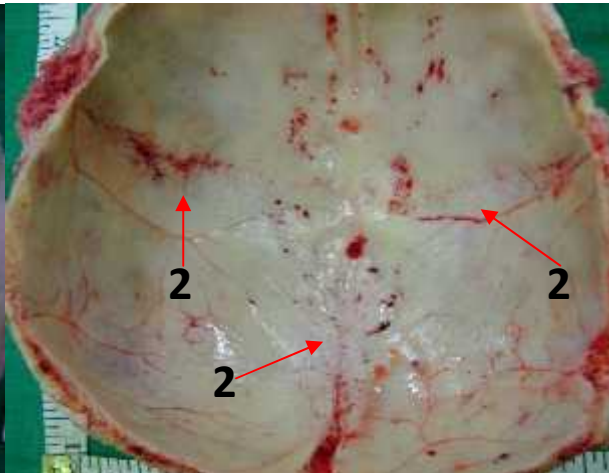


LAMDOID SUTURES (ENDOCRANIAL)

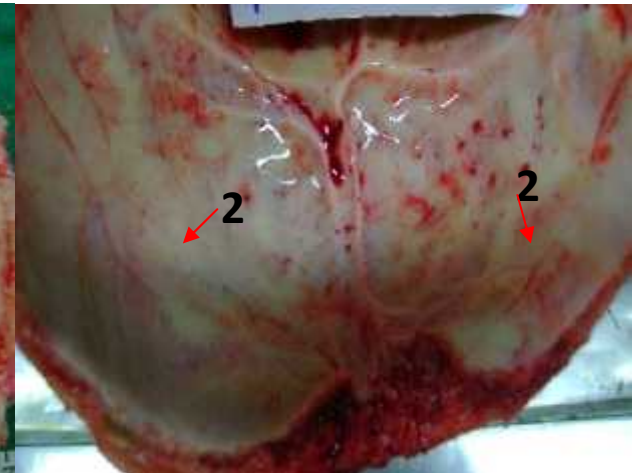
CASE-66



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



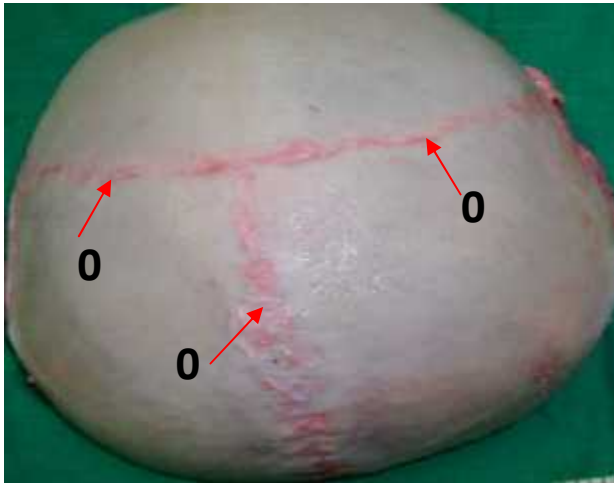
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



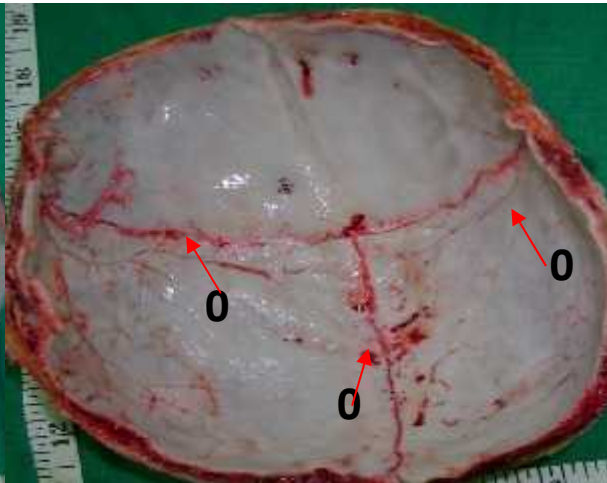
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-67



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

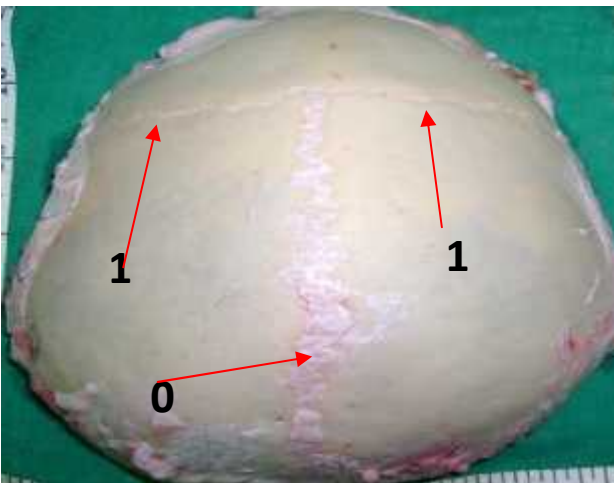


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

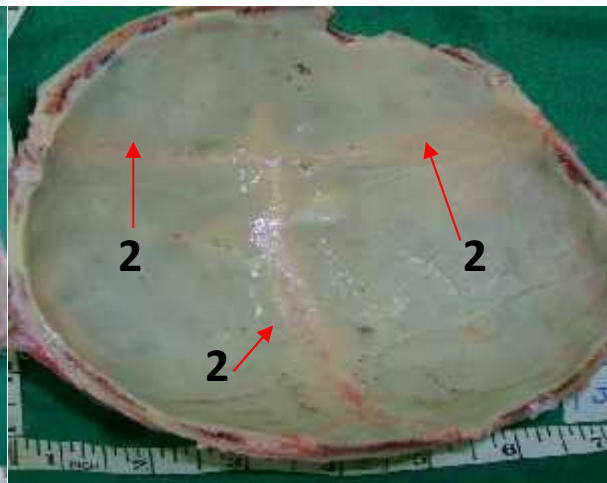


LAMDOID SUTURES (ENDOCRANIAL)

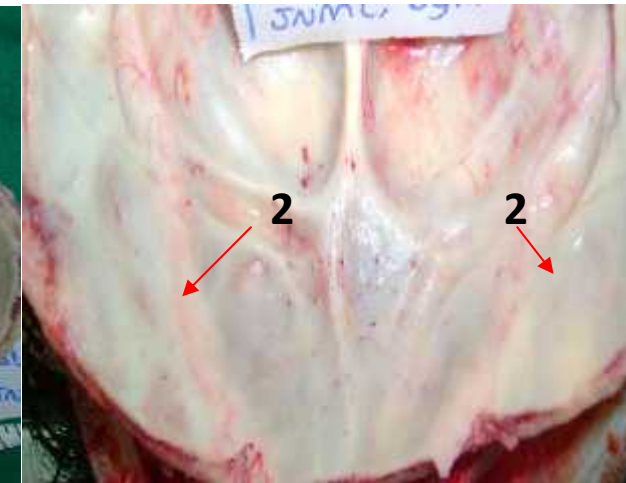
CASE-68



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



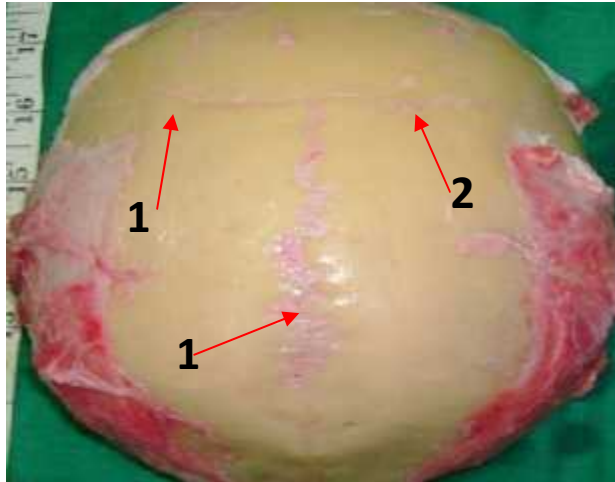
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



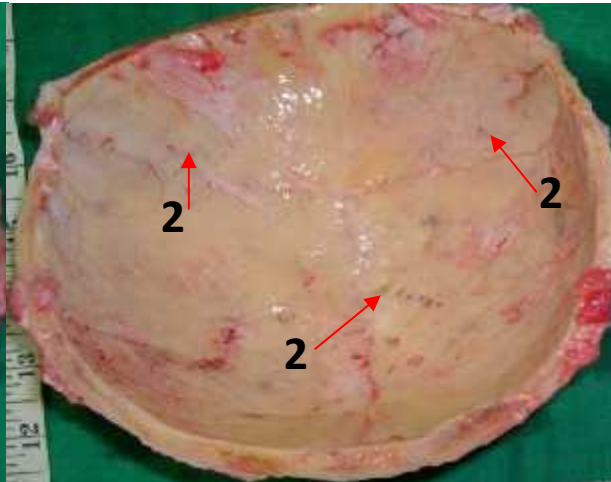
LAMDOID SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

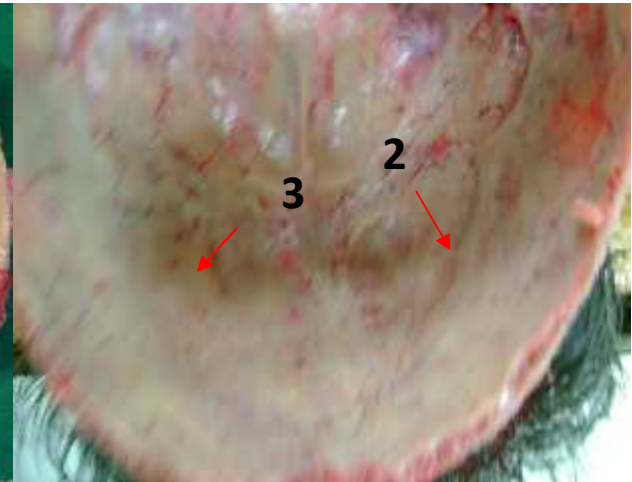
CASE-69



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

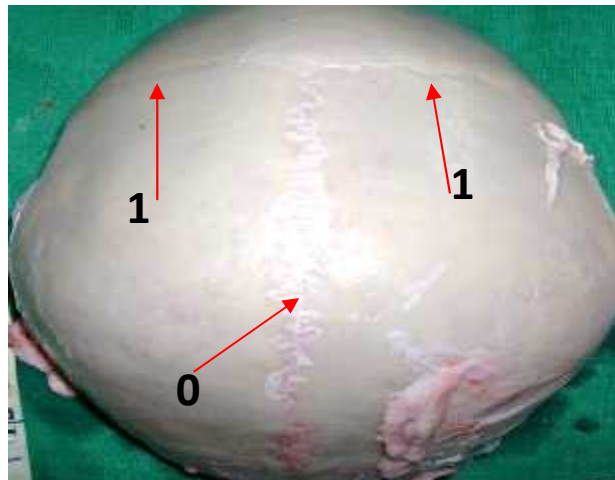


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

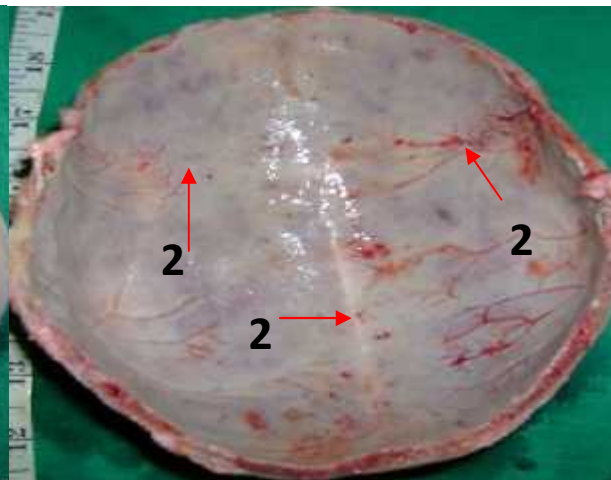


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

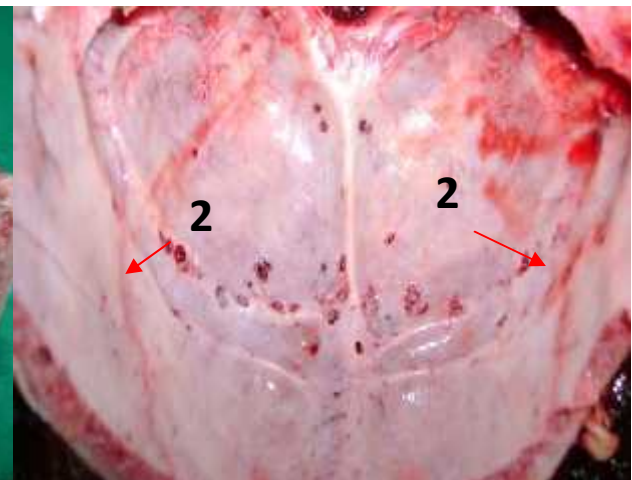
CASE-70



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

INFORMED CONSENT

Date:

Time:

I, Mr./Ms..... aged years
father/mother/son/husband. of deceased give my full, free and
voluntary consent to take photograph of skull vault from my
Mr./Ms..... required for the dissertation work
undertaken by THE CANDIDATE REG. NO.BF0108002, Department of Forensic medicine and
Toxicology, JNMC, Belgaum.

I have been informed that in no way identity of deceased shall be revealed by any means
and the procedure has been clearly explained to me.

**I have gone through the contents of this form and have understood the same before
signing it.**

Signature of the consenting person

Witness: (Name and signature)

1

2

**FUSION OF SKULL VAULT SUTURES IN RELATION TO AGE – A
CROSS SECTIONAL POSTMORTEM STUDY DONE IN 3RD, 4TH AND 5TH
DECADES OF LIFE AT KLEs PRABHAKAR KORE HOSPITAL AND MRC,
BELGAUM.**

PROFORMA

I. GENERAL PARTICULARS

- | | |
|-----------------------------------|----------------------|
| 1. S1. NO:- | 2. P. M. No:- |
| 3. Date:- | 4. Cr/UDR No:- |
| 5. U/S:- | 6. IP No:- |
| 7. DOA: - | 8. DOD:- |
| 9. Name of deceased:- | |
| 10. Age a) as per police inquest: | b) as per relatives: |
| 11. Date of birth- | 12. Sex:- |
| 13. Address: | |
| 14. Religion: - | 15. Occupation;- |

II. OTHER FEATURES

- | | |
|---|--|
| 1. Identification marks: - a. | b. |
| 2. Identified by: - a. Escorting constable: - | b. Relatives: |
| 3. Length: - cms | 4. Weight: - kgs. |

III. EXAMINATION OF SUTURES OF SKULL VAULT:

Sr. No.	Name of Suture	Part	Open [o]		Less than half fused [1]		Half fused [2]		More than half fused [3]		Completely fused [4]	
			Inner table	Outer table	Inner table	Outer table	Inner table	Outer table	Inner table	Outer table	Inner table	Outer table
1.	Metopic suture											
2.	Saggital suture	A/3 P/3 M/3										
3.	Coronal suture [R]	U/2 L/2										
4.	Coronal suture [L]	U/2 L/2										
5.	Lambdoid suture [R]	U/2 L/2										
6.	Lambdoid suture [L]	U/2 L/2										

Place :

Date :

Signature :

KEY WORDS

S -SAGITTAL

C -CORONAL

L -LAMBDOID

R -RIGHT

L -LEFT

U- UPPER

L-LOWER

ENDO -ENDOCRANIAL

ECTO -ECTOCRANIAL

S1 -PARS BREGMATICA

S2 -PARS VERTICES

S3 -PARS OBELICA

C1- PARS BREGMATICA

C2- PARS COMPLICATA

L1- PARS LAMBDAICA

L2 -PARS INTERMEDIA

m -MALE

f -FEMALE

SI	Nc	P(Mno/date)	AGE	SEX	METOPIC SUTURE		SAGITAL SUTURE						CORONAL SUTURE®				CORONAL SUTURE(L)				LAMDOID SUTURE(R)				LAMDOID SUTURE(L)			
					inner table		outer table		inner table		outer table		inner table		outer table		inner table		outer table		inner table		outer table		inner table		outer table	
					A13	P13	M13	A13	P13	M13	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12
1	159/08	50	M	4	4	0	4	2	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
2	160/08	46	M	3	0	4	3	1	0	0	0	3	1	0	0	0	3	1	0	0	0	0	2	0	0	0	0	
3	163/08	30	M	4	4	3	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0		
4	164/08	26	M	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5	167/08	26	M	4	4	1	1	1	0	0	0	1	1	0	0	3	3	0	0	1	1	1	1	1	1	1		
6	171/08	28	M	4	4	2	2	2	0	0	0	3	2	0	0	3	3	0	0	2	4	0	0	2	1	0	0	
7	5/09	50	F	4	4	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1		
8	7/09	23	M	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
9	8/09	20	M	4	4	1	1	3	2	2	2	1	1	1	1	2	3	3	4	1	0	1	0	1	0	1	0	
10	9/09	38	F	4	4	4	4	4	4	4	1	4	4	4	3	4	4	4	4	3	3	3	4	4	4	4		
11	10/09	32	F	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
12	11/09	50	M	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
13	12/09	42	M	4	4	4	4	4	0	0	0	4	4	0	0	4	4	0	0	1	1	1	1	1	1	1		
14	13/09	50	M	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3		
15	14/09	25	M	4	4	1	1	1	0	0	0	1	1	1	1	1	1	1	1	2	2	1	1	2	2	1	1	
16	15/09	50	M	4	4	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2	
17	18/09	20	F	4	4	3	3	3	0	2	0	4	4	0	0	3	3	0	0	4	4	4	4	4	4	4	4	
18	21/09	45	M	4	4	4	2	1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	
19	22/09	21	M	4	4	0	0	0	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	
20	33/09	50	M	4	4	2	2	2	1	1	1	3	2	1	2	3	2	1	2	3	3	1	1	3	3	1	1	
21	35/09	22	M	4	4	0	0	0	1	1	1	0	0	2	2	0	0	2	2	0	0	0	0	0	0	0	0	
22	40/09	23	F	4	4	0	0	0	0	0	0	1	1	1	1	1	1	2	2	0	0	0	0	0	0	0		
23	44/09	20	M	4	4	0	0	0	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	
24	46/09	25	M	4	4	1	1	0	0	0	0	1	1	1	1	1	1	1	2	2	1	1	2	2	1	1		
25	48/09	50	M	4	4	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2	
26	49/09	22	M	4	4	1	1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0		
27	55/09	49	F	4	4	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1		
28	58/09	38	M	4	4	0	0	0	0	0	0	0	4	1	1	0	0	1	1	2	2	2	2	2	2	2		
29	63/09	25	M	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
30	68/09	22	M	4	4	2	2	2	0	0	0	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1		
31	69/09	27	M	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
32	70/09	27	M	4	4	1	1	1	2	0	0	2	2	3	2	1	1	3	2	1	3	1	1	1	1	1		
33	73/09	48	M	4	4	2	2	2	0	0	0	2	2	1	1	2	2	1	1	1	1	1	1	2	2	2	2	
34	74/09	35	M	4	4	4	4	4	4	4	4	4	3	1	3	1	3	1	4	4	4	4	4	4	4	4		
35	77/09	25	M	4	4	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0		
36	81/09	50	M	4	4	2	2	2	0	0	0	3	3	2	2	3	3	3	3	4	4	4	4	4	4	4		
37	82/09	25	M	4	4	0	0	0	0	0	0	1	1	0	0	1	1	0	0	2	2	1	1	2	2	1	1	
38	83/09	28	M	4	4	2	2	2	0	0	0	2	2	0	0	2	2	0	0	1	1	1	1	1	1	1		
39	85/09	32	M	4	4	1	1	1	0	0	0	2	2	0	0	2	2	0	0	1	1	0	0	1	1	0	0	
40	86/09	20	M	4	4	1	1	1	0	0	0	3	3	0	0	4	4	0	0	1	1	1	1	1	1	1	1	
41	89/09	20	F	4	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
42	90/09	28	F	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
43	91/09	25	F	4	4	2	2	2	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
44	93/09	25	M	4	4	2	2	2	0	0	0	3	3	0	0	3	3	0	0	1	1	0	0	1	1	0	0	
45	94/09	21	M	4	4	1	1	1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	
46	96/09	35	M	4	4	4	4	4	2	2	2	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2	
47	97/09	28	F	4	4	1	1	1	0	0	0	1	3	2	2	1	3	2	2	4	4	4	4	4	4	4	4	
48	98/09	50	M	4	4	4	4	4	0	0	0	4	4	1	1	4	4	1	1	4	4	0	0	4	4	0	0	
49	100/09	29	M	4	4	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1	
50	101/09	42	F	4	4	2	2	2	0	0	0	3	3	0	0	4	4	0	0	2	2	2	2	2	2	2	2	
51	110/09	38	M	4	4	1	1	1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	
52	112/09	47	M	4	4	1	1	1	0	0	0	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	
53	114/09	20	F	4	4	2	1	1	1	1	1	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	
54	120/09	50	M	4	4	4	4	4	2	3	3	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2	
55	122/09	23	M	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
56	127/09	22	M	4	4	4	4	4	2	2	4	4	3	3	4	4	3	3	1	1	1	1	1	1	1	1	1	
57	128/09	20	F	4	4	4	4	4	1	3	1	3	3	1	1	4	4	1	1	4	4	1	1	4	4	1	1	
58	138/09	27	M	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
59	139/09	35	F	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
60	140/09	29	M	4	4	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	2	2	1	1	
61	141/09	26	M	4	4	1	1	1	1	1	1	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	
62	151/09	20	M	4	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
63	152/09	45	M	4	4	4	4	4	1	1	1	4	4	2	2	4	4	2	2	4	4	1	1	4	4	1	1	
64	153/09	35	F	4	4	1	1	1	0	0	0	1	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	
65	154/09	47	M	4	4	2	2	2	0	0	0	2	2	0	0	2	2	0	0	2	2	0	0	2	2	0	0	
66	155/09	35	M	4	4	4	4	4	1	1	1	4	4	1	1	4	4	1	1	4	4	1	1	4	4	1	1	
67	156/09	20	M	4	4	0	0	0	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	
68	159/09	26	M	4	4	1</																						

69	160/09	50	F	4	4	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
70	161/09	50	M	4	4	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1

Sl. No	AGE	SEX	METOPIC SUTURE		SAGITAL SUTURE			
			inner table	outer table	inner table			
					A\3	P\3	M\3	A\3
1	20	M	4	4	1	1	3	2
2	20	F	4	4	3	3	3	0
3	20	M	4	4	0	0	0	1
4	20	M	4	4	1	1	1	0
5	20	F	4	4	2	2	2	2
6	20	F	4	4	2	1	1	1
7	20	F	4	4	4	4	4	1
8	20	M	4	4	1	1	1	1
9	20	M	4	4	0	0	0	1
10	21	M	4	4	0	0	0	1
11	21	M	4	4	1	1	1	0
12	22	M	4	4	0	0	0	1
13	22	M	4	4	1	1	1	0
14	22	M	4	4	2	2	2	0
15	22	M	4	4	4	4	4	2
16	23	M	4	4	0	0	0	0
17	23	F	4	4	0	0	0	0
18	23	M	4	4	1	1	1	1
19	25	M	4	4	1	1	1	0
20	25	M	4	4	1	1	1	0
21	25	M	4	4	0	0	0	0
22	25	M	4	4	0	0	0	0
23	25	M	4	4	0	0	0	0
24	25	F	4	4	2	2	2	0
25	25	M	4	4	2	2	2	0
26	25	M	4	4	1	1	1	1
27	26	M	4	4	0	0	0	0
28	26	M	4	4	1	1	1	0
29	26	M	4	4	1	1	1	0
30	27	M	4	4	1	1	1	1
31	27	M	4	4	1	1	1	2
32	27	M	4	4	1	1	1	1
33	28	M	4	4	2	2	2	0
34	28	M	4	4	2	2	2	0
35	28	F	4	4	4	4	4	4
36	28	F	4	4	1	1	1	0
37	29	M	4	4	1	1	1	1
38	29	M	4	4	2	2	2	1
39	30	M	4	4	3	0	0	0
40	32	F	4	4	4	4	4	4
41	32	M	4	4	1	1	1	0
42	35	M	4	4	4	4	4	4
43	35	M	4	4	4	4	4	2
44	35	F	4	4	1	1	1	1
45	35	F	4	4	1	1	1	0
46	35	M	4	4	4	4	4	1
47	38	F	4	4	4	4	4	4
48	38	M	4	4	0	0	0	0
49	38	M	4	4	1	1	1	0

50	42	M	4	4	4	4	4	0
51	42	F	4	4	2	2	2	0
52	45	M	4	4	4	2	1	0
53	45	M	4	4	4	4	4	1
54	46	M	3	0	4	3	1	0
55	47	M	4	4	1	1	1	0
56	47	M	4	4	2	2	2	0
57	48	M	4	4	2	2	2	0
58	49	F	4	4	1	1	0	2
59	50	M	4	4	0	4	2	0
60	50	F	4	4	1	1	0	2
61	50	M	4	4	1	1	1	1
62	50	M	4	4	1	1	1	1
63	50	M	4	4	3	3	3	1
64	50	M	4	4	2	2	2	1
65	50	M	4	4	3	3	3	1
66	50	M	4	4	2	2	2	0
67	50	M	4	4	4	4	4	0
68	50	M	4	4	4	4	4	2
69	50	F	4	4	3	3	3	1
70	50	M	4	4	1	1	0	2

CORONAL SUTURE®

CORONAL SUTURE (L)

outer table		CORONAL SUTURE®				CORONAL SUTURE (L)			
P\3	M\3	inner table		outer table		inner table		outer	
		U\2	L\2	U\2	L\2	U\2	L\2	U\2	
2	2	1	1	1	1	2	3	3	
2	0	4	4	0	0	3	3	0	
1	1	0	0	1	1	0	0	1	
0	0	3	3	0	0	4	4	0	
2	2	2	2	2	2	2	2	2	
1	1	2	2	1	1	2	2	1	
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0	0	3	3	0	0	3	3	0	
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)	LAMDOID SUTURE(R)					LAMDOID SUTURE (L)			
	table	inner table		outer table		inner table		outer table	
		L\2	U\2	L\2	U\2	L\2	U\2	L\2	U\2
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	0	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	1
	1	4	4	1	1	4	4	1	1
	2	1	1	1	1	1	1	1	1
	1	0	0	1	1	0	0	1	1
	1	0	0	1	1	0	0	1	1
	0	1	1	0	0	1	1	0	0
	2	0	0	0	0	0	0	0	0
	0	1	1	0	0	1	1	0	0
	1	1	1	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1
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	1	1	1	1	1	1	1	1	1
	1	2	2	1	1	2	2	1	1
	1	2	2	1	1	2	2	1	1
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	1	0	0	0	0	0	0	0	0
	0	2	2	1	1	2	2	1	1
	1	1	1	1	1	1	1	1	1
	0	1	1	0	0	1	1	0	0
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	0	0	0	0	0	0	0	0	0
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	1	2	2	1	1	2	2	1	1
	1	1	1	1	1	1	1	1	1
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	1	1	1	1	1	1	1	1	1
	0	2	4	0	0	2	1	0	0
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	4	4	4	4	4	4	4	4	4
	2	4	4	4	4	4	4	4	4
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	1	4	4	1	1	4	4	1	1
	4	3	3	3	3	4	4	4	4
	1	2	2	2	2	2	2	2	2
	0	1	1	0	0	1	1	0	0

