

**“A CROSS SECTIONAL POSTMORTEM STUDY ON
CLOSURE OF SKULL VAULT SUTURES WITH RESPECT
TO AGE FROM 3RD TO 6TH DECADES OF LIFE”**

By

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Under the Guidance of

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I hereby declare that this dissertation entitled “**A CROSS SECTIONAL POSTMORTEM STUDY ON CLOSURE OF SKULL VAULT SUTURES WITH RESPECT TO AGE FROM 3RD TO 6TH DECADES OF LIFE**” is a bonafide and genuine research work carried out by me under the guidance of **Dr. KIRAN J**, Professor & Head, Department of Forensic Medicine And Toxicology, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award “**M. D. DEGREE IN FORENSIC MEDICINE AND TOXICOLOGY**”, the examination to be held in May 2017 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

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Dr. Raj Kumar M. G.



LIST OF ABBREVIATIONS

S	SAGITTAL
C	CORONAL
L	LAMBDROID
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
r	CORRELATION COEFFICIENT
t-test	STUDENT'S T TEST

ABSTRACT

Background: 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 from 3rd to 6th decades of life in Kolar region of South india.

Aims and Objectives: To find out the pattern of cranial vault suture closure with respect to age in 3rd to 6th decades of life in Kolar region of South india .To document bilateral and gender variations in cranial suture closure if any and to find out the earliest age of fusion of individual sutures of the skull.

Methodology: This study was conducted in the mortuary of R.L.Jalappa Hospital and MRC, KOLAR on dead bodies coming for medicolegal post-mortem examination, during the period of 1st December 2014 to 30th June 2016. Coronal, sagittal and lambdoid sutures of 150 subjects of age 21-60 years were studied. Acsadi and Nemeskeri method was applied to both endo and ectocranial sides of the sutures. Photographs were taken in every case. A predesigned proforma was filled up for every case, master chart was prepared. Cases were stratified into 10 year groups. The results obtained after statistical analysis were analysed and compared with the works of previous authors.

Results: The study consisted of 150 cases brought to the mortuary of R.L.Jalappa Hospital and Medical Research Center, Kolar, during the period of Decmeber 2014 to June 2016. The age of the victims varied from 21 to 60 years. Age groups were classified 10 year interval so as to test accuracy of method based on different age

groups and to compare with the previous studies. Majority of subjects in the study were in the age group 21 to 30 years (33.3%), followed by 31 to 40 yrs (24.7%), 41 to 50 years (22%) and 51 to 60 years (20%). In our study, out of 150 cases there were 41 females and 109 males. When comparison between male and female subjects were made, closure was earlier in males (Mean 7.56 vs. 6.68 in case of endocranial suture closure & 5.21 vs. 4.26 in case of ectocranial suture closure). When comparison was made between sagittal, coronal and lambdoid suture, overall coronal suture closes early followed by sagittal and lambdoid respectively. 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. Right and left side of coronal and lambdoid sutures were compared both ectocranially and endocranially, there were no significant difference after applying student 't' test ($P \text{ value} > 0.05$). It implies that there is no bilateral variation in ectocranial and endocranial suture closure.

Conclusion: Cranial suture closure is yet a fairly reliable method for age estimation. In the present study we tried the possibilities for suture closure to contribute to one of the essential foundations of Paleodemography: age estimation. In our study suture obliteration starts earlier on endocranial surface than on the ectocranial surface and males showed earlier union than females. There is no significant variation in suture closure of right and left sides of coronal and lambdoid sutures, both ectocranially and endocranially. Endocranially and Ectocranially-coronal suture closes earlier followed by sagittal and lambdoid. Our analyses strengthen the view that, there is a significant relationship between suture closure and

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INTRODUCTION

Age estimation, either in living, dead or human remains, is a complex problem in medical justice in both civil and criminal matters such as identification, senior citizen concession, retirement benefits, competency as witness, attainment of majority, marriage, impotency, sterility, consent, juvenile offender, kidnapping, rape etc. In general, age estimation is done by team of forensic expert and radiologist. If proper opinion regarding the age is not given then injustice may occur to the patient. Age estimation by means of closure of skull sutures is a very important tool to solve above mentioned cases. Meanwhile in the application of most of the methods all over the world, inter-population differences have been revealed. Therefore, testing the adequacy of the used methods on local populations is highly recommended.^{1,2}

Question of identification arises in everyday of medico legal practice both in civil and criminal cases. The examination of human remains by the forensic anthropologist focuses on identifying the victim or at least providing a biological profile (age, sex, stature, ancestry, anomalies, pathology, individual features). As age determination is one of the very important aspects in forensic identification, therefore, various methods are used to estimate age at death, such as in the sub-adult group; long bone lengths, appearance of primary and secondary ossification centers (usually by X-ray), epiphyseal union, tooth formation, and tooth eruption have long been studied and proved useful. In adults; pubic symphyses, auricular surface, sternal rib ends, cranial suture closure, dental changes and histological methods were also mentioned in various studies. Some were widely used as standard procedures for data collection from human skeletal remains, and cranial suture closure is one of them although it has a long and controversial history.³

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. (Among all these, the work of Forensic Expert requires special attention because the findings are directly related to the administration of the justice and the expert's 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 to 6th 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 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.^{4, 5.}

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.^{6, 7.}

Studies regarding age estimation from changes in skull vault sutures are mostly conducted in abroad countries. Only handful of studies has been conducted in India, and data on heterogeneous population of south Indian region is virtually

non-existent. Therefore, this study is intended to find out the pattern of cranial vault suture closure in 3rd to 6th decades of life with respect to age and sex of an individual.

OBJECTIVES

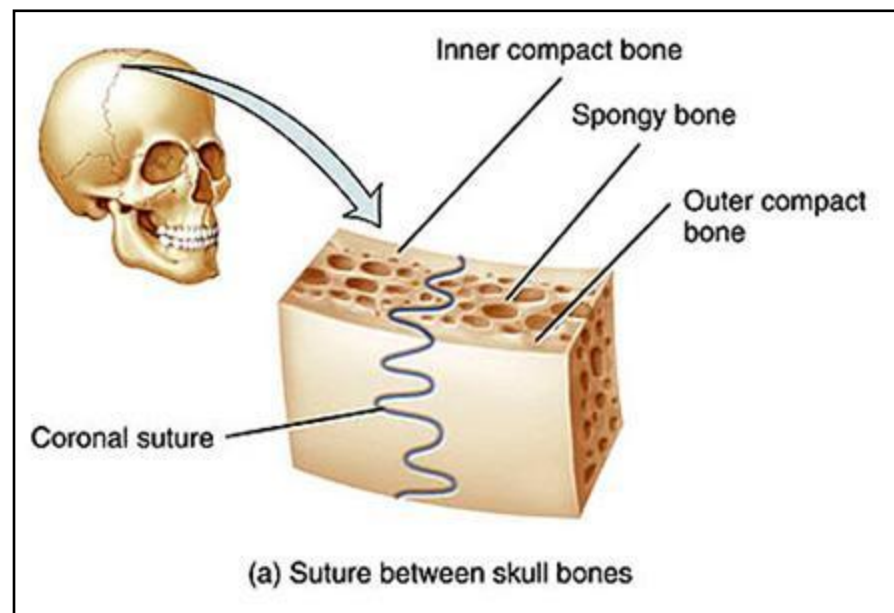
1. To find out the pattern of cranial vault suture closure with respect to age in 3rd to 6th decades of life in Kolar region of South India .
2. To document bilateral and gender variations in cranial suture closure if any.
3. To find out the earliest age of fusion of individual sutures of the skull.
4. To compare patterns of closure of skull suture region wise with available data of previous work of different workers in India and abroad.

REVIEW OF LITERATURE

Structure and Development

The human skull or cranium consists of 22 bones (eight paired and six unpaired), which are separated by at least 24 easily observable sutures (McKern 1957, Bass 2005). Cranial bone consists of three layers (Jaslow 1990). The inner and outer layers (*tabula interna* and *tabula externa*) are compact bone and the middle layer is cancellous, called the *diplöe*. Bones adjacent to one another are joined together by collagenous connective tissue fibers within the sutures. 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. (Figure.1).⁸

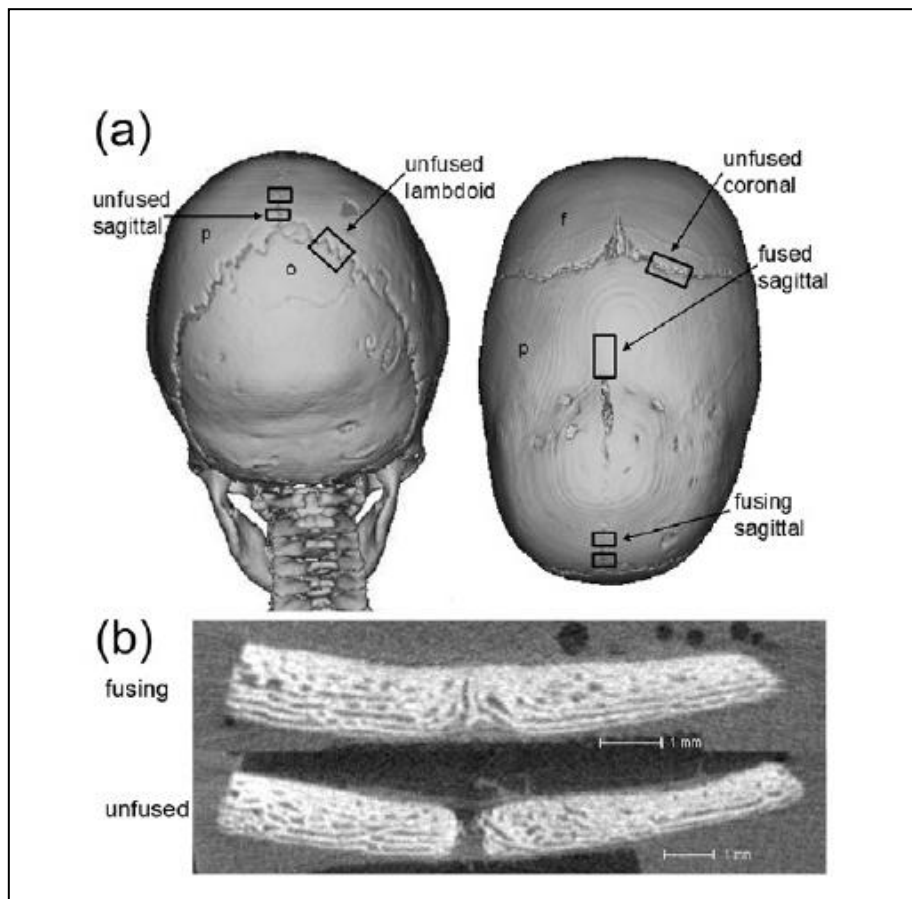
Figure 1. Anatomy of cranial sutures



The sutural ligament is a thin layer of dense connective tissue found between the flat bones of the skull after growing together. An infant's skull is incompletely developed. The bones are connected by membranous areas called fontanels, which allows the child's skull to change during childbirth. Sutures are synarthrotic joints

meaning they are immovable. 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 (Figure.2).⁹

Figure 2. (a) Macroscopy and (b) Cross section of fused and unfused cranial sutures



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.¹⁰

The morphology of the sutures, though variable, becomes more complex with age as interdigitation, the formation of ossified processes between the two bones, occurs. When the two adjacent bones become interlocked, the joint is no longer movable. Such a trend from openness to interlocking joints is due to the effect of mechanical forces and other factors (Jaslow 1990, Sabini and Elkowitz 2006). In some individuals, however, lapsed union can occur, in which the sutures do not completely close and ossification of the separated ectocranial bone edges occurs (Todd and Lyon 1924, Krogman and Iscan 1986). Generally, cranial bone tends to become thinner with age, but internal bone growth can occur, causing a thickening of the skull (Ashley-Montagu 1938). The variability of suture closure and morphology is rather great. Premature obliteration, asymmetrical suture closure, wormian bones and interdigitations will be discussed further as they are common types of suture variations.¹¹

Premature Obliteration

Premature obliteration, or craniosynostosis, is a condition in which cranial sutures close at an earlier age than normal. If this occurs in children, normal brain and skull growth is inhibited and the skull will exhibit a deformity. For example, early

closure of the sagittal suture leads to the deformity of the skull known as scaphocephaly. Bolk (1915) reported on the premature obliteration of sutures in 1,820 non-adult skulls. He placed the skulls into seven age groups (from three years to adult) based on their dental development and found that the masto-occipital suture was obliterated ten percent of the time across all groups and ten percent in infantile individuals. The sagittal suture was closed prematurely occasionally (2.5 percent) but, after the seventh year, would often remain open even to eighty years of age. Obelion was always observed as the point of suture commencement for the sagittal suture, but the coronal suture was more irregular and asymmetrical in its closure. Premature obliteration of the coronal suture is also much less frequent, occurring less than one percent of the time in Bolk's sample, and the squamosal suture exhibited premature synostosis even less frequently than the coronal. Premature obliteration of sutures, Bolk concluded, is based on physiological, and potentially genetic factors, but not pathological ones. Premature synostosis of the sagittal suture is the most common of craniostenoses in modern populations, representing 60 to 78 percent of the total (White 1996). It is three times more likely to occur in males than females. Several factors, including genetics, metabolism, teratogens and congenital syndromes, such as Apert's and Crouzon's, have been suggested as possible causes for sagittal synostosis. It is also commonly thought that sagittal synostosis is related to cranial base deformation or an early descent of babies prenatally, resulting in constraint of the head against the pelvis. Craniostenoses in skeletal populations have received little attention but White reported a high frequency among Maya Indians as a result of cranial modification. Premature sagittal synostosis was present in both deformed and undeformed skulls, but was highly correlated with fronto-occipital cranial deformation, an anteroposterior deformation resulting in flattened frontal and occipital

bones, laterally bulging parietals, and a depression along the sagittal suture. The percentage of sagittal synostosis within both groups was significantly higher than that found in modern populations.¹²

Asymmetry

Asymmetrical suture closure is defined as uneven closure on the left and right sides of the skull. Sauvage (1870) observed asymmetrical suture closure in the lambdoid and coronal sutures and suggested that the right side closes before the left (Parsons and Box 1905). Parsons and Box (1905), however, found that asymmetry typically commences and proceeds in the opposite direction, from left to right. Todd and Lyon (1924) reported that suture closure commences on the endocranial surface and then spreads unevenly through the rest of the skull. For the few decades that followed, scarce attention was given to asymmetrical suture closure and its importance to age-related studies (Ashley-Montagu 1938, Zivanovic 1983). Ž Zivanovic (1983) recorded observations of the left and right sides of the coronal and lambdoid sutures, both endocranially and ectocranially, on East African Bantu skulls and European skulls. Pars bregmatica and pars complicata of the coronal suture and the “intermediate portion” of the lambdoid suture were the most asymmetrical. Asymmetry was very common and similar in both populations and sexes. Ž Zivanovi points out that if obliteration occurs in only one side of the skull, that side should be interpreted as premature synostosis and be discarded from any age estimation. Therefore, he advises that age estimation, when only one side of a skull is available, could lead to erroneous information. Asymmetrical closure was most common between 41 and 55 years. Baker (1984) found asymmetry most predominately in individuals from 36 to 40 years and 61 to 65 years of age. Generally, it is accepted that symmetry is predominant over asymmetry (Hauser et. al 1991), though

asymmetrical suture closure is not abnormal or rare (28 percent in Baker's study (1984)). Asymmetry can commence on either side with no significant bias for one side over the other (Baker 1984, Key et. al 1994).^{6,13,14,15,16}

Wormian bones

Wormian bones are defined as small ossicles of irregular size and shape located within the fontanelles and the two borders of cranial sutures (White 1996:398).” They are primarily found, from zero to over 100 in number, in the lateral and posterior vault. The presence of wormian bones is variable but typically quite high. What factors are involved in wormian bone formation has been brought into question. Some have attributed wormian bones to heredity, others support extrinsic factors, such as hydrocephaly or mechanical stress, and some support the imposition of both nature and nurture. Many authors have reported on an association between increased sutural complexity (wormian bones, interdigitations, etc.) and external stresses (Sabini and Elkowitz 2006).Cranial deformation has been shown to impact the presence of wormian bones as well. A significantly higher number of wormian bones have been found in rats with experimentally deformed skulls (White 1996). Anton (1992) found an increase in wormian bones of antero-posteriorly deformed skulls. In White's study (1996) on 143 adult crania from Laminai, Belize, wormian bones were present in 46 percent of normal skulls and 88 percent of the deformed crania. It is suggested, therefore, that wormian bones have both genetic and environmental causes.^{17,18}

Interdigitations

Cranial sutures begin as simple and straight structures, but they become more complex, developing interdigitations, through growth and bone resorption (Sabini and Elkowitz 2006). Evidence has demonstrated that interdigitations form to aid in the

transmission of forces from one bone to another. Increased surface area and more complex interdigitations of the suture facilitate displacement of large forces. Jaslow(1990) set out to determine how mechanical properties affect the skull in relation to the proximity and presence of cranial sutures as well as degree of interdigitation of the sutures. The mechanical properties, bending strength and impact energy absorption, were tested on goat crania. Results showed that sutures have lower bending strengths than bone but absorb more energy. Highly interdigitated sutures loaded slowly are as strong as bone and also absorb more energy than simpler sutures. It is suggested that the increase in bending strength and energy absorption of highly interdigitated sutures is due to the presence of additional collagen fibers across the joint and an increased surface area of the joint.^{18,19}

Factors: Environmental and Genetic

The human body is highly adaptive and has led some authors to emphasize that it is very unlikely for age to be the only factor affecting suture closure (Key et. al 1994, Sabini and Elkowitz 2006). White (1996:406), for instance, concluded that sagittal synostosis and wormian bones are “adaptive responses to abnormal forces.” Intrinsic and extrinsic factors, such as genetics, tensile forces, the growing brain, and muscle stresses, play a role in suture obliteration and morphology (Hauser et. al 1991). The effect of mechanical stress on suture closure has been well documented. When stress is applied to sutures, as studied in rats, they react by becoming more complex (Hauser et. al 1991, Sabini and Elkowitz 2006). Suture closure, therefore, is attributed to a presence or lack of physical force on the bones of the skull, with one of these factors being muscle tension. Sabini and Elkowitz (2006) reported observations on the coronal, lambdoid, and sagittal sutures of 36 skulls. The lambdoid suture remained open most often. The authors suggest that the continued patency of the

lambdoid suture is a reaction to the large number of muscles and ligaments attached to the occipital bone (myofascial continuity). Additional evidence to support this hypothesis comes from the facial sutures, which tend to be more complex (serrated and interdigitated), remain open longer than the cranial sutures, and are more affected by muscles. On the opposite end, very few muscles affect the sagittal suture, and the tension from those that do may be easily displaced to the coronal or lambdoid sutures. Herring and Teng (2000) attached strain gages to the frontal and coronal bones of seventeen miniature pigs, and the strains were recorded during stimulation of the cranial muscles used in mastication. The authors suggest that patent sutures contribute to the flexibility of the skull and aid in energy absorption. Strain on the braincase was observed as a definite result of muscle contraction. The vault sutures had the highest strains, but all sutures showed strain during jaw closing. The authors also identified that the skull tends to bend at the sutures, with the ectocranial surface tensed and the endocranial compressed. Though the findings were on pigs, this data may be applied to primate studies because of the similar arrangement and size of their masticatory muscles.

The evidence that the development and growth of sutures are strongly affected by tensile forces exhibits how important it is to account for environmental factors in cranial suture closure studies. Genetic factors should also not be overlooked. For instance, HersHKovitz et. al (1997) identified a hereditary basis for suture closure by discovering a predominance of Double Y suture closure in American Black males as compared to American White males. The authors also addressed the question of whether suture closure is normal or pathological. At the beginning of the 20th century, British and Italian schools of thought differed in regards to suture closure. The British model emphasized the obliteration of the sutures as a normal process of

age and became dominant in physical anthropology over the Italian model (suture closure as pathologic) due to dependence on the English language. Their findings indicated that suture closure is non-pathological and is, therefore, more likely genetically based.^{17,19, 20,21,22,23}

Function

Though many factors may affect the rate of suture closure and the complexity of sutural patterns, little is known as to the exact functionality of suture closure and its various states. During brain growth, sutures allow movement to occur between bones and, upon closure, sutures create an immovable joint that absorbs energy and prevents separation of the bones when externally impacted (Zambrano 2005). However, this does not explain the function, if any, of sutures that stay open long after full growth has been reached. This question has led investigators to address the evolutionary basis of suture closure.²⁴

Evolution

If a selective mechanism for cranial suture closure exists, it could only be discovered and explained through observation of suture closure in humans, fossil remains, and our closest extant relatives, the anthropoid apes, and by determining the function of suture closure, which to this point has been elusive (Key et. al 1994). Several authors have undertaken cranial suture closure studies in mammals, primates, and humans and commented on the possibilities of an evolutionary condition of suture closure.²⁰

Bolk (1915) reported on the obliteration of sutures in 800 platyrrhine and catarrhine monkey and ape skulls. He found that, in humans, the principal sutures are open somewhat independently of skull formation. Conversely, suture closure in apes usually follows immediately the cessation of skull growth and, therefore, obliteration

is reached before the individual reaches an adult state. The higher predominance of premature synostosis in apes is most likely due to the strong forces exerted by large muscles of mastication. Furthermore, obliteration of the sutures commences upon cessation of brain growth in apes but often is delayed until long after brain growth has ceased in humans. Bolk concludes, therefore, that the condition of sutures to stay open in man is an evolutionary adaptation whereas premature obliteration is an example of an atavistic, or primitive, phenomenon.¹²

Typical mammalian suture closure begins with the vault, followed by the sphenoccipital, circummeatal, palatal, facial, and cranio-facial sutures (Krogman 1930, Schweikher 1930). In primates, this sequence begins to change. Krogman (1930) reported on the sequences of cranial and facial suture obliteration in eight species of primates, including gorillas, chimpanzees, orangutans, gibbons, baboons, and macaques. He adopted Todd and Lyon's method of suture closure on humans, observing both endocranial and ectocranial surfaces. The vault was the site of earliest union in *Papio*, *Pongo*, and *Gorilla*. In chimpanzees (*Pan*), though closure is similar to that found in all the other primates, especially gorillas, delayed closure of the cranial sutures, similar to what is expressed in humans, was found. *Gorilla*, *Pan*, and *Homo* all show a trend towards earlier closure of the facial sutures. Gibbons exhibited a delayed closure of the circummeatal sutures, a first stage of human-like closure, and a uniformity of closure in the vault sutures, of which the other great apes "break away (Krogman 1930:329)." The non-ape species showed earlier onset of closure for all cranial sutures. Suture closure sequences on the endocranial surface differed from those observed for the ectocranial surface. In primates, similar to what Todd and Lyon suggested for humans, the direction of suture closure is often reversed from the endocranial to ectocranial surfaces. Males seemed to express a slightly accelerated"

suture closure, which is consistent with data on humans, but no major sex differences were noted.^{6,25,26}

Falk et. al (1989) scored suture closure on skull endocasts of 330 rhesus monkeys (*Macaca mulatta*). The endocranial and ectocranial scores were compared to those found for humans, by Todd and Lyon (1924-25) and Meindl and Lovejoy (1985) respectively. A strong relationship between age and suture closure was observed for the macaques, but, like in humans, the relationship tends to dwindle in older individuals. Humans and macaques were more similar in the order of sutural obliteration than commencement of suture closure, but exhibited several key similarities and differences. The basilar suture is first to close in both species, but the sphenofrontal and rostral squamosal sutures close much faster in rhesus monkeys. The retarded closure of the sphenofrontal suture in humans (ten times slower than macaques) is possibly related to brain size, specifically the expansion of the frontal lobes and/or temporal poles. No significant sexual dimorphism was found in relation to suture closure. A small but significant amount of asymmetry, with closure starting on the right then proceeding to the left, was observed. Echoing authors on human suture closure, Falk et. al (1989:426) conclude that suture closure should be “used with caution ”for estimating age in macaques and is not useful for aging older macaques.^{6,27,28}

In *Homo sapiens*, Perizonius (1984) found a negative correlation for suture closure and age for individuals over the age of 70. He suggests that an underlying mechanism could be present that keeps sutures from closing in individuals that reach extreme ages. Cranial suture closure, therefore, could be part of a selective process that allows some individuals to grow older than others. Masset (1989:99) thought that a secular trend for suture closure, based on a move to sedentary life, was possible in

populations separated temporally. HersHKovitz et. al (1997) pointed out that though data does not exist to clearly identify an evolutionary advantage (form of selection) of suture closure in humans, degrees of suture closure do represent a biological adaptation (or lack thereof) for absorbing mechanical stresses, with open sutures capable of more efficiently absorbing stress (Jaslow 1990, HersHKovitz et. al 1997). Key et. al (1994) criticize the assumption that age and suture closure represent a strictly linear relationship because it implies a lack of selective value. If selection were at work in conferring maximum fitness in individuals, then the most suited individuals would be those who retain open sutures throughout life. However, since evolution has ensured that most humans have open ectocranial sutures up to the age of about 30, even those individuals who undergo complete sutural obliteration are still capable of passing on their close suture genes to their offspring, allowing a wide degree of suture closure variability to advance into further generations (Key et. al 1994:206).^{7,18,20,23,29}

Cranial Suture Closure Studies

The most commonly studied aspect of the cranial sutures is the degree of their obliteration as an indicator of age. Observations of cranial suture closure were first observed as far back as the 1st century in the work of Hippocrates, but were not utilized as an “identification tool” with relation to age until a much later date (Todd and Lyon 1924, McKern 1957). Vesalius and his pupil Fallopius are credited for first noting the apparent progression of suture obliteration with age in 1542 (Todd and Lyon 1924, Ashley-Montagu 1938, Singer 1953, Masset 1989, HersHKovitz et. al 1997). Despite some early descriptions of the variability of cranial suture closure, scientific studies addressing its relationship with age have been published in great number from the 19th Century to present (Parsons and Box 1905). In America, the

standards established by Todd and Lyon (1924) and, later, by Meindl and Lovejoy (1985), propelled the usage of cranial suture closure for determining the skeletal ages of both forensic and archaeological material. This continued popularity may simply be wrapped up in its history; it has survived not due to its validity but rather the idea that, if it has been studied for so long, surely there has to be something to it, and thus it becomes a traditional research obsession (Hershkovitz et. al 1997). Though the history of cranial suture closure studies has been discussed elsewhere in great detail, I will attempt to summarize, in chronological order, the methodologies and conclusions of previous studies spanning the last 160 years. The relationship between cranial suture closure and age, sex, and group affiliation will be discussed, with the greatest emphasis on age, the primary consideration of almost all suture closure studies. Studies on cranial suture closure as part of a multifactorial approach are also summarized.^{6, 7,23,28,30}

Age and Suture Closure

1856-1920: Early Studies

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.⁶

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.⁶

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: 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.⁶

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 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.⁶

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.³¹

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.^{6, 31}

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.^{6,13.}

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.^{6, 31}

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.^{6,32-34}

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'.³²

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.^{6, 32,33,34}

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.¹⁹

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”.⁶

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.³¹

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.⁶

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.^{6, 31}

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.⁶

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].

6, 31, 32,33

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.⁶

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.³⁵

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".⁶

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.³²

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.^{6,32,33,34}

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.³⁴

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.³⁴

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.³⁶

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, the some of the skeletons employed by Todd from the Hamann Museum collection were used for review.

6,32,33,34

1950-57: New studies on different populations

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.³¹

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.⁶

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.²⁸

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.^{30,31}

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).³¹

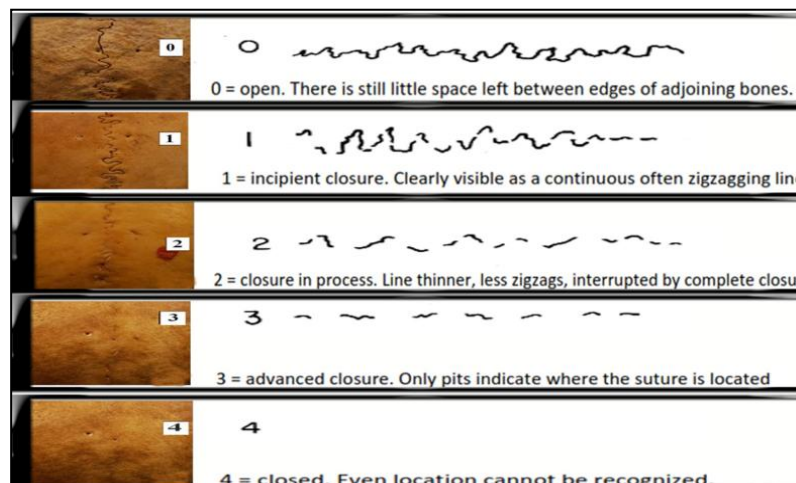
Krogman provided the following cranial morphological age sequence: 1) from the age of 25, muscular markings become increasingly evident, especially on the temporal, occipital and on the lateral side of the mandible; 2) around 35 to 45 years, the surface begins to assume a matted, granular appearance; 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.³¹

1960-1985: Complex and Revised Methods

In 1960, Nemeskéri et. al developed the “complex method” for cranial suture closure (Acsádi and Nemeskéri 1970, Krogman and Iscan 1986). A multifactorial” approach, four areas of the skeleton were utilized, the pubic symphysis, femoral head, humeral head, and endocranial sutures. The ectocranial sutures were later observed as well (Acsádi and Nemeskéri 1970). 16 sections of the vault sutures were used (three on coronal, four on sagittal, and three on lambdoid). A modified version of Broca’s system (using Martin’s scale) with less discrete boundaries was applied (Figure.3).³⁷

Figure .3 Acsádi and Nemeskéri Scoring System



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.^{6,32-34}

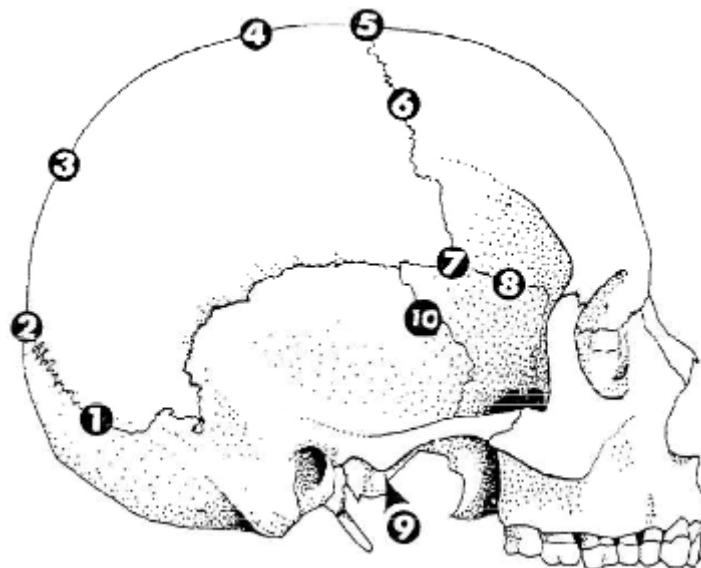
Meindl and Lovejoy thus chose 17 ectocranial points for 236 crania from the Hamann-Todd collection, based upon the reliability of stated age at death. Seven of these sites were later rejected based on a lack of association with age, openness to extreme age, poor interpretability of the site, asymmetry, and other factors. The remaining ten landmarks were placed into two groups, labeled the vault and lateral anterior systems (Table 1, Figure 4). Composite scores for each system were calculated.²⁸

Table 1
Cranial Landmarks and Systems (after Meindl and Lovejoy 1985:59)

Vault	1	Midlambdoid	Midpoint of each half of the lambdoid suture
	2	Lambda	The intersection of the sagittal and lambdoidal sutures in the midline ²
	3	Obelion	At obelion (in “pars obelica” of the sagittal suture); point on the sagittal suture located at the level of the parietal foramina near the lambdoid suture
	4	Anterior Sagittal	Point on the sagittal suture at the juncture of the anterior one-third and posterior two-thirds of its length
	5	Bregma	The intersection of the coronal and sagittal sutures, in the midline ²
Lateral Anterior	6	Midcoronal	Midpoint of each half of the coronal suture
	7	Pterion	A region of the upper portion of the greater wing of the sphenoid, usually the point at which the parietosphenoid suture meets the frontal bone
	8	Sphenofrontal	Midpoint of the sphenofrontal suture
	9	Inferior Sphenotemporal	Point on the sphenotemporal suture lying at its intersection with a line connecting both articular tubercles of the temporomandibular joint
	10	Superior Sphenotemporal	Point on the sphenotemporal suture lying 2 cm below its juncture with the parietal bone

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, spheno-frontal, inferior spheno-temporal and superior spheno-temporal). Meindl and Lovejoy found a chronological age ranking at the pterion, spheno-frontal, midlambdoid and lambdoid, respectively. These were based upon the assumption of underlying continuity of ordinal closure scales (the Kendall coefficient).²⁸

Figure 4. Location of cranial suture landmarks (from Meindl and Lovejoy 1985).



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.²⁸

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.²⁸

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.¹⁹

1985-2005: After Meindl and Lovejoy

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.²⁸

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.²³

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.³⁸

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.³⁸

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.³⁸

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).³⁸

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.²³

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.^{37,38}

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.²⁹

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.²⁸

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.²⁸

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.³⁷

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.³⁷

21st century research

In 2002 Verma RK, conducted a study to determine the age of individual in the fourth decade to seventh decades by correlating radiological findings of various views of skull along with the other physical findings. This prospective study was conducted in department of Forensic Medicine and Toxicology of S.M.S. Medical College &

Associate Hospital, Jaipur with the age group of 30-35yrs , 36-40yrs, 41-45yrs, 46 - 50yrs, 51-55yrs, 56-60yrs, 61-65yrs, 66-70yrs, 71-75yrs, 76-Onwards. Study concluded with the inference regarding Male subjects (67%) are that Coronal Suture the fusion occurred in the lower part of this of suture at the age of 42-44 yrs and then proceed to upper 1/2 part at the age of 52yrs. Squamosal Suture - This suture is visualized in lateral view of skull x-ray only, it get fused at the age of 80 yrs. Important Inference regarding Female subjects (33%) are that Coronal Suture - the lower ½ part of this suture get fused at the age of 42-44 yrs and is followed by upper ½ part, which is found fused at the age of 56 yrs. Squamosal Suture-appreciable fusion occur at the age of 81 yrs.⁴⁰

In 2004, pradeep et al researched to determine the age in old individual by CT scan, in his study 100 cases with age of 40 to 70 years were taken. This study was carried out to estimate timings of suture closure with help of axial sections at different levels of suture of skull on CT scan. The closures of lambdoid, parieto-mastoid, coronal and squamous sutures were studied and grading was done depending upon closure of sutures. Each suture was found to close at particular age group. Each individual was exposed to CT scan and 3 axial sections (cuts) were taken for each individual. Each suture was found to close at particular age group. Like lambdoid by 40years, parieto mastoid by 45years, squamous by 45years and coronal by 40 years.¹

In 2005, Sanhi D et al conducted a study regarding time of closure suture in northwest Indian adults by conducting autopsy in 535 male and 127 female adults of known ages belonging to Chandigarh zone of northwest India. In this study the sagittal suture was divided into four segments and each side of coronal and lambdoid suture into three segments. Whether a segment was open or closed on either surface was recorded. On analyzing the record the study concluded that obliteration of sutures

commences earlier in males than in females, suture obliteration starts earlier on endocranial surface than on ectocranial and commencement and complete obliteration of segment or the entire suture is so erratic that it is not useful for estimating the age of a skull.³⁹

In 2007 Banchong j et al conducted a study regarding cranial suture closure and age determination in order to determine whether the time of cranial suture closure in the Thai population has changed compared to findings in the past or not. And to check any difference between sexes, also to determine the difference between the time of ectocranium and endocranium closure and their reliability for age determination in the Thai population. The time of closure of the sagittal, coronal and lambdoid sutures was studied in 166 crania (known age Thai adults, 30 females and 136 males) for which the medicolegal autopsies were performed at the Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, during the year 2006, age range between 15 to 83 years old. The sagittal suture was divided into four segments and those of each side of the coronal and lambdoid sutures into three segments. The degree of suture closure was recorded for endocranial and ectocranial sides. The sum of all endocranial suture scores, which were also defined as composite scores, were divided into 7 stages (designated as S0-S6). The graph showing the association between chronological age and endocranial composite scores was plotted. The correlation coefficient, chi-square tests, and independent t test were used for statistical analysis, P-value <0.05 was statistically significant. Study found that the Thai new generations ectocranial suture closure starts and completes earlier than those in the past while endocranial sagittal suture closure starts and completes at a similar time as found in the past. Endocranial sutures start closing before ectocranial and endocranial closure is more related to age than another and no difference between

sexes could be found. Using the closure of each suture separately to determine the age at death, somehow, may not be appropriate while using the sum of suture scores reduces variations. The sum of endocranial suture scores (composite scores) are statistically proven to be most related to age without significant statistical difference between the two sexes. The association between age and the interval of composite scores was shown and suggested to be the age predicting tool. And study concluded saying the time of cranial suture closure is stated as one of indicators of age at death but its progression varies greatly. According to the study, using composite scores helps in diminishing this variation. The information on suture closure is useful when other criteria are not available or when being used in conjunction with other attributes.⁴¹

In 2007 Gaur VB et al, conducted a study 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.⁴²

In 2009 Alves JC et al ,conducted research on Sagittal Suture of the Human Cranium and the Time of Closing, with objectives; to examine the ossification of the external surface of the sagittal suture, observing eventual differences due to age, sex and ethnic group. Research material consisted of 88 dry craniums of variable ages, both sexes belonging to the ethnic groups: white and black. In the study they observed that: with progression of age, the relation between age and stage of ossification of the sagittal suture stops existing. The statistical analysis didn't demonstrate significant differences between sexes and ethnic groups in the stages of ossification of the sagittal suture. The ossification of the sagittal suture starts developing from the posterior third.⁴³

In 2009, shetty U conducted a descriptive cross sectional study of cranial suture closure at autopsy for estimation of age study was conducted on cases in New Delhi. Study showed better estimation of age not only morphological but also histological age indicators may be used. There was limited relationship between suture closures, at least above 40 years of age seem to be dependent on factors other than biological aging, and these factors can dictate fast closure or persisting nonclosure. Our analyses strengthen the view that regardless of scoring method, there is only a very loose association between suture closure and age, and this poses a real problem in terms of practical use for age determination. Researcher has emphasized the importance to refine the methods of quantifying the structures, in order to render the methods of quantification as unbiased as possible. 1) Ectocranial suture closure could not be used for age estimation. Lapsed union is a major deterrent for age estimation. It was pronounced in coronal suture. 2) Suture obliteration started earlier

on endocranial surface than on the ectocranial. 3) There was some correlation between endocranial suture closure and age upto 40-50 year's age group, there after there was no significant correlation.⁴⁴

A study was conducted in 2011 by Alexandra B, on age assessment from cranial suture closure with the goal to determine if significant sex or ancestry differences exist in the rate of cranial suture closure, to test the rates of intra-observer and inter-observer error associated with cranial suture closure as a method of age assessment, and to compare the age distribution of a sample from the Pima County Office of the Medical Examiner derived from cranial suture closure to the known age distribution of a separate sample from the same location published by Anderson (2008). A modern, representative sample of individuals from the Forensic Anthropology Data Bank Collection were statistically analysed, which include independent samples t-tests and analysis of covariance. The results indicate that sex and ancestry differences are not significant for this sample. Rates of intra-observer error are high for individual suture locations, however rates for the vault and lateral-anterior systems are only 10% and 20%, respectively. The results of the PCOME test suggested a tendency of cranial suture closure to overage.⁴⁵

In 2011 Goyal M K et al , researched regarding Comparison of Lambdoid Suture Closure by X-Ray and CT scan in Two States of India here comparison was done for closure of squamous suture of skull of living individuals from Punjab and Rajasthan. The cases studied in Punjab were 100 individuals between the age group of 45 years to 70 years with age interval of five years and twenty cases from each age group were studied who were CT scanned for closure of squamous suture at Punjab. In Rajasthan X-ray examination of 100 individuals was done having age group 40 years to 70 years with age interval of ten years in male and female separately for

squamous suture closure and accordingly the squamous suture is divided into 2 parts- (1) Upper half($\frac{1}{2}$), (2) Lower half ($\frac{1}{2}$). In both studies, squamous suture was studied ectocranially. It was seen that endocranially suture closure did not give reliable results and sometimes endocranially sutures remained unfused for whole life. No differences in right or left side of squamous suture was reported by Todd and Lyon. Occasionally there was considerable sclerosis and condensation along the various sutures, particularly sagittal, squamous and coronal suture.⁴⁶

In 2012 Kumar et al, conducted a Cross Sectional Postmortem Study on Fusion of Skull Vault Sutures in Relation to Age- in 3rd, 4th & 5th Decades of Life. Mainly to find out the pattern of cranial vault suture closure in relation to age in 3rd to 5th decades of life; to detect bilateral and bisexual variations in cranial suture closure; and to specify any relationship between progression of union of cranial suture and age. Cross-sectional observational study was done November 2008 to October 2009 with sample size of 70. All the autopsy cases, between 21 to 50 years of age were studied for relation between age and cranial suture closure. Ectocranial and endocranial closure pattern were studied for sagittal coronal and lambdoid sutures. It was found that Endocranial fusion of cranial suture was more regular than ectocranial fusion, and was observed as early as 21-30 years. Coronal suture was the first to fuse. Closure was found earlier in females compared to males. No definite correlation was found to exist between age and suture closures. Researcher couldn't find any possibility for suture closure to contribute substantially as one to the factors for age estimation.⁴⁷

In 2012, Parmar and Rathod.,GB conducted a study to determine the age by study of skull sutures and comparing the age with standard data mentioned in different textbooks and previous studies. Study was based on closure of skull sutures among 220 cases between age group of 15 - 70 years with age interval of 5 years and

20 cases from each age group were studied, who were exposed to digital X-ray of skull for closure of suture ecto-cranially for age estimation. The closure of sagittal, coronal, lambdoid, parieto-mastoid, parieto-temporal (squamous) and baso-occiput with baso-sphenoid sutures were studied and compared with standard data mentioned in different textbooks and previous studies. Age of each individual studied was confirmed from birth certificate, service record, driving license, passport, ration card or voter's card. It was reported that each suture was found to close at particular age group. Suture closure occurred for sagittal, lambdoid, coronal, parieto-mastoid, parieto-temporal and baso-occiput with baso-sphenoid at age group of 50-60 years, 45-55 years, 50-60 years, 55-70 years, 60-70 years and 18-25 years respectively. And the study concluded that age of closure of sagittal, coronal, lambdoid, parieto-mastoid, parieto-temporal and baso-occiput with baso-sphenoid suture was matching with standard data given in most of the textbooks and other studies. Sutures closure occurred from their endo-cranial to ecto-cranial aspects. Closure of skull sutures occurred earlier in male than in females. The most successful estimate was done from sagittal suture, next lambdoid suture and then coronal suture.⁴⁸

Khandare.S.V in 2014 conducted a CT scan study regarding Age estimation from cranial sutures. The method of determining age by cranial suture closure has always been more generally used, but because the cranium is frequently the best preserved portion of the recovered skeleton. The study was done on post-mortem cases referred to Government hospital, Mumbai which is a tertiary referral centre to do study on cranial suture closure by actually viewing the stage of closure of suture by CT Scan, to see the actual fusion and its correlation with age and to compare with the documented present studies. Age was determined on the basis of endocranial suture fusion as Ectocranial closure of the various segments of the three main sutures of the

skull is so inconclusive that it doesn't help in estimating the age of the deceased. It was found that Complete closure of Sagittal suture occurs at the age of 61 to 65 yrs, Complete closure of coronal suture occurs at the age of 66 to 70 yrs, Complete closure of lambdoid suture occurs after the age of 70 yrs and Complete closure of temporoparietal suture occurs after the age of 70 yrs.⁴⁹

In 2014 Masih.F.W done a study on the closure of vault sutures on both inner and outer surface of skull and its correlation with age. Total 200 skulls in autopsy cases (157 males and 43 females) from all age groups were studied. Results showed dat in males the minimal age of fusion in endocranium were 40 years for both sagittal suture (SS) and coronal suture (CS) & 50 years for lambdoid suture (LS). In females it was 40, 33 and 53 years for SS, CS & LS respectively. The maximum age of non-union of suture on endocranium in males was 42, 45, 55 years for SC, CS & LS respectively. In females it was 45, 45 and 55 years for SC, CS and LS respectively. 2 males (1% of all cases) showed nonfusion of vault sutures at the age of 70 years at ectocranium. Among the females maximum age of non-union of ectocranium was observed to be 59, 58 and 69 years for SS, CS and LS respectively. Study concluded noting the fusion of endocranial vault sutures occurred 5-10 years earlier as compared to ectocranium and it is more reliable. The obliteration sets little early and proceeds more slowly in the females than in males.⁵⁰

In 2015, Khandare. S.V, did a postmortem study to estimate age from cranial suture. The study was done on post-mortem cases referred to Government hospital, Mumbai which is a tertiary referral centre. It becomes difficult to determine age in middle and older age groups and as Very few studies have been conducted on cranial suture closure of Mumbai region subjects we decided to do study on suture closure by actually viewing the stage of closure of suture of autopsy dead body, to see the actual

fusion and its correlation with age and to compare with the documented present studies. Study revealed that Ectocranial obliteration of the various segments of the three main sutures of the skull is so inconclusive that neither does it help in estimating the age of the deceased nor does it provide any supportive evidence in determining the age of skeletal remain. Age was determined on the basis of endocranial suture fusion. It was found that almost Complete closure of Sagittal suture occurs at the age of 61 to 65 yrs, almost Complete closure of coronal suture occurs at the age of 56 to 60 yrs, almost Complete closure of lambdoid suture occurs at the age of 66 to 70 yrs and almost Complete closure of Temporoparietal suture occurs at the age of 66 to 70 yrs.⁵¹

In 2015 Parchake SB et al, researched to see the chronology and pattern of union of sagittal suture; to know the relationship between closure of cranial suture and age of deceased; to formulate a practical method for age estimation based on the closure of cranial sutures using the data collected. Study concluded by reporting that Age estimation from the skull suture is a reliable parameter. The strongest positive correlation of ectocranial with endocranial suture was found in the age group of 30-39 years for sagittal sutures. Suture obliteration starts earlier on endocranial surface than on the ectocranial. Endocranial sagittal suture start to close at 20 to 29 years near complete closure occurs by the age of 50 to 59 years and complete closures occur by the age of more than 70 years. Ectocranial union start in the age group of 20-29 years in sagittal maximum closure occurred in the age group above 70 years.⁵²

Sex and Suture Closure

Data on sex differences, based on the morphology of the skull, have been widely published and utilized in most forensic and archaeological contexts by physical anthropologists (Keen 1950). Though the cranial sutures and their degree of closure and morphology have primarily drawn interest in age estimation studies,

several authors have looked at variations in sex (Hauser et. al 1991). This information is necessary, since differences in suture closure and morphology based on sex would require the creation of unique standards for males and females.⁵³

In 1905, Parsons and Box reported that suture closure in females typically commences later than in males. Todd and Lyon (1924), however, suggested that sex differences were insignificant to suture closure, despite the fact that only males were observed. As Todd and Lyon's method was long accepted as the standard, many authors assumed that sex could be ignored. Brooks (1955), though, concluded what Parsons and Box had earlier, that female cranial sutures tend to remain open much more frequently than in males; cranial suture closure is somewhat sexually dimorphic, and it should not be used as any more than a secondary confirmation, with caution" in males and never in females.^{6,16}

On the contrary, Acsádi and Nemeskéri (1970) calculated total scores for each suture on 208 male and 144 female crania. The authors found no significant differences in mean suture closure stages, either ectocranially or endocranially, based on sex. Perizonius (1984) confirmed this using the same method. The same year, however, Baker (1984), using a different method, concluded that sex differences were significant. The males from a Los Angeles sample exhibited suture obliteration at a younger age than the females (Baker 1984). Baker suggested that ectocranial suture closure is not useful for males but can be applied limitedly for females (the opposite of Brooks' suggestion) and that age estimates should not be made without first identifying the sex of the individual. Though these findings may have been significant, Meindl and Lovejoy (1985) reported no statistically significant differences in patterns of cranial suture closure based on sex using their method.^{15,29,37}

Due to the large amount of conflicting data up to 1985 and the rise of Meindl and Lovejoy's method as a new standard, it became generally accepted that sex did not need to be addressed before applying age estimates. However, more recent authors disagree. Key et. al (1994) found, in a comparison of three popular scoring methods and two populations, that sexual dimorphism was significant and females demonstrated a greater correlation with age. Hauser et. al (1991) observed the patterns, both size and shape, of the cranial sutures. Suture segments of the coronal, lambdoid and sagittal sutures were scored on 35 male and 35 female crania according to their degree of maximal shape extension, basic configuration and secondary protrusions. Results showed heterogeneity for all three criteria of all three sutures, but differences in sex were minimal. Hershkovitz et. al (1997) reported that the sagittal suture of females more frequently remained patent, until age 65, than in males. Zambrano (2005) also established a clear relationship between sex and suture closure. Females were better correlated with age from the vault and endocranial sutures whereas males had the strongest correlation in the lateral-anterior system. Sex was determined, therefore, to influence the pattern and rate of suture closure.^{20,23,24,28}

In 2013 Kumar AGV et al, did a Cross Sectional Post Mortem Study in Tertiary Care Hospital regarding Sexual Variation in Cranial Suture Closure with the objective to find out the sexual variations in cranial suture closure. After reflecting the scalp, coronal, sagittal and lambdoid sutures were studied applying five point scale ectocranially. For endocranial suture closure, same score system was applied after removing the calvaria by craniotome. Lambdoid suture was studied in-situ. Photographs were taken in all cases. The study resulted when comparison between males 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). The study concluded that suture closure contributes to sex determination. Researcher's analyses strengthen that there is a very close association between suture closure and sex.⁵⁴

MATERIALS AND METHODS

Source of data:

In this study, all the cases brought for post-mortem examination at mortuary of R.L.JALAPPA HOSPITAL AND MRC, KOLAR between 1ST December 2014 to 30th June 2016 have been studied. All autopsies performed on deceased belonging to 3rd to 6th decades of life are included in this study.

Study design:

A descriptive cross-sectional study and sample size is 150.

Inclusion criteria:

1] Deceased between 21-60 years of life.

Exclusion criteria:

- 1) Cases with skull vault fractures involving sutures.
- 2) Pathological conditions involving skull bones

Method of collection of data:

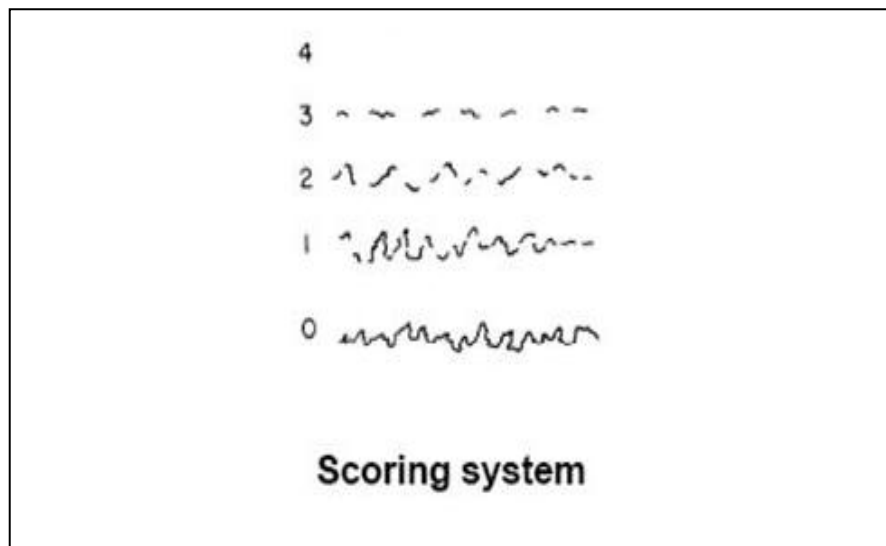
Informed consent was obtained from the next of the kin of the relatives, before collecting the data. Preliminary data was recorded as per the proforma. Age of each individual studied was confirmed from driving licence, passport, ration card, aadhar card or voter's card. After reflecting the scalp, coronal, sagittal, lambdoid sutures were studied applying Acsadi and Nemeskeri scoring method. For endocranial same score system was applied after removing the calvaria by craniotome by taking due care to include complete coronal and sagittal suture. Lambdoid suture was studied in-situ. The calvarium was cleaned of soft tissues on both sides and was dried, which made the sutures more prominent. Photographs were taken in all cases depicting the

suture closures. The obliteration of the sutures was ascertained endocranially as well as ectocranially. The sagittal suture was studied in three parts and coronal and lambdoid sutures two parts each on left and right side.

All cases were studied with reference to ectocranial and endocranial closure of sutures using Acsadi and Nemeskeri³⁷ scoring method which is as follows;

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



Mean ectocranial as well as endocranial closure stages were calculated for the three main sutures by adding the scored closure stages of the different sections and dividing the result by number of sections which compose the suture in question. Endocranially closure indices were calculated in similar fashion adding the

closure stages of all the sections and dividing the result by 16.^{29,55} A detailed pre-designed proforma was completed for every case studied.

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.

Statistical Methods:

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions.

Chi-square test of Continuous data was represented as mean and standard deviation.

Independent t test or Mann Whitney U test was used as test of significance to identify the mean difference between two quantitative variables and qualitative variables respectively.

Graphical representation of data: MS Excel and MS word was used to obtain various types of graphs such as bar diagram and Pie diagram.

Spearman's correlation was done to find the correlation between two qualitative variables respectively.

p value (Probability that the result is true) of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

Statistical software: MS Excel, SPSS version 22 (IBM SPSS Statistics, Somers NY, USA) was used to analyze data. EPI Info (CDC Atlanta), Open Epi, Med calc and Medley's desktop were used to estimate sample size, odds ratio and reference management in the study

Figure.5 -Ectocranial Sutures

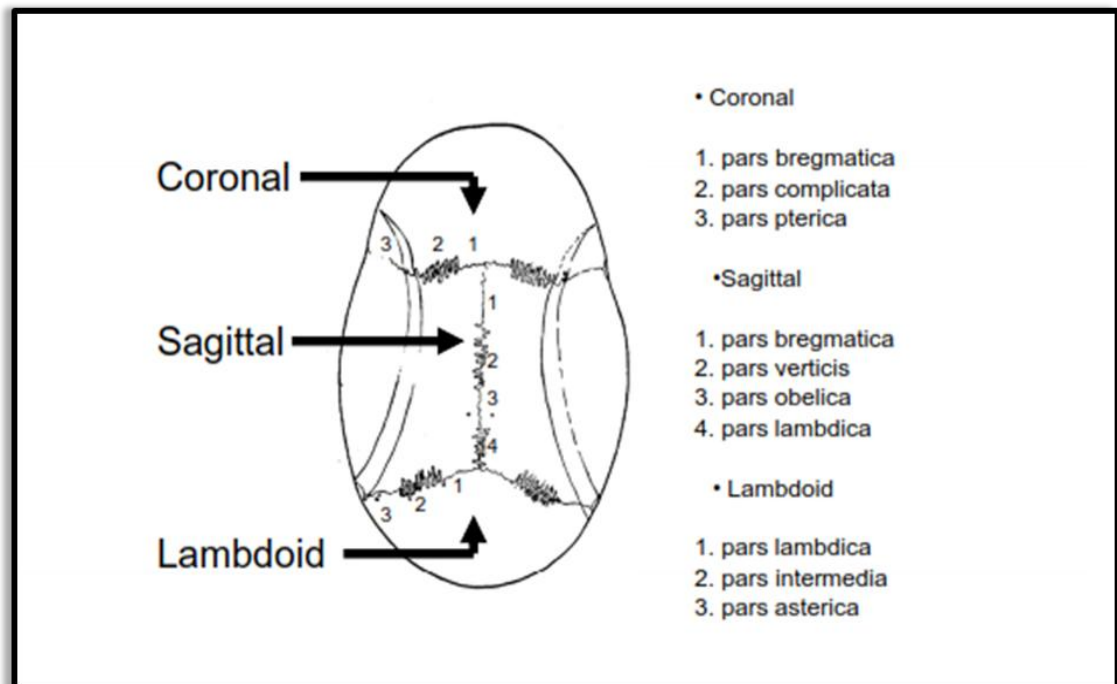
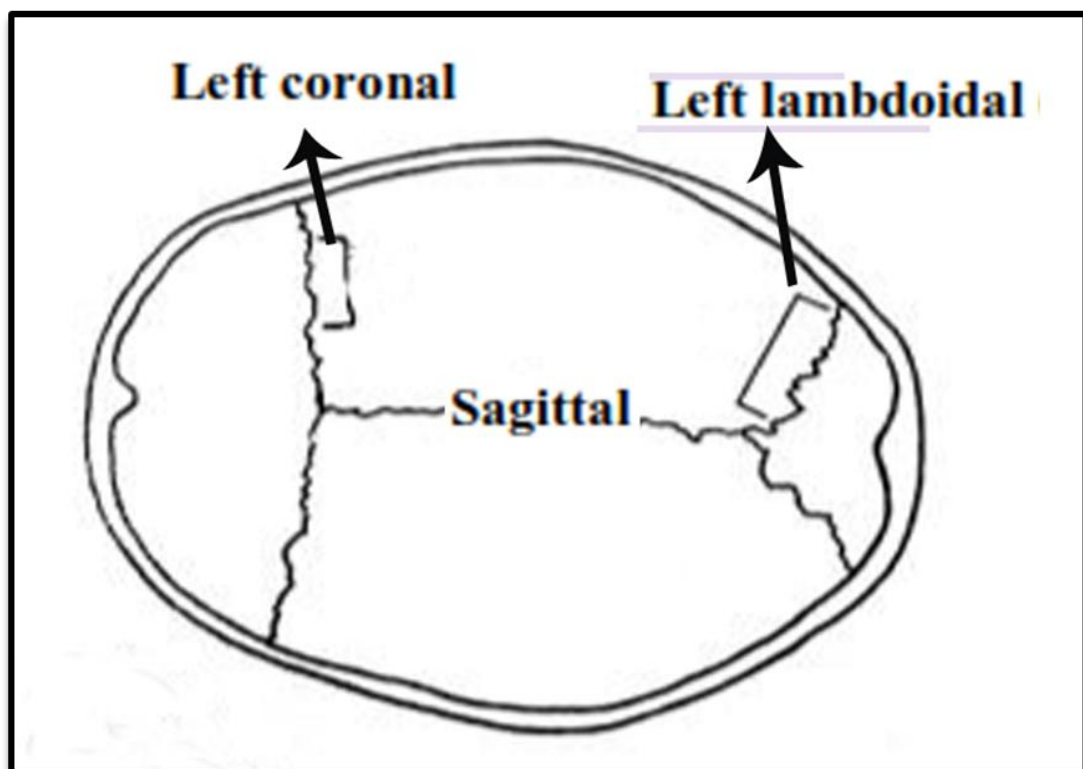


Figure.6-Endocranial Sutures



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 LAMBDA

L2 -PARS INTERMEDIA

m -MALE

f -FEMALE

r- CORRELATION COEFFICIENT

t-test -STUDENT'S T TEST

RESULTS

The study consisted of 150 cases brought to the mortuary of R.L.Jalappa Hospital and Medical Research Center, Kolar, during the period of Decmeber 2014 to June 2016.

AGE AND SEX DISTRIBUTION

The age of the victims varied from 21 to 60 years. Age groups were classified 10 year interval so as to test accuracy of method based on different age groups and to compare with the previous studies (Table-1, 2 & Graph-1). It was observed that maximum numbers of cases were in 21-30 age group which also tells us regarding the age distribution of cases coming for autopsy in RLJH. There were 50 cases i.e. valid percentage is 33.3% and cumulative is 33.3%. In 31-40 groups there were 37 cases, valid percentage is 24.7% and cumulative is 58%. In 41-50 age groups, there were 33 cases which accounts for 22% of the total cases and cumulative is 80%. There were 30 cases in 51-60 age groups. It constituted 20% of cases and cumulatively 100%.

TABLE-2**AGE AND SEX WISE DISTRIBUTION**

Age groups in years	Frequency	Percent	Valid percent	Cumulative percent
21 to 30 years	50	33.3%	33.3%	33.3%
31 to 40 years	37	24.7%	24.7%	58.0%
41 to 50 years	33	22.0%	22.0%	80.0%
51 to 60 years	30	20.0%	20.0%	100.0%
Total	150	100.0%	100.0%	100.0%

TABLE-3

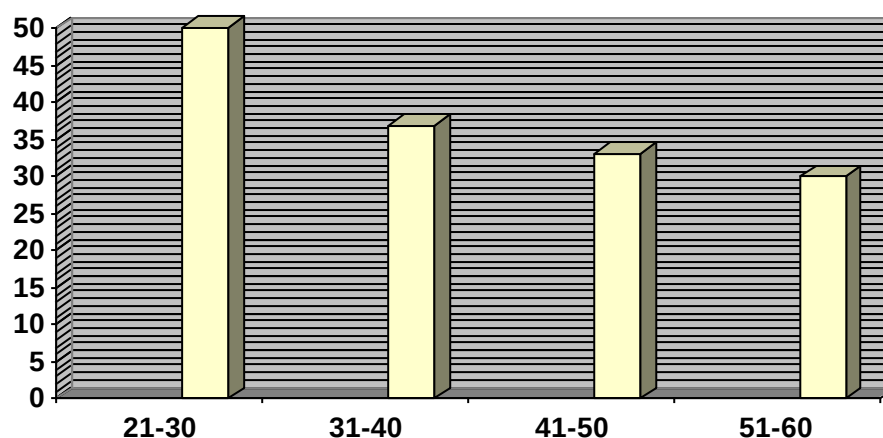
**RANGE, MEAN, STANDARD DEVIATION, MEDIAN STANDARD AND
ERROR OF MEAN OF THE CASES**

N	Minimum	Maximum	Range	Mean	Std. Deviation	Median Std.	Error of Mean
150	20	60	40	38.88	12.13	38.00	0.99

The minimum age of case is 21 and maximum age is 60, mean is age is 38.88, standard deviation is 12.13 and median age is 38.00.

GRAPH-1

DISTRIBUTION OF CASES –ACCORDING TO AGE GROUP



Majority of subjects in the study were in the age group 21 to 30 years (33.3%), followed by 31 to 40 yrs (24.7%), 41 to 50 years (22%) and 51 to 60 years (20%).

TABLE-4
MALE AND FEMALE WISE DISTRIBUTION OF CASES

	Frequency	Percentage
Male	109	72.7%
Female	41	27.3%
Total	150	100.0%

TABLE-5
MALE AND FEMALE DISTRIBUTION OF CASES ACCORDING TO AGE

		Gender			
		Female		Male	
		Count	%	Count	%
Age	21 to 30 years	17	41.5%	33	30.3%
	31 to 40 years	8	19.5%	29	26.6%
	41 to 50 years	7	17.1%	26	23.9%
	51 to 60 years	9	22.0%	21	19.3%
	Total	41	100.0%	109	100.0%

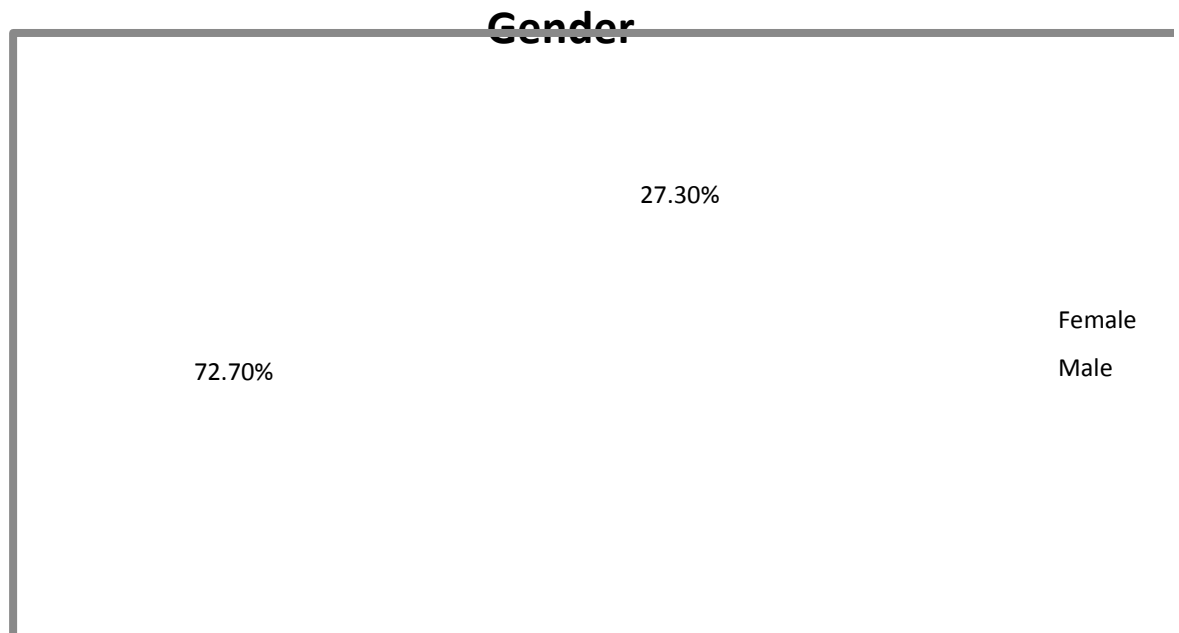
$\chi^2 = 2.456$, df = 3, p = 0.483

In the study among females and males majority of them were in the age group 21 to 30 years. There was no significant difference in age distribution with respect to gender.

GRAPH-2

SEX WISE DISTRIBUTION OF CASES

In our study, out of 150 cases there were 41 females and 109 males.



GRAPH-3

SEX WISE DISTRIBUTION OF CASES

Male dominance was observed in all age groups.

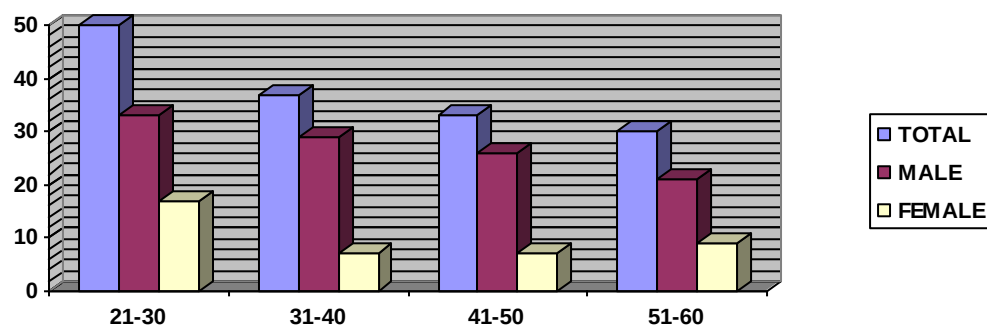


TABLE-6
ENDOCRANIAL SUTURE CLOSURE-SEXUAL VARIATION

Age group	N(m/f)		Mean(m/f)	
21-30	33	17	5.55	5.25
31-40	29	8	7.00	6.37
41-50	26	7	8.08	8.03
51-60	21	9	9.62	7.09
Total	109	41	7.56	6.68

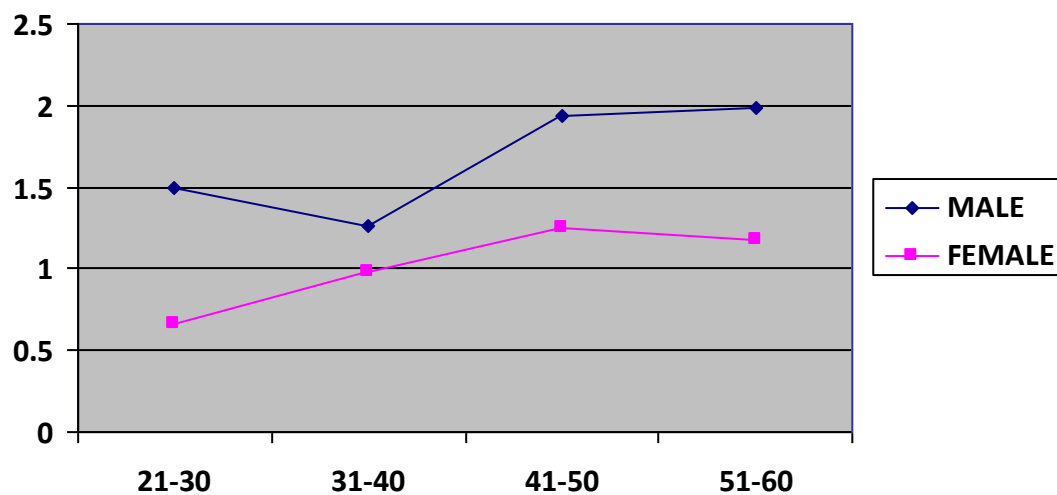
TABLE-7
ECTOCRANIAL SUTURE CLOSURE-SEXUAL VARIATION

Age group	N(m/f)		Mean(m/f)	
21-30	33	17	3.74	3.39
31-40	29	8	4.66	3.53
41-50	26	7	5.45	4.98
51-60	21	9	6.98	5.16
Total	109	41	5.21	4.26

When comparison between male and female subjects were made, closure was earlier in males (Mean 7.56 vs. 6.68 in case of endocranial suture closure & 5.21 vs. 4.26 in case of ectocranial suture closure).

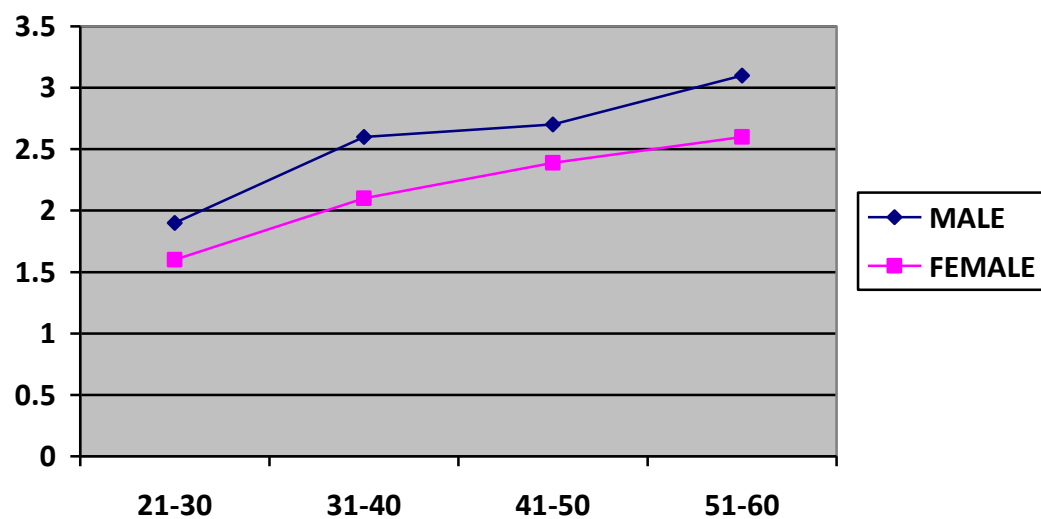
GRAPH-4

ECTOCRANIAL SAGITTAL SUTURE CLOSURE-SEXUAL VARIATION



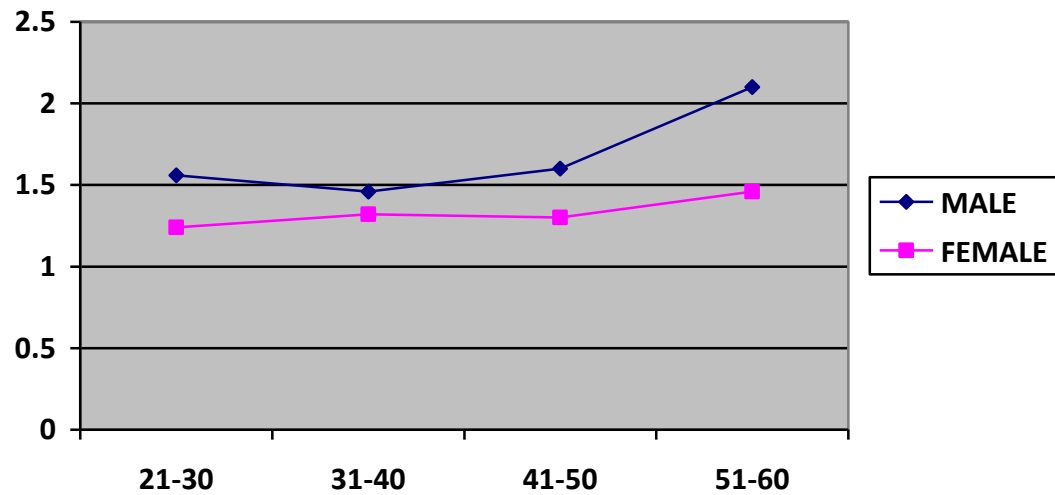
GRAPH-5

ENDOCRANIAL SAGITTAL SUTURE CLOSURE-SEXUAL VARIATION



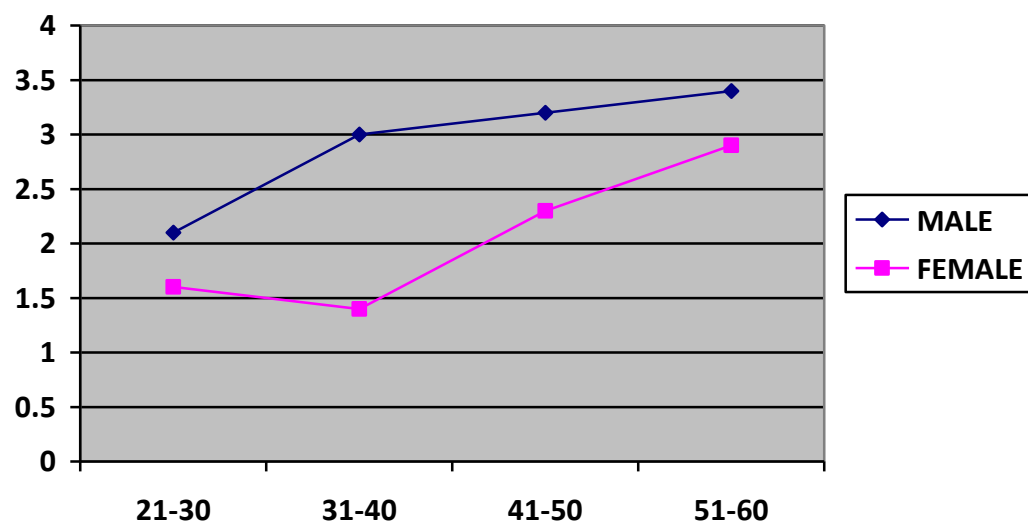
GRAPH-6

ECTOcranial CORONAL SUTURE CLOSURE-SEXUAL VARIATION



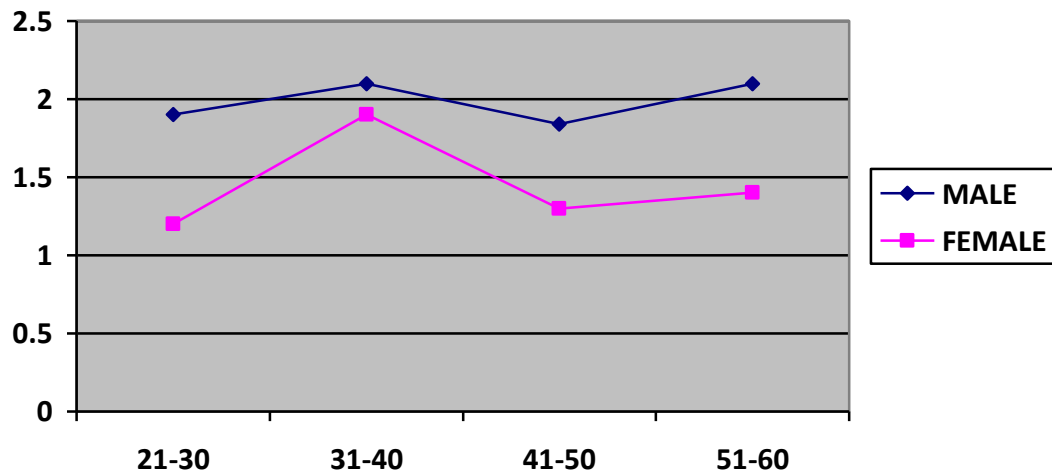
GRAPH-7

ENDOcranial CORONAL SUTURE CLOSURE-SEXUAL VARIATION



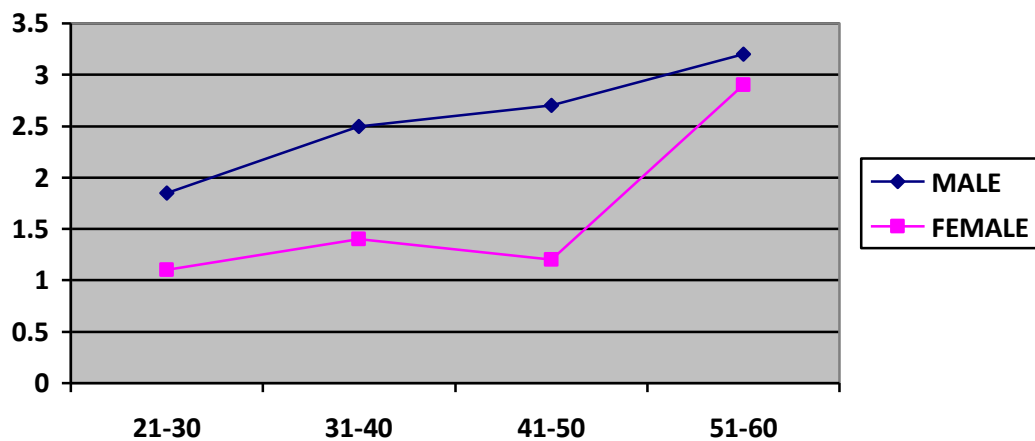
GRAPH-8

ECTOCRANIAL LAMBDOID SUTURE CLOSURE-SEXUAL VARIATION



GRAPH-9

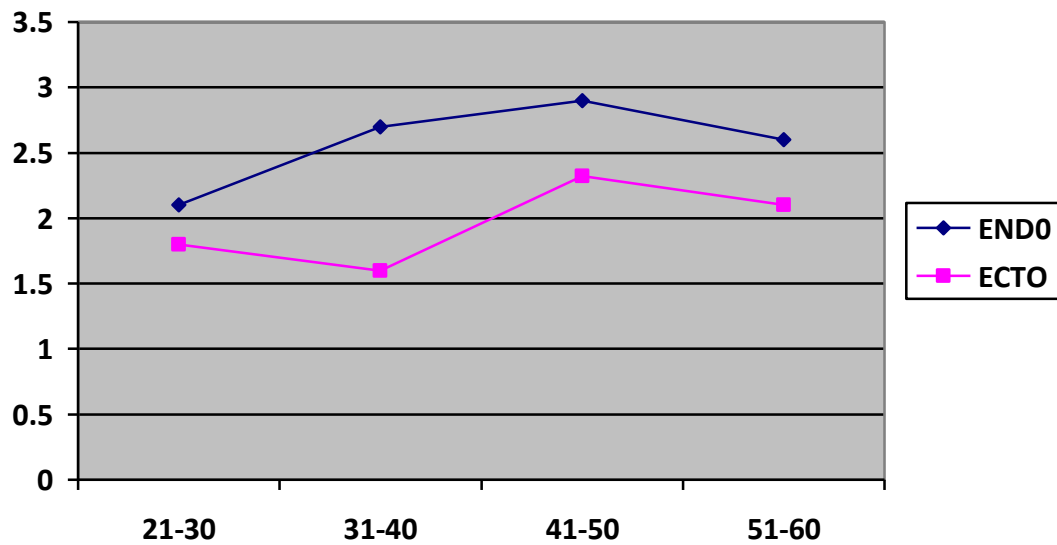
ENDOCRANIAL LAMBDOID SUTURE CLOSURE-SEXUAL VARIATION



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

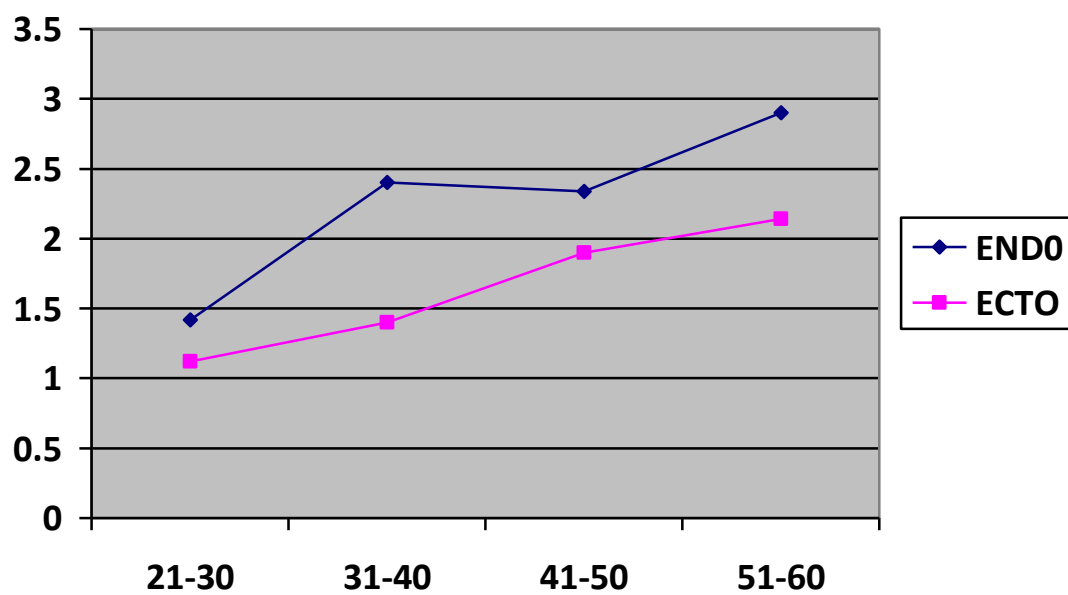
GRAPH-10

ECTOCRANIAL AND ENDOCRANIAL CLOSURE OF CORONAL SUTURE



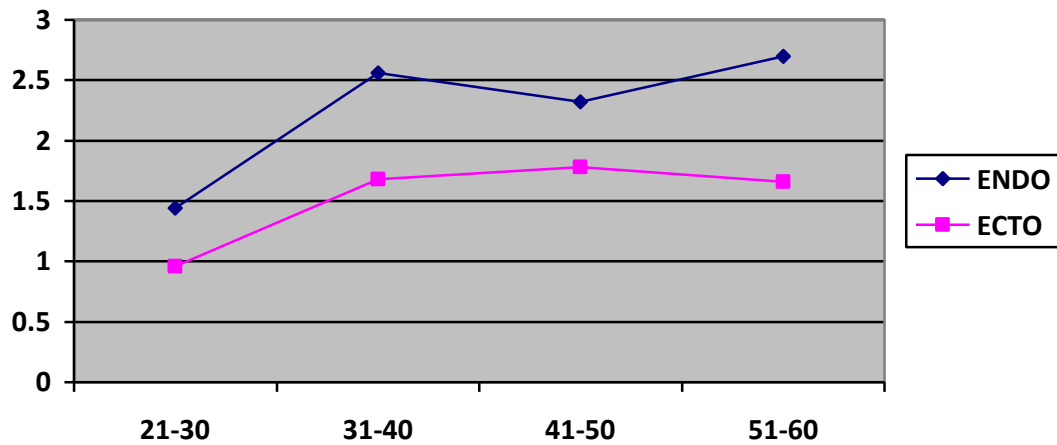
GRAPH-11

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-8

MEAN VALUES OF SUTURES

SUTURES	MEAN
CORONAL	14.68
SAGITTAL	11.92
LAMDROID	9.94

When comparison was made between sagittal, coronal and lambdoid suture, overall coronal suture closes early followed by sagittal and lambdoid respectively. (Table 8)

TABLE-9

SPEARMAN'S RANK CORRELATION BETWEEN STAGE OF CLOSURE AND OBSERVED AGE (* Correlation is significant at the 0.05 level (2-tailed),

** Correlation is significant at the 0.01 level (2-tailed)).

RIGHT			LEFT		
LAMBDOID LOWER			LAMBDOID LOWER		
Age	Endos	Ectos	Age	Endos	Ectos
21-30	0.497**	0.001*	21-30	0.606**	0.001*
31-40	0.725**	0.001*	31-40	0.749**	0.001*
41-50	0.515**	0.002*	41-50	0.454**	0.008*
51-60	0.516**	0.004*	51-60	0.446*	0.014*
LAMBDOID UPPER			LAMBDOID UPPER		
Age	Endos	Ectos	Age	Endos	Ectos
21-30	0.504**	0.001*	21-30	0.530**	0.001*
31-40	0.725**	0.001*	31-40	0.749**	0.001*
41-50	0.561**	0.001*	41-50	0.497**	0.003*
51-60	0.446*	0.013*	51-60	0.446*	0.014*
SAGITTAL ANT 1/3					
Age	Endos	Ectos			
21-30	0.046	0.751			
31-40	0.386*	0.018*			
41-50	0.205	0.253			
51-60	0.244	0.194			
SAGITTAL MID 1/3					
Age	Endos	Ectos			
21-30	0.140	0.332			
31-40	0.218	0.194			
41-50	0.143	0.427			
51-60	0.339	0.067			
SAGITTAL POS 1/3					
Age	Endos	Ectos			
21-30	0.144	0.318			
31-40	0.426**	0.009			
41-50	0.344*	0.005			
51-60	0.526**	0.003			
CORONAL UPPER			CORONAL UPPER		
Age	Endos	Ectos	Age	Endos	Ectos
21-30	0.032	0.824	21-30	0.071	0.627
31-40	0.232	0.168	31-40	0.048	0.777
41-50	0.153	0.395	41-50	0.349*	0.046
51-60	0.033	0.861	51-60	0.003	0.987
CORONAL LOWER			CORONAL LOWER		
Age	Endos	Ectos	Age	Endos	Ectos
21-30	0.228	0.111	21-30	0.068	0.641
31-40	0.664**	0.004	31-40	0.491**	0.002
41-50	0.513**	0.002	41-50	0.248	0.164
51-60	0.378*	0.039	51-60	0.139	0.462
RIGHT			LEFT		

Ectocranial sutures were compared with endocranial sutures through sagittal, right and left coronal and lambdoid (Table 9). To estimate the possible relation between suture closure and age at death Spearman rank correlation coefficients (2 tailed) were calculated. Because of the considerably skewed age distribution of the sample, Pearson correlation coefficients are less appropriate. Significant positive correlation was observed between endo and ecto anterior third, posterior third of sagittal suture closure score in 31 to 40 years. I.e. Scores were similar in 31 to 40 years age group between endo and ecto sagittal suture score.

Significant positive correlation was observed between right endo and ecto lower coronal suture scores in 31 to 40 years, 41 to 50 years and 51 to 60 years. Similarly significant positive correlation was observed between left endo and ecto lower coronal suture scores in 31 to 40 years.

In the study significant positive correlation was observed between endo and ecto lambdoid suture scores at every point such as upper, lower on right and left in all the age group.

TABLE-10

ENDOCRANIAL AND ECTOCRANIAL CLOSURE OF SAGITTAL SUTURE

Age group		Endo-S1	Ecto-S1	Endo-S2	Ecto-S2	Endo-S3	Ecto-S3
21-30	N	50	50	50	50	50	50
	mean	1.52	0.72	1.64	0.66	1.44	0.52
31-40	N	37	37	37	37	37	37
	mean	2.32	1.42	2.1	1.24	1.94	1.32
41-50	N	33	33	33	33	33	33
	mean	2.64	1.13	2.63	1.51	2.58	1.12
51-60	N	30	30	30	30	30	30
	mean	3.12	1.89	2.82	1.34	2.68	1.46
Total	N	150	150	150	150	150	150
	mean	2.42	1.16	2.29	1.31	2.21	1.05

When ectocranial suture closure was taken it is observed that S1 closure started early followed by S2 and S3 respectively (Mean in 21-30 decade---S1- 0.72>S2-0.66>S3-0.53). Within the sagittal suture S1 appears to fuse much faster and S2 seems to close much slower (Mean in 51-60 decade---S1- 1.89>S3-1.46>S2-1.34).

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- 1.64>S1-1.52>S3-1.44). Within the sagittal suture S1 appears to fuse much faster and S3 seems to close much slower (Mean in 51-60 decade---S1- 3.12>S2-2.82>S3-2.68). (Table 10)

TABLE-11

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	50	50	50	50	50	50	50	50
	mean	2.28	1.54	2.36	1.52	2.43	1.42	2.76	1.76
31-40	N	37	37	37	37	37	37	37	37
	mean	2.41	1.7	2.81	1.5	2.96	1.67	3.02	1.55
41-50	N	33	33	33	33	33	33	33	33
	mean	2.83	1.42	3.01	1.61	2.56	1.87	2.88	1.86
51-60	N	30	30	30	30	30	30	30	30
	mean	2.86	1.76	2.98	1.84	2.98	1.66	3.12	1.76
Total	N	150	150	150	150	150	150	150	150
	mean	2.59	1.6	2.79	1.61	2.73	1.65	2.94	1.73

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- 1.76>U-1.42). Within the coronal suture, lower (L) coronal suture appears to fuse much faster compared to upper (U) coronal suture (Mean in 51-60 decade---L- 1.76>U-1.66).

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- 2.76>U-2.43). Within the coronal suture, lower (L) coronal suture appears to fuse much faster compared to upper (U) coronal suture (Mean in 51-60 decade---L- 3.12>U-2.98).

TABLE-12

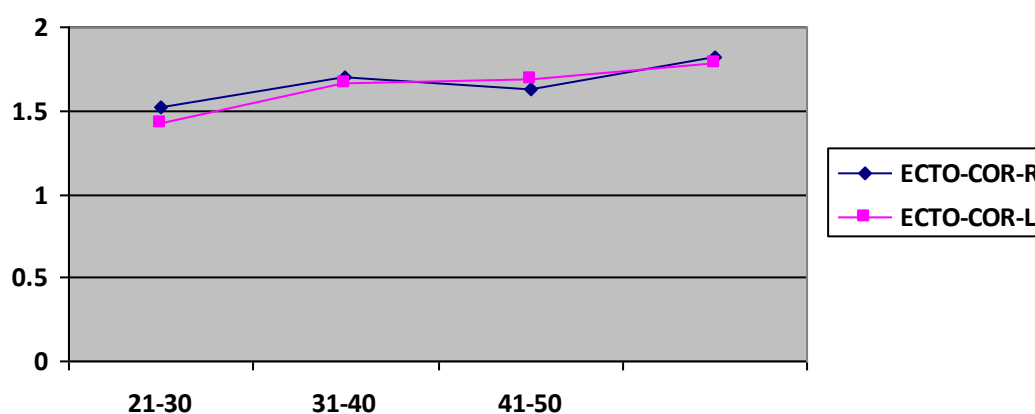
ENDOCRANIAL AND ECTOCRANIAL CLOSURE OF LAMDOID SUTURE

Age group		Endo-RU	Ecto-RU	Endo-RL	Ecto-RL	Endo-LU	Ecto-LU	Endo-LL	Ecto-LL
21-30	N	50	50	50	50	50	50	50	50
	mean	2.73	1.47	2.33	1.41	2.83	1.47	2.21	1.42
31-40	N	37	37	37	37	37	37	37	37
	mean	2.85	1.88	2.65	1.81	2.69	1.91	2.76	1.9
41-50	N	33	33	33	33	33	33	33	33
	mean	3.13	1.23	2.83	1.63	2.92	1.48	2.67	1.58
51-60	N	30	30	30	30	30	30	30	30
	mean	2.92	2.38	2.86	2.23	3.12	2.48	2.87	2.38
Total	N	150	150	150	150	150	150	150	150
	mean	2.91	1.74	2.67	1.77	2.89	1.83	2.62	1.82

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-1.47>L-1.42). Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture (Mean in 51-60 decade---U- 2.48>L-2.38). 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-2.83>L-2.21). Within the lamdoid suture, upper (U) lamdoid suture appears to fuse much faster compared to lower (L) lamdoid suture (Mean in 51-60 decade---U- 3.12>L-2.9).

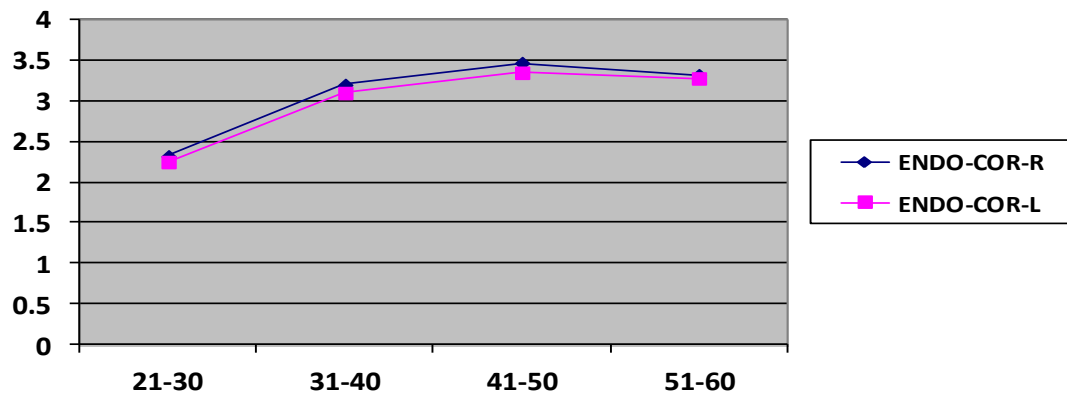
GRAPH-13

BILATERAL VARIATION IN ECTO-CORONAL SUTURE



GRAPH-14

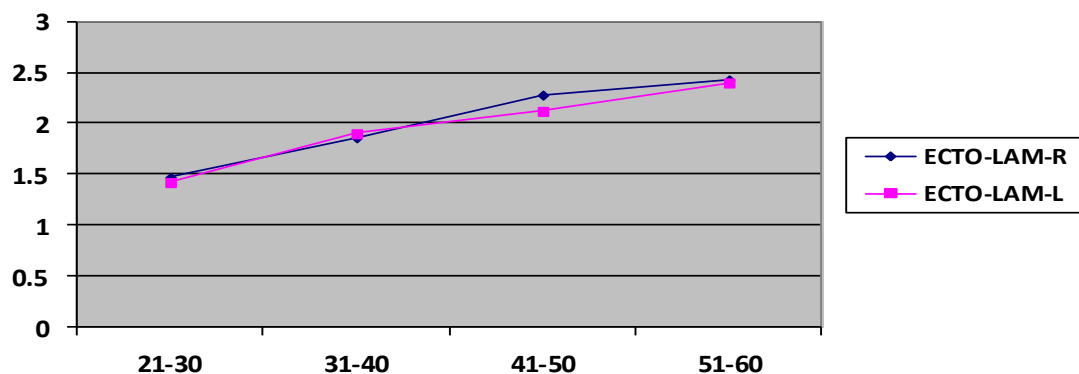
BILATERAL VARIATION IN ENDO-CORONAL SUTURE



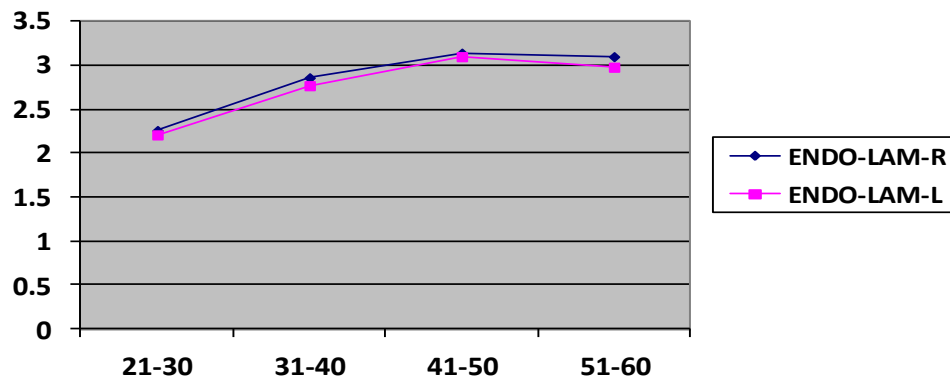
In coronal suture right and left side were compared and no significant difference was found. When males and females were considered separately there were no significant difference between right and left side of coronal suture.

GRAPH-15

BILATERAL VARIATION IN ECTO-LAMBDROID SUTURE



GRAPH-16

BILATERAL VARIATION IN ENDO-LAMDOID SUTURE

Right and left side of coronal and lambdoid sutures 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)

For person identification, age estimation is certainly one of the important biological profiles. Cranial suture closures have been used as an age determination tool since the 16th century, but their reliability is still questionable. Several studies have revealed that the cranial suture closure could be useful in determining age at death, on the other hand, some concluded that it was unreliable. Although cranial sutures generally close with increasing age, there is considerable variability in closure rates.^{28, 56}

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, gives a fairly accurate idea but here also we find that the determination of age can only be in decades, based on sole criterion of suture obliteration.

Skulls can provide a lot of information about age at death and that is the reason why there are many age determination methods based on cranial features. In the present study, macroscopic findings are studied for closure of sagittal, coronal and lambdoid suture to determine age.

Coronal suture

In present study endocranial fusion of coronal suture was observed as early as 21-30 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 24 years endocranially and 34 years ectocranially. Moondra (2000) reported endocranial closure between 46-50 for males.⁴⁴ As per Schmidt & Modi complete closure occurs in between 40-60 yrs while as per Krishnan vij lower half closes first in between 40-50 yrs followed by upper half which closes in between 50-60yrs.^{57,59} According to Parikh lower half

closes first in between 40-60 yrs followed by upper half which closes in between 50-60yrs.⁵⁸ 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.⁹

Sagittal Suture

In present study we have found that the sagittal suture, endocranially, starts fusing at the end of 24-34 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.⁶

Lambdoid suture

Lambdoid endocranially, starts fusing at the age of 27-35 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. From 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 males is

some what earlier than that of females. 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.^{6, 32, 33, 34}

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%.³⁰

In the present material all the three main sutures of the skull started closing earlier in the males than in the females. Some workers in USA and India have shown the epiphyses of the long bones fused with the metaphyses earlier in females than in males.¹⁹

Table-13

AGES FOR SUTURE CLOSURE

SI No	Name of suture	Age of fusion in majority of cases (Age group)	Age of earliest union in years
1	Sagittal	41-50	24
2	Coronal	41-50	24
3	Lambdoid	51-60	27

According to Hrdlicka the estimated age from the skull sutures is within 10 years, one or the other from the real age.³⁶

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.¹⁶

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.³

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.²⁹

Kirk (2007) used laser technology in order to estimate age from cranial suture closure based on principle that solid cranial bone will reflect less light than open cranial sutures. According to him laser device may add invaluable information to our knowledge of cranial sutures as well as elucidate the capabilities of establishing a definite & accurate ageing method from cranial sutures.^{1,46, 48, 49}

In 2009, Ullas Shetty carried out study on 100 cases brought to mortuary of Maulana Azad College, Delhi, for post-mortem. He concluded that ectocranial suture cannot be used for age estimation. Suture obliteration starts earlier on endocranial suture than ectocranial, also suture closure occurred earlier in males. Commencement and complete obliteration of segment or the entire suture is so erratic that it is not amenable for estimating the age.⁴⁴

Mukesh Goyal carried out study to determine the age of individual in the fourth decade to seventh decades by correlating radiological finding of various views of skull along with the other physical findings. He found that Coronal Suture fusion occurred in the lower part of suture at the age of 42-44 yrs and then proceed to upper 1/2 part at the age of 52yrs in case of males. In case of Female subjects the lower 1/2 part of this suture get fused at the age of 42-44 yrs and is followed by upper 1/2 part, which get fused at the age of 56 yrs. His study was based on the radiological facts of the fusion process where the difference between ecto and endocranium was not possible on x-ray of skull.¹¹ Our present study autopsy method to determine age both ectocranially and endocranially.⁴⁶

According to Anil Aggrawal estimation of age from suture closure of skull can be given in a range of 5-10 yrs in age of 30-60 yrs, the range may even be more in higher age groups.⁴ Also according to Reddy estimation of age from suture closure of skull can be given only in a range of decades. In our study age has been given in range of 5 yrs.³⁵

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?⁵

The difference of few years between autopsy study and radiological studies is due to radiological appearance of union appears earlier than union indicated by gross examination.³⁵ The details of our observations comparable to studies done by various researchers from various regions of India and other countries by various methods (Table 13).

Table-14**AGE OF FUSION OF SUTURES BY DIFFERENT AUTHORS**

SI No	Author/Worker	Sagittal (Age group in years)	Coronal (Age group in years)	Lambdoid (Age group in years)
1	Todd and Lyon (1924)	20-29 20-32	26-50 23-35	26-31 23-31
2	Krogman (1962)		Type 1,2:24 -38 Type 3,4:26 -41	31
3	Ribbe's (1885)	Closure 21-50 years frequent between 44-45 years Ectocranially sagittal closes first then lambdoid, coronal suture		
5	Parikh	30-50	40-60	50-70
6	Rajesh verma (2002)	---	M : 42-52 F: 42-56	---
7	R.K Gorea (2004)	---	45-50	45-50
8	Pradeep et al (2004)	---	45-50	45-50
9	J.B Mukherji (2007)	35-40	40-45	45-55
10	Ullas shetty (2008) ECTO ENDO	>70 60-69	Lapsed union 40-49	>70 40-49
11	Parmar P Rathod (2012)	---	50-60	---
12	Zanzrukiya (2013-14)	---	Ant 1/3: 40-69(m) 51-64(f) Mid 1/3: 40-49(m) 35-54(f) Pos 1/3: 40-49(m) 35-49(f)	---
13	Krishan Vij (2014)	Pos1/3: 30-40 Ant 1/3: 40-50 Mid 1/3: 50-60	Lower half: 40-50 Upper half: 50-60	55
14	Reddy KSN (2014)	Pos 1/3: 30-40 Ant 1/3: 40-50 Mid 1/3: 50-60	Lower half: 40-50 Upper half: 50-60	45
15	Modi's (2016)	30-50	40-60	50-70
16	Present study ECTO ENDO	M : 41-50 F: 51-60 M : 31-40 F: 41-50	M : 31-40 F: 41-50 M : 21-30 F: 31-40	M : 41-50 F: 51-60 M : 31-40 F: 41-50

CONCLUSION

In the present study we tried the possibilities for suture closure to contribute to one of the essential foundations of Paleodemography: age estimation. Age estimation from the skull suture is a reliable parameter. There is a need for more detailed studies (different age groups, sub samples, individual suture segments etc.) for a subject like suture closure. 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) Cranial suture closure is yet a fairly reliable method for age estimation.
- 2) Suture obliteration starts earlier on endocranial surface than on the ectocranial surface.
- 3) There is significant variation in suture closure in male and female (Males showed earlier union than females).
- 4) There is no significant variation in suture closure of right and left sides of coronal and lambdoid sutures, both ectocranially and endocranially.
- 5) Endocranially and Ectocranially- coronal suture closes earlier followed by sagittal and lambdoid.
- 6) 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.
- 7) 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

CONCLUSION

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. 8) 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.

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. Our present study findings are almost similar to studies done by other authors like Modi, Parikh, Moondra, Mukherjee, P C vyas , Krishan vij etc. This can be considered as reference study for people of Kolar region for determination of age.

Introduction: Age estimation, either in living, dead or human remains, is a complex problem in medical justice in both civil and criminal matters such as identification, senior citizen concession, retirement benefits, competency as witness, attainment of majority, marriage, impotency, sterility, consent, juvenile offender, kidnapping, rape etc. The skeleton and the teeth are the principal sources of information towards the age estimation. Determination of age becomes progressively more difficult as the age advances, particularly after the age of 20-25 years. Therefore, this study is intended to find out the pattern of cranial vault suture closure in 3rd to 6th decades of life with respect to age and sex of an individual in Kolar region of South india.

Aim: The main objective of the study was to observe the chronology and pattern of closure of cranial sutures. In this study, we also tried to explore the feasibility of using cranial sutures for age estimation.

Methodology: This study was conducted in the mortuary of R.L.Jalappa Hospital and MRC, KOLAR on dead bodies coming for medicolegal post-mortem examination, during the period of 1st December 2014 to 30th June 2016. Coronal, sagittal and lambdoid sutures of 150 subjects of age 21-60 years were studied. Acsadi and Nemeskeri method was applied to both endo and ectocranial sides of the sutures. Unknown and unclaimed bodies were not taken because of difficulty in knowing the age. Cases showing deformed or diseased or fractured skull were also excluded from study (which may hamper the sutural integrity). Photographs were taken in every case. A predesigned proforma was filled up for every case, master chart was prepared. Cases were stratified into 10 year groups. The results obtained after statistical analysis were analysed and compared with the works of previous authors

CONCLUSIONS:

- 1) Cranial suture closure is yet a fairly reliable method for age estimation.
- 2) Suture obliteration starts earlier on endocranial surface than on the ectocranial surface.
- 3) Males showed earlier union than females.
- 4) There is no significant variation in suture closure of right and left sides of coronal and lambdoid sutures, both ectocranially and endocranially.
- 5) Endocranially and Ectocranially- coronal suture closes earlier followed by sagittal and lambdoid.
- 6) 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.
- 7) 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.
- 8) 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.

RECOMMENDATIONS:

1. In present study, persons between the ages of <20 and >60 years for closure of suture are not taken, so to find good results, these groups should be included.
2. Sutures like basilar suture and metopic suture, lateral sutures, palatal sutures etc. should be included.
3. As in present study difference between each age group is 10 years and so it should be reduced to get better results.
4. In order to have a more accurate and better assessment of suture closure various other modalities like radiology (x-ray, CT scan, MRI, Laser), histology may have to be combined.
5. In our study age (34% of cases in 20-29 age group) distribution and sex (73% males) is not uniform. Hence, this (sampling error) has to be taken into consideration in future studies.
6. In present study there are only 150 cases which may not be the representation of whole population. Regression equation could not be formulated on small sample size. Hence the study population (sample size) has to be increased in future studies.
7. Age estimation from morphological changes in bone has always been a matter of debate as it is very erratic and affected by various factors such as climatic, dietetic, hereditary, nutritional, sociological, racial, environmental, geographical etc. Cranial sutures are no exception to that. So, much study is needed in estimation of age from cranial sutures.

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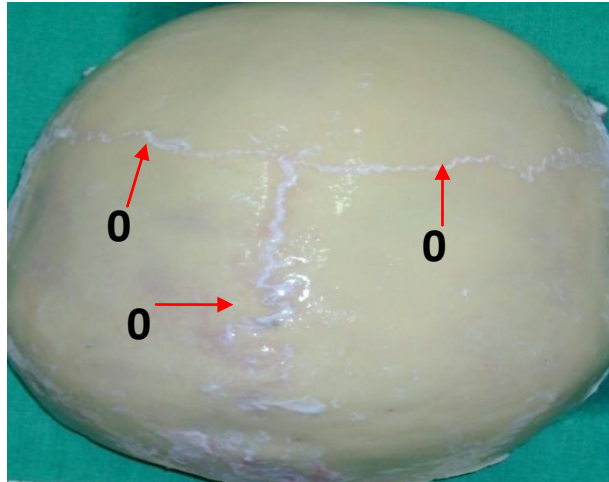
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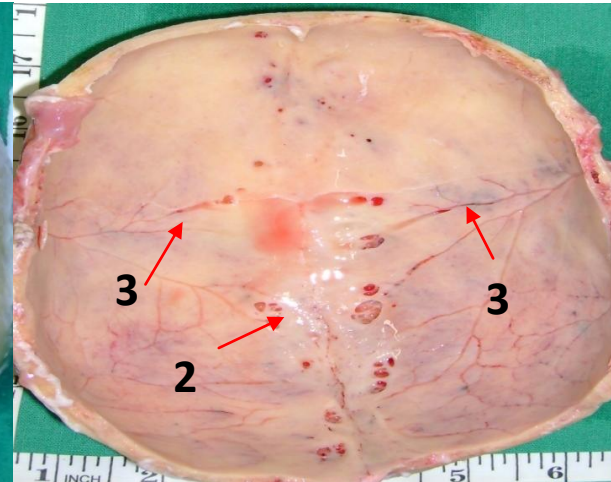
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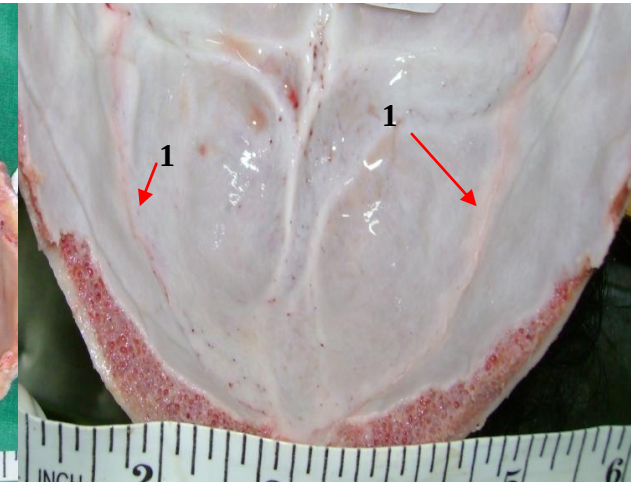
CASE-1



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

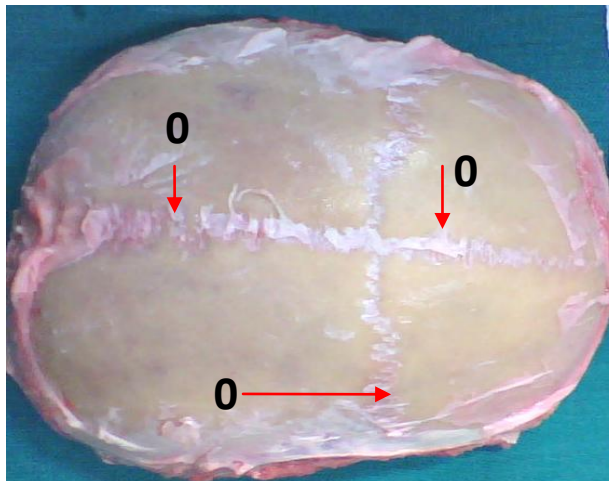


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

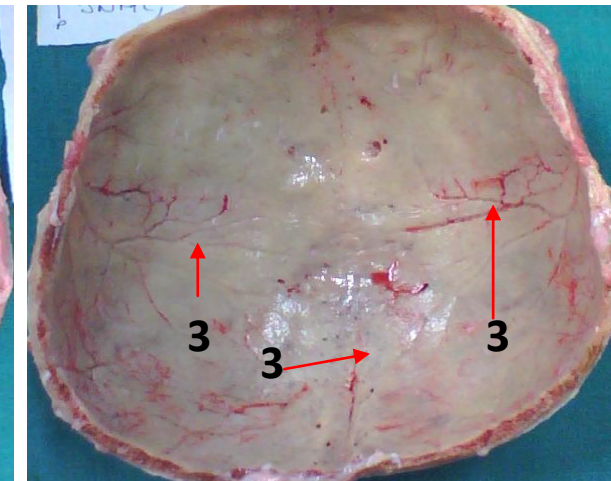


LAMDROID SUTURES (ENDOCRANIAL)

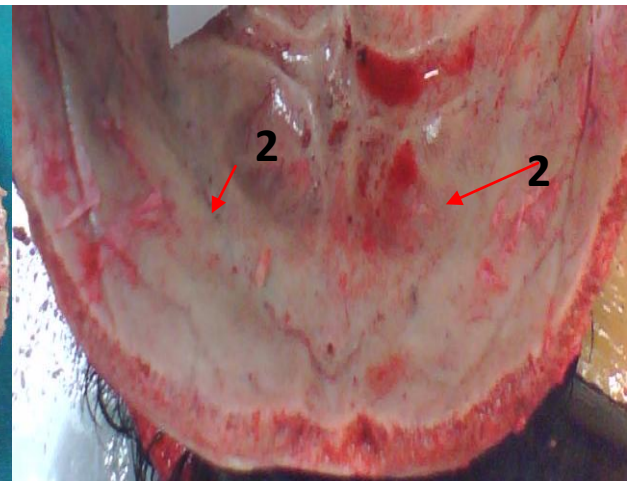
CASE-2



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



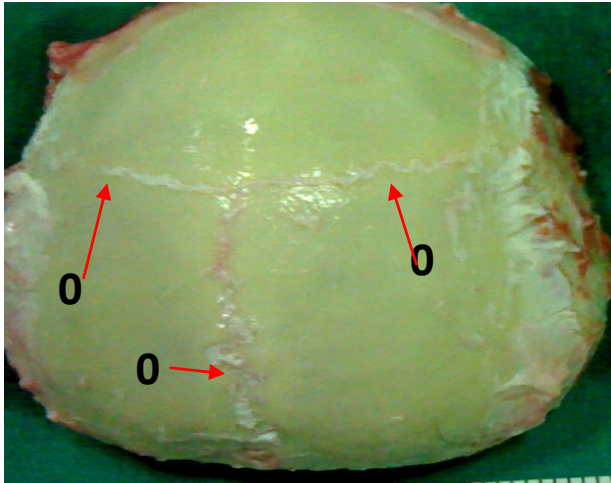
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



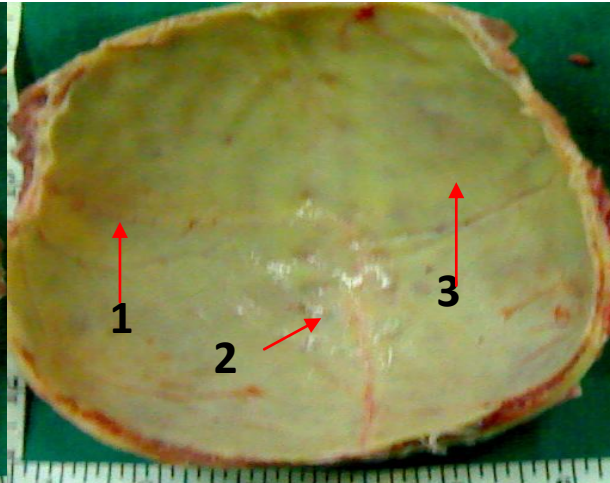
LAMDROID SUTURES (ENDOCRANIAL)

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

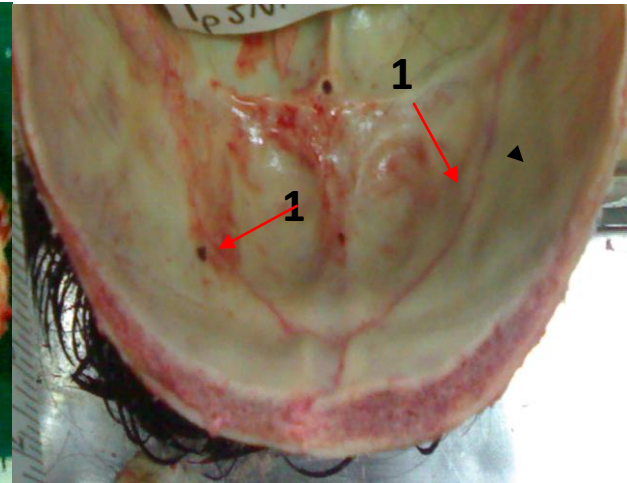
CASE-3



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

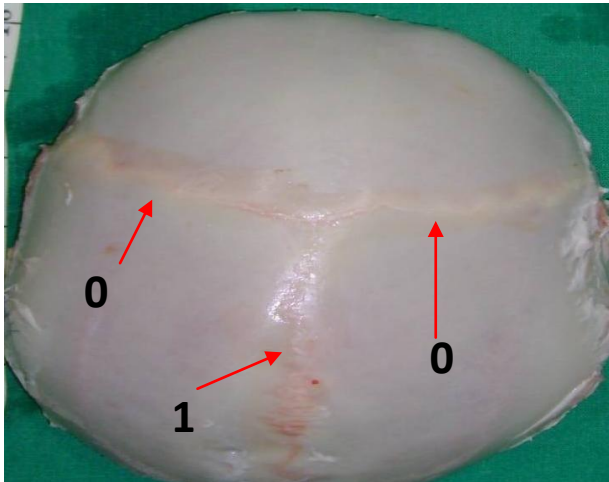


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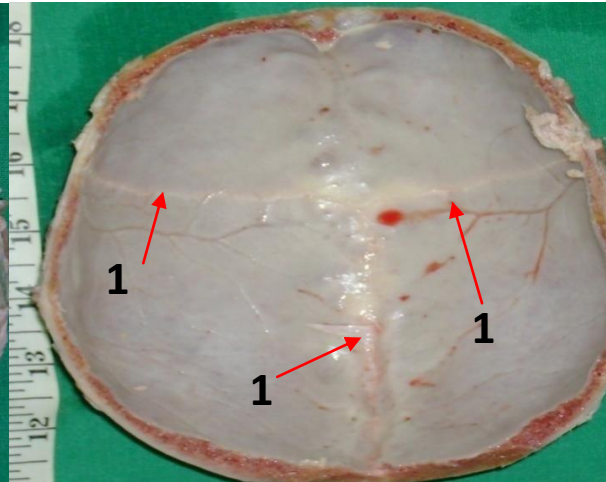


LAMDOID SUTURES (ENDOCRANIAL)

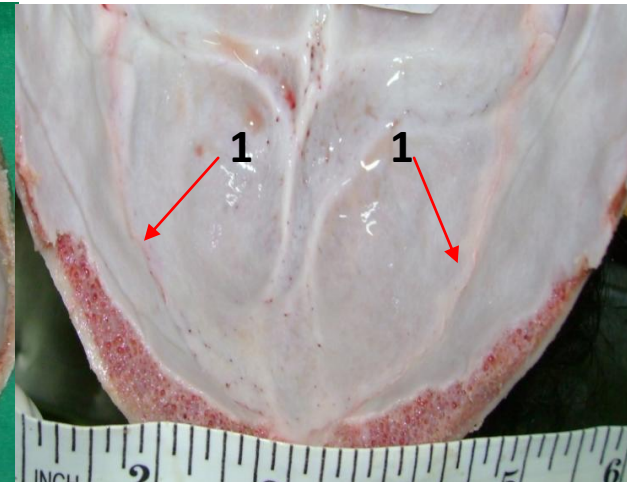
CASE-4



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



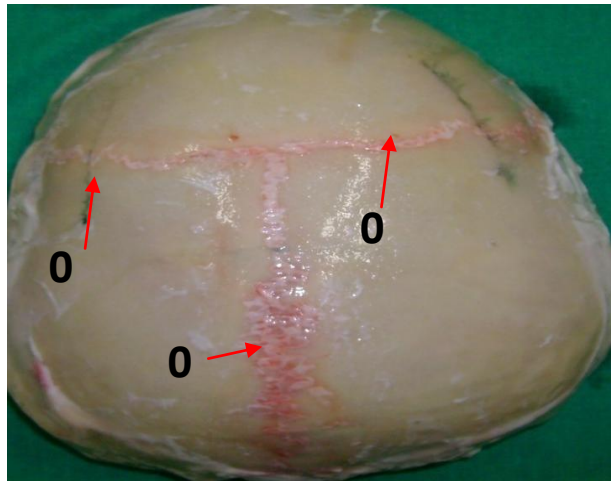
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



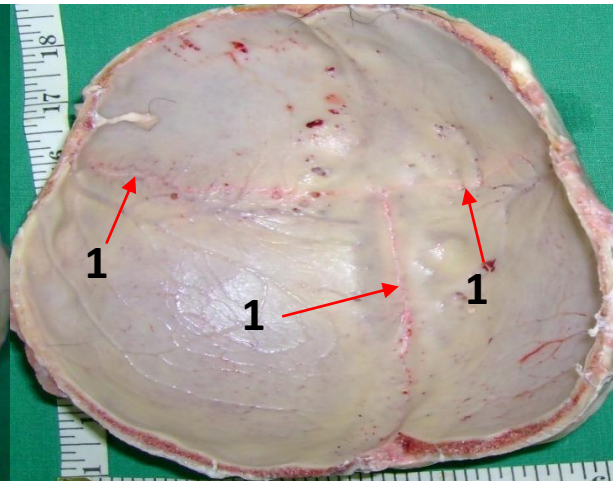
LAMDOID SUTURES (ENDOCRANIAL)

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

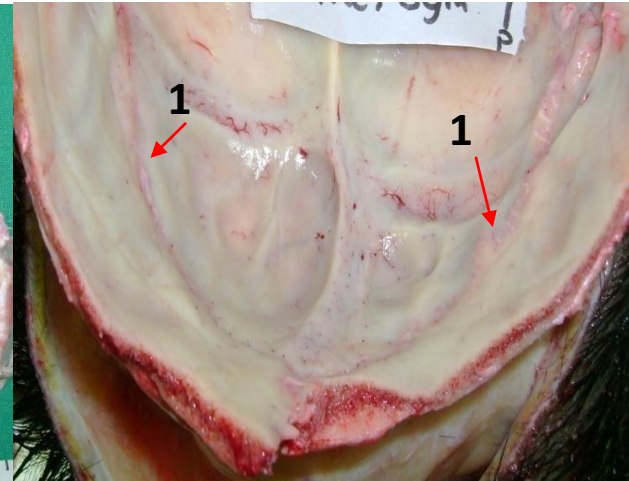
CASE-5



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

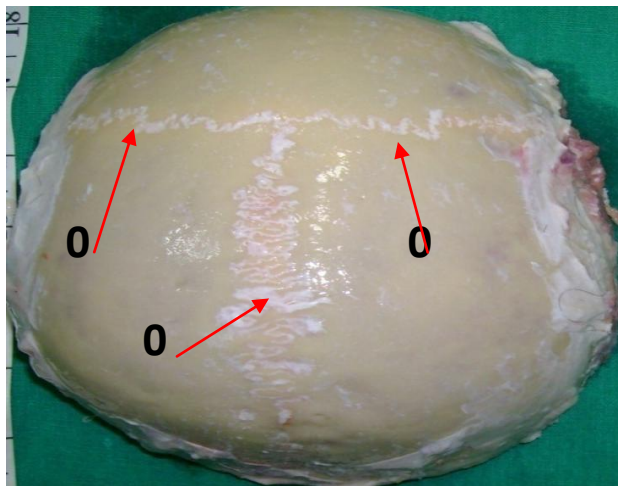


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

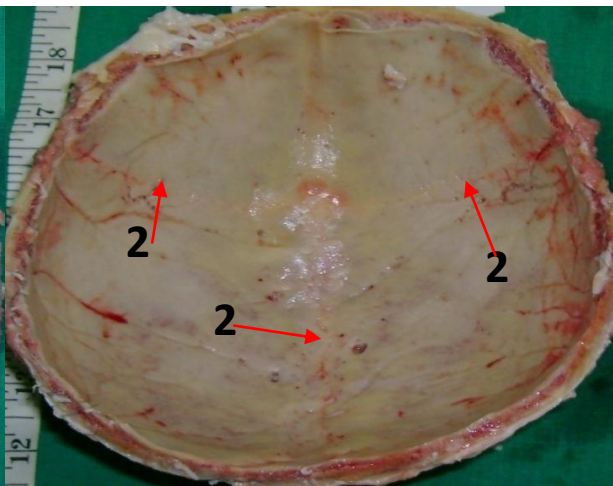


LAMDROID SUTURES (ENDOCRANIAL)

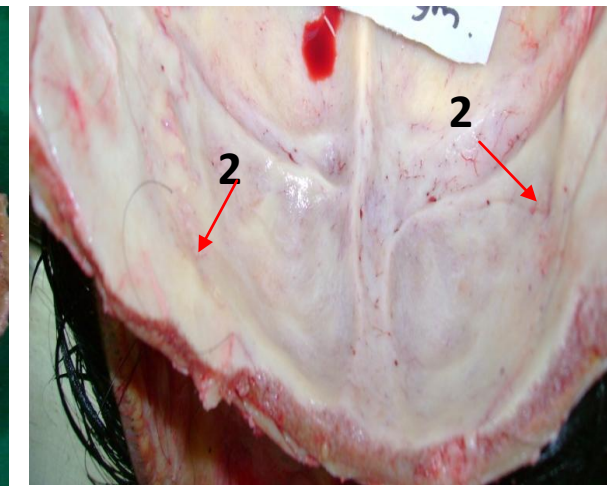
CASE-6



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



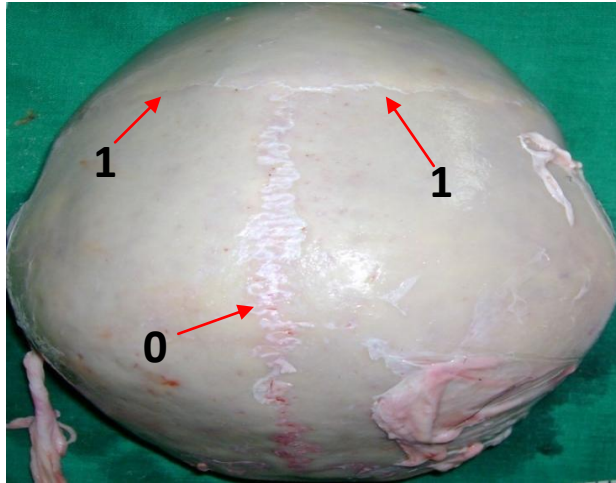
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



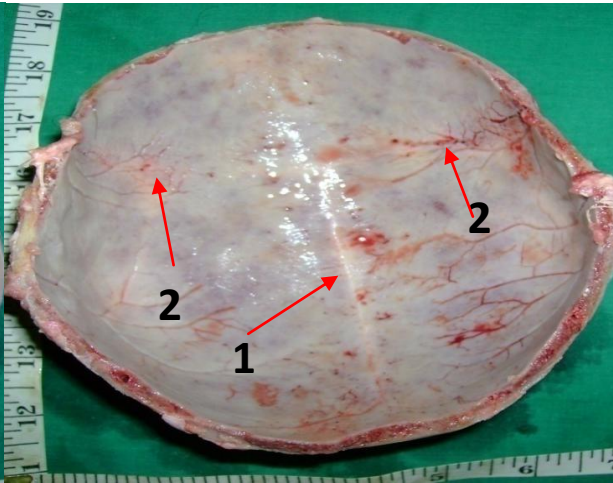
LAMDROID SUTURES (ENDOCRANIAL)

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

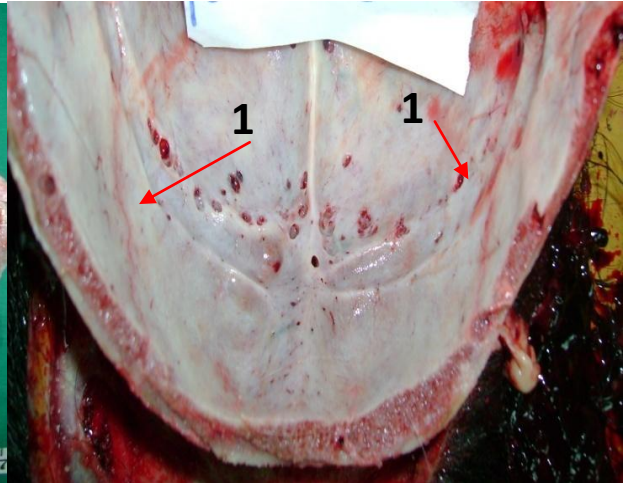
CASE-7



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

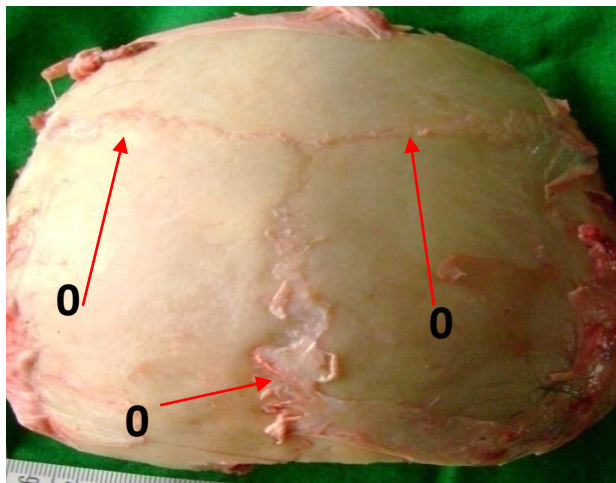


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

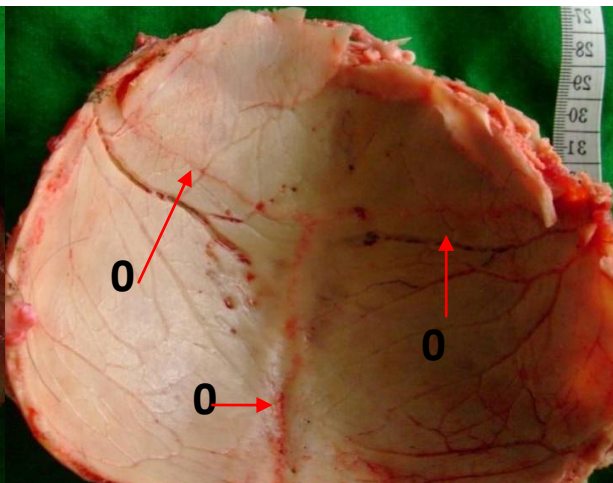


LAMDROID SUTURES (ENDOCRANIAL)

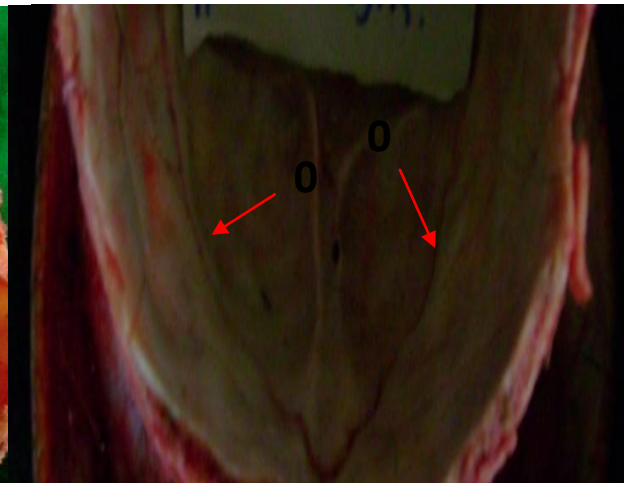
CASE-8



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



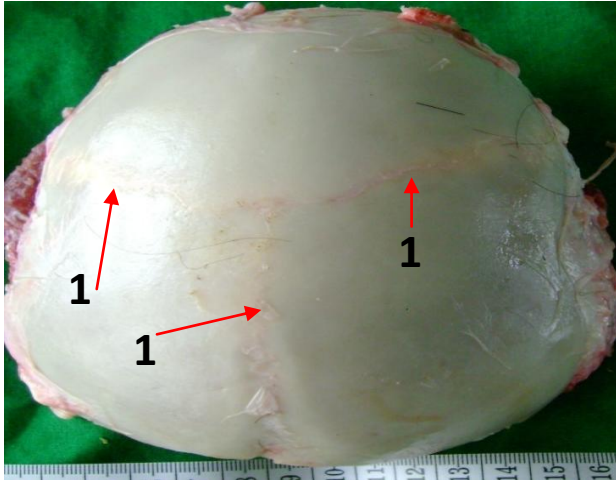
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



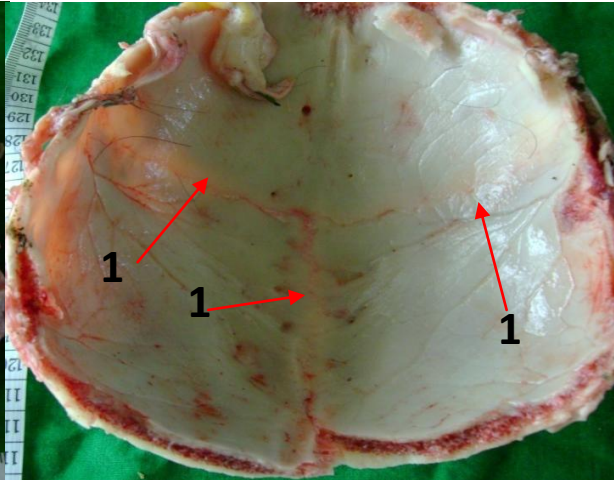
LAMDROID SUTURES (ENDOCRANIAL)

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

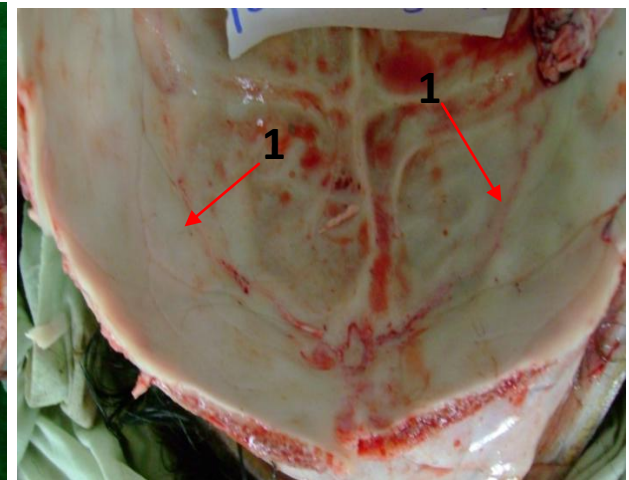
CASE-9



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

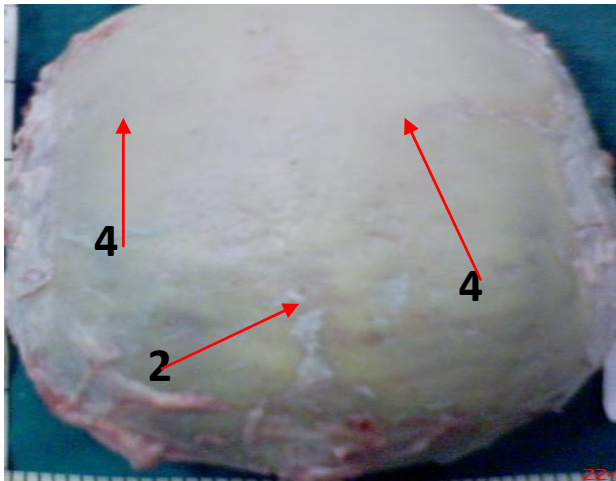


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

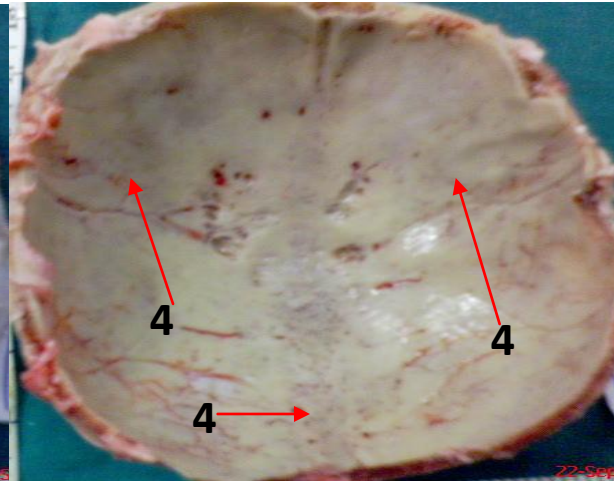


LAMDROID SUTURES (ENDOCRANIAL)

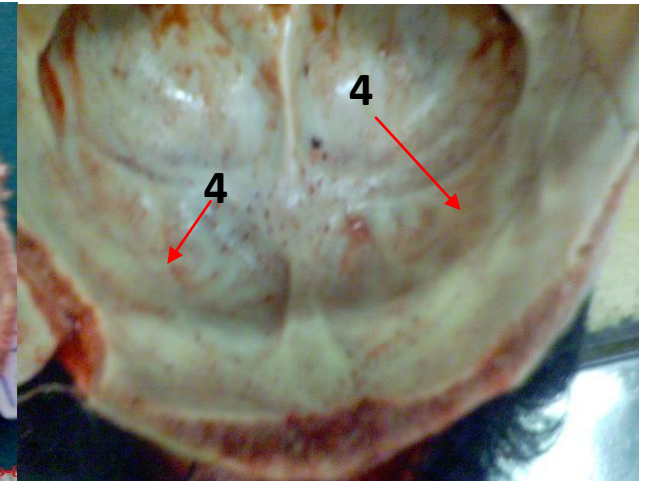
CASE-10



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



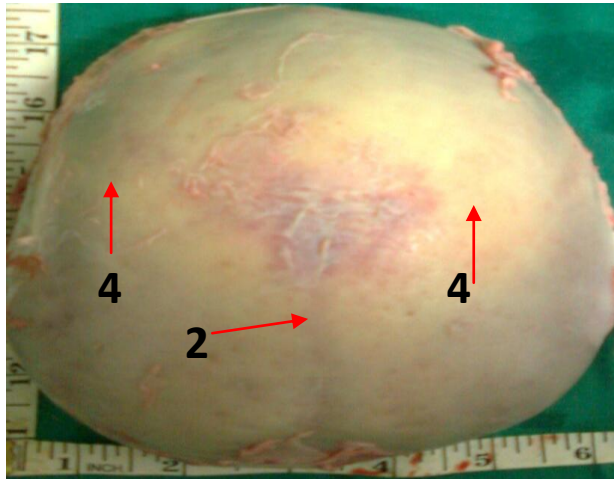
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



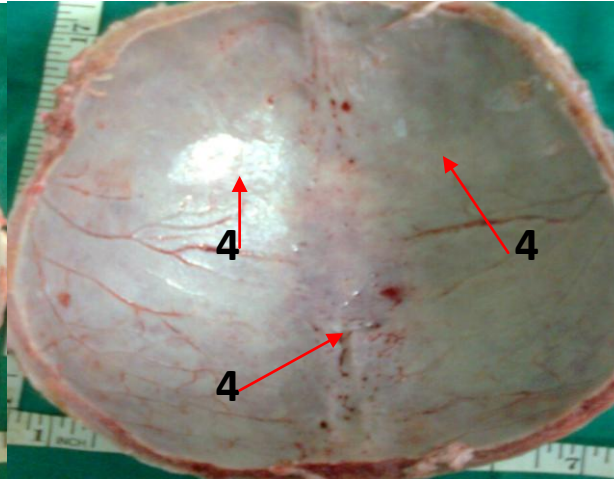
LAMDROID SUTURES (ENDOCRANIAL)

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

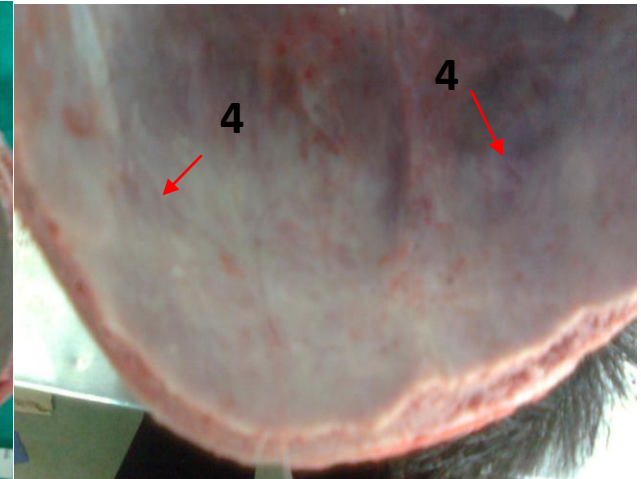
CASE-11



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

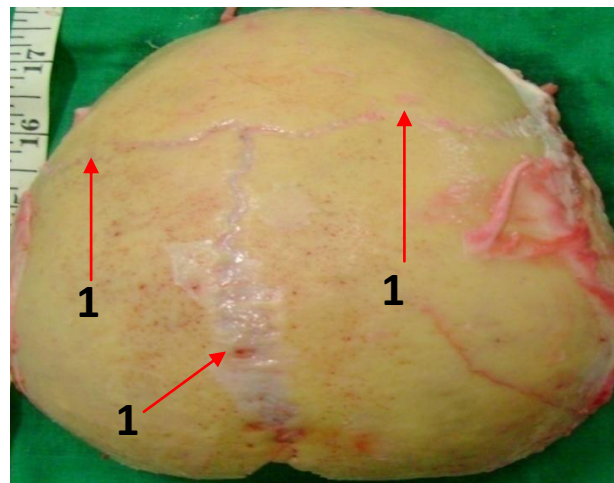


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

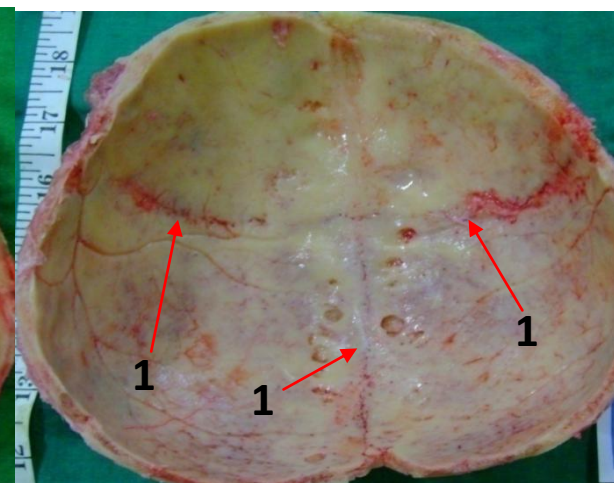


LAMDROID SUTURES (ENDOCRANIAL)

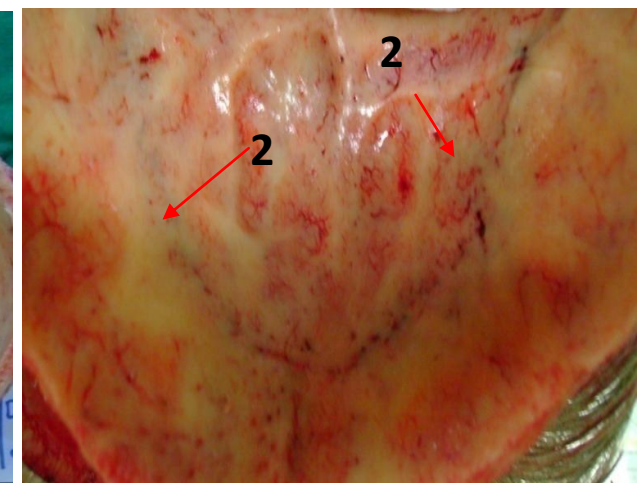
CASE-12



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



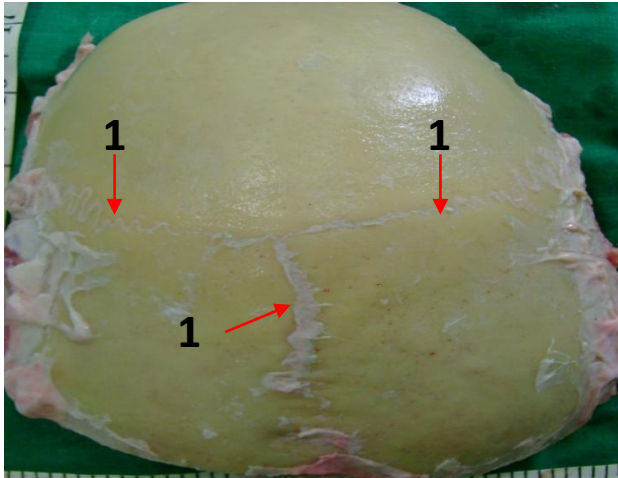
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



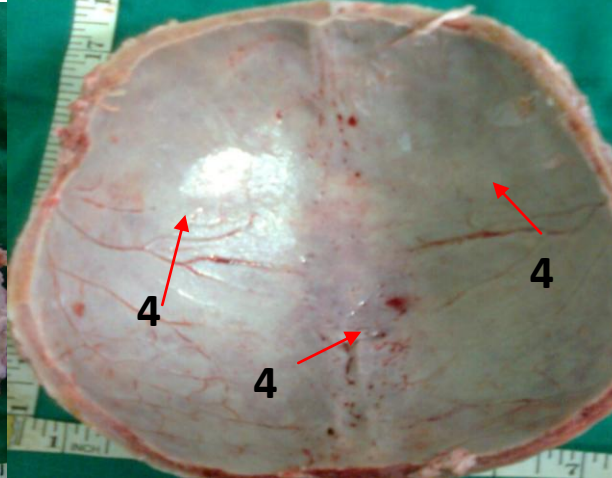
LAMDROID SUTURES (ENDOCRANIAL)

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

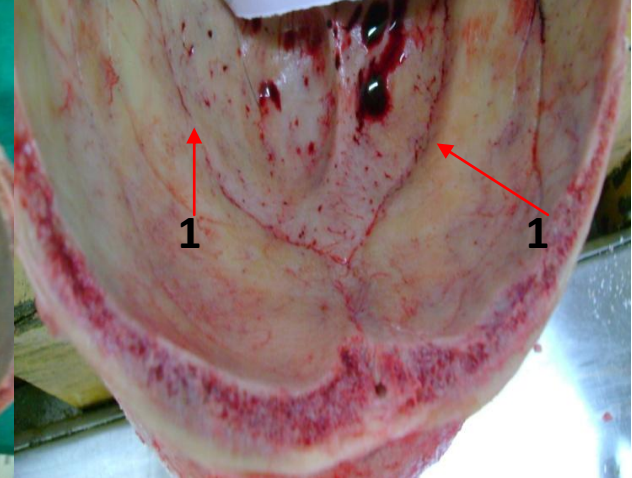
CASE-13



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

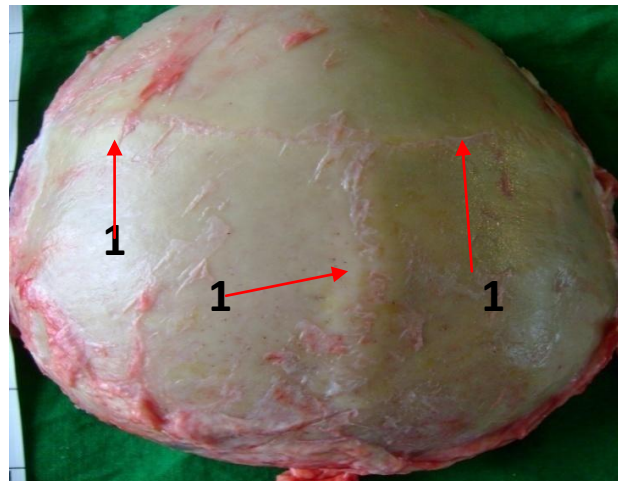


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

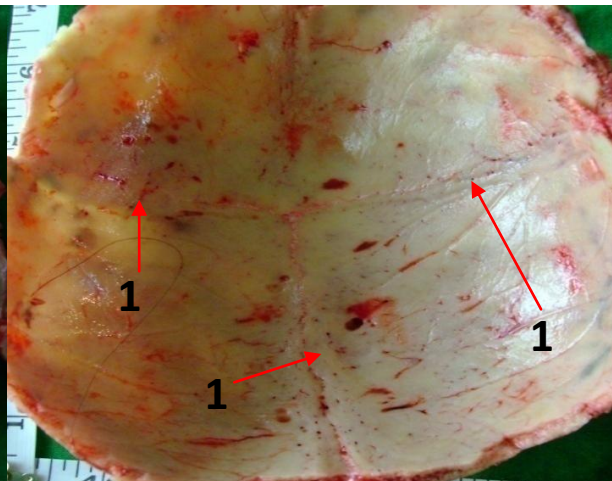


LAMDROID SUTURES (ENDOCRANIAL)

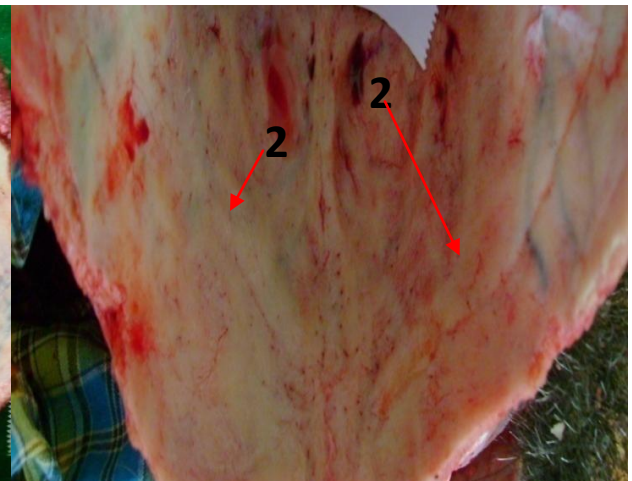
CASE-14



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



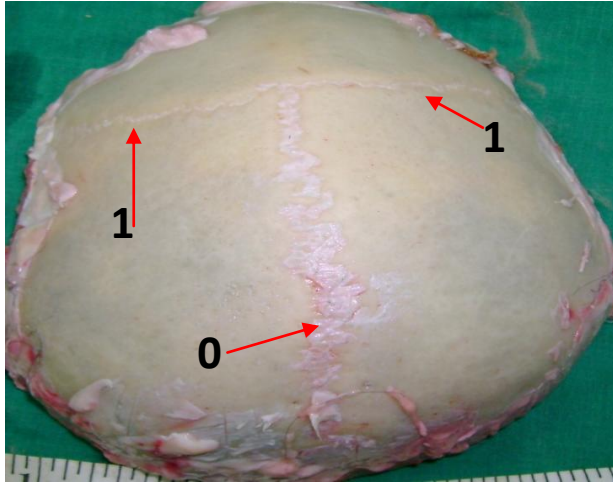
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



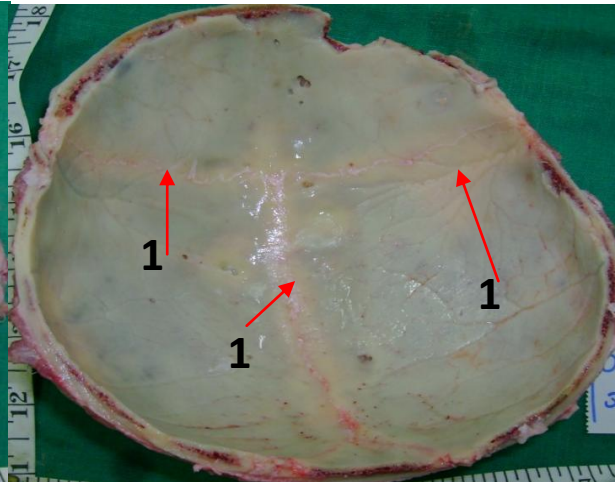
LAMDROID SUTURES (ENDOCRANIAL)

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

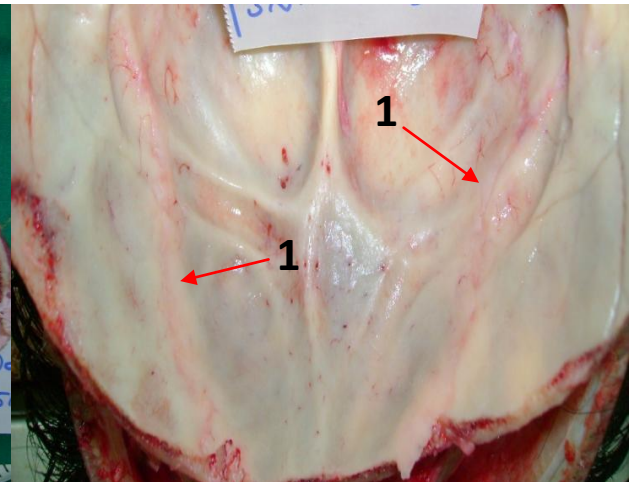
CASE-15



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

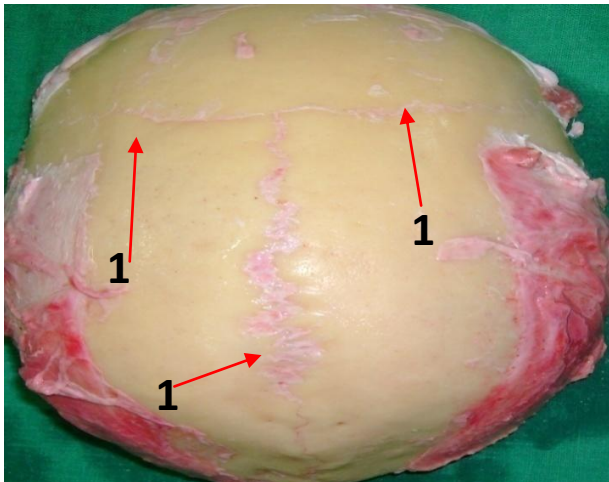


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

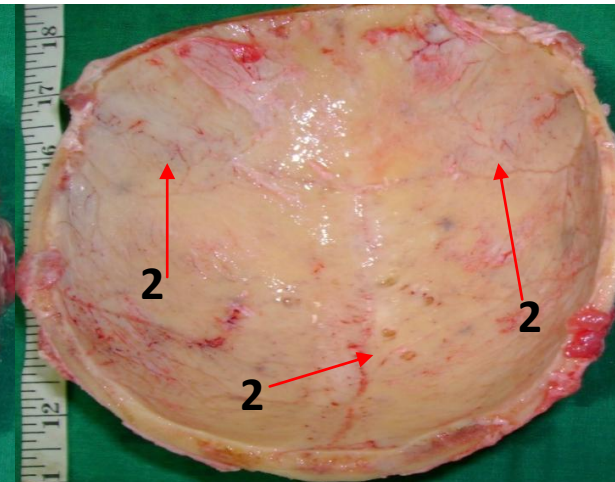


LAMDOID SUTURES (ENDOCRANIAL)

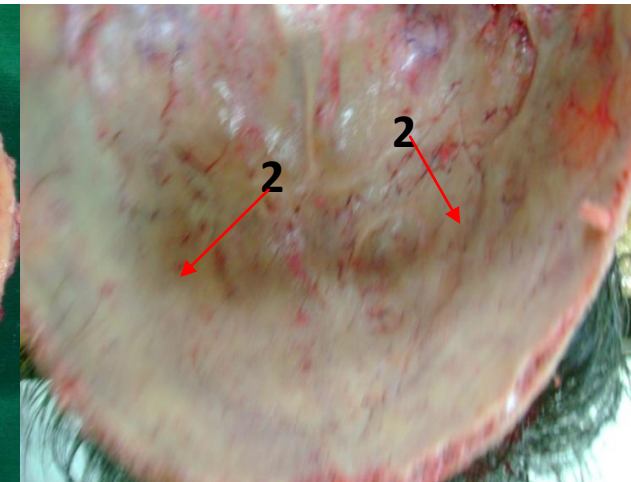
CASE-16



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



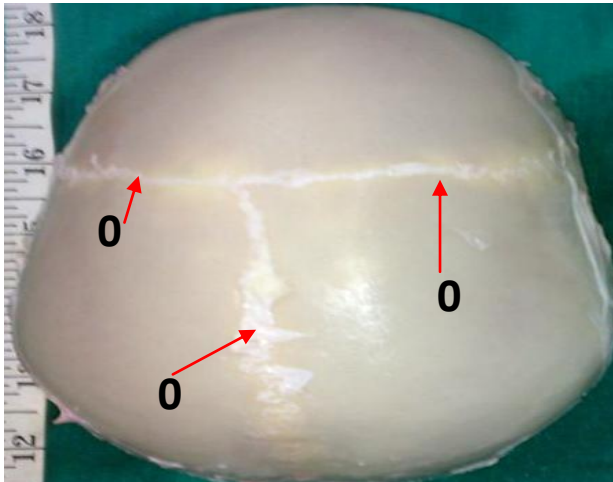
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



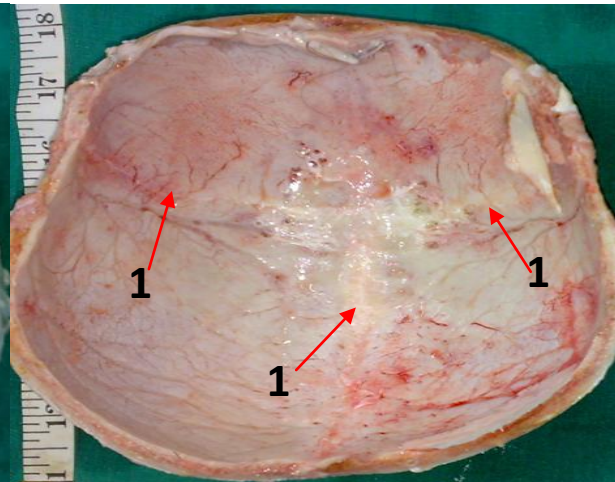
LAMDOID SUTURES (ENDOCRANIAL)

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

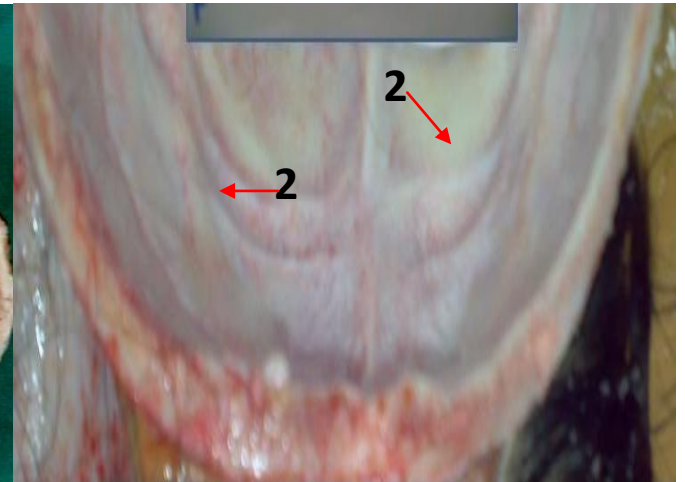
CASE-17



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

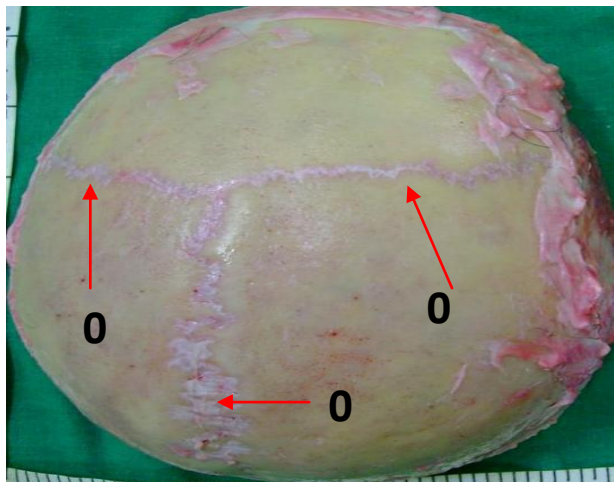


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

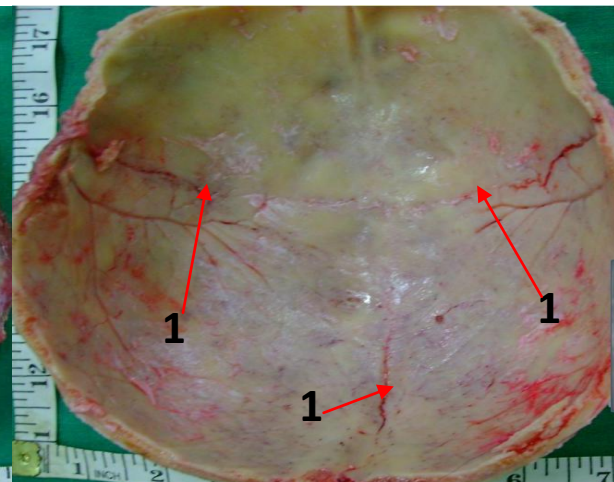


LAMDROID SUTURES (ENDOCRANIAL)

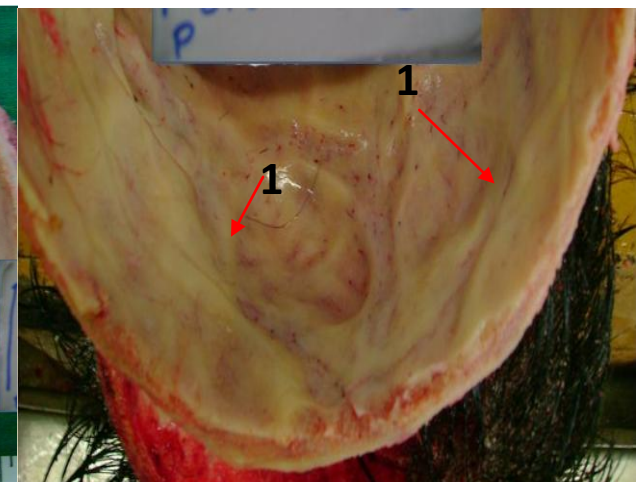
CASE-18



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



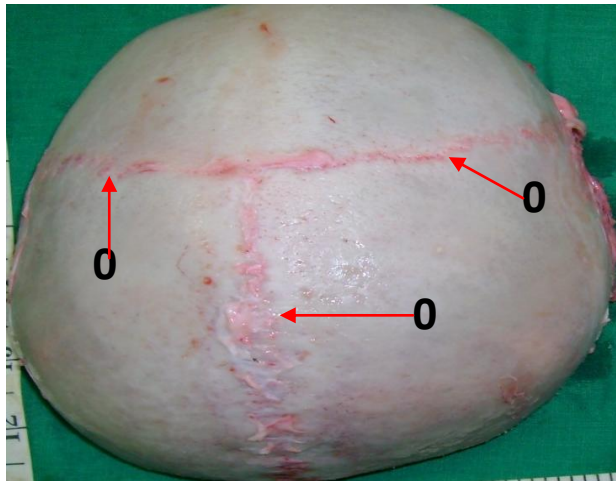
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



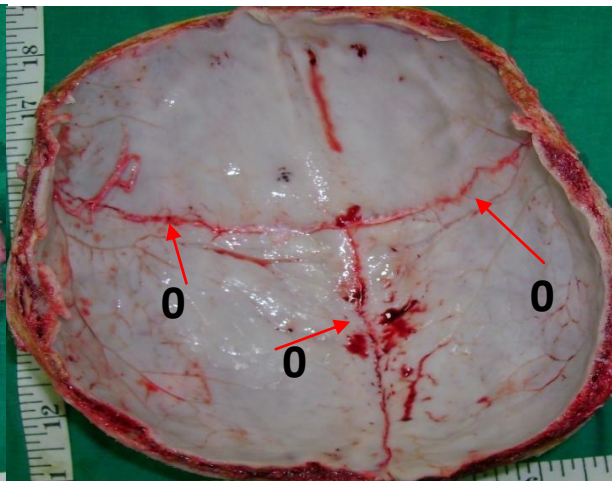
LAMDROID SUTURES (ENDOCRANIAL)

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)

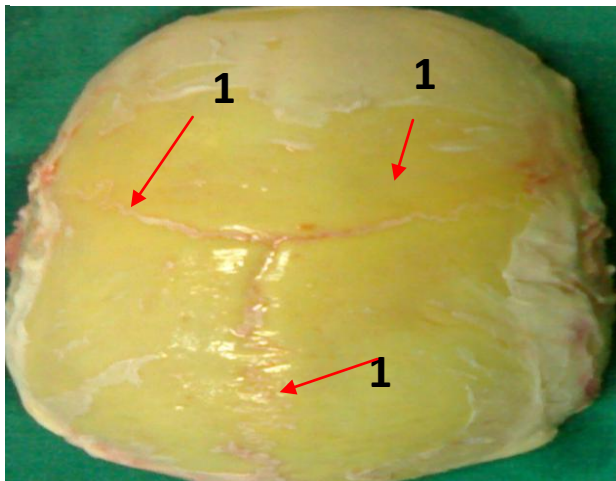


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

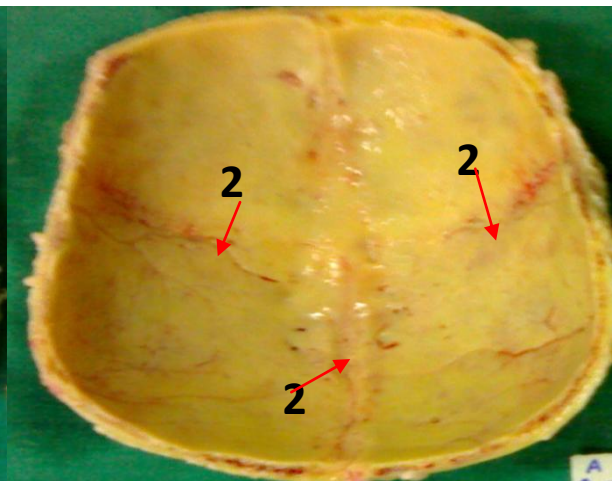


LAMDROID SUTURES (ENDOCRANIAL)

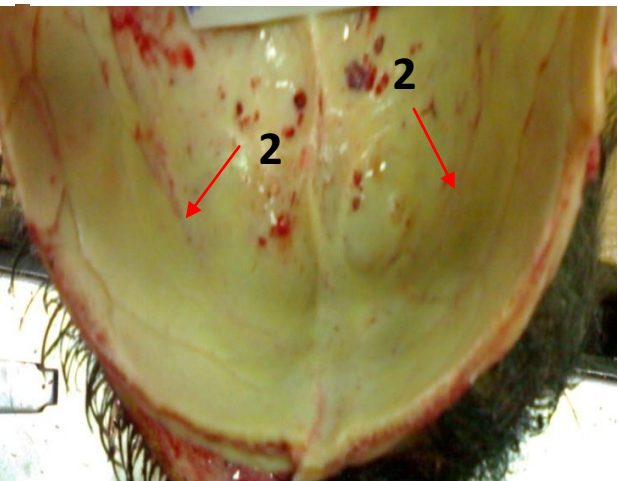
CASE-20



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



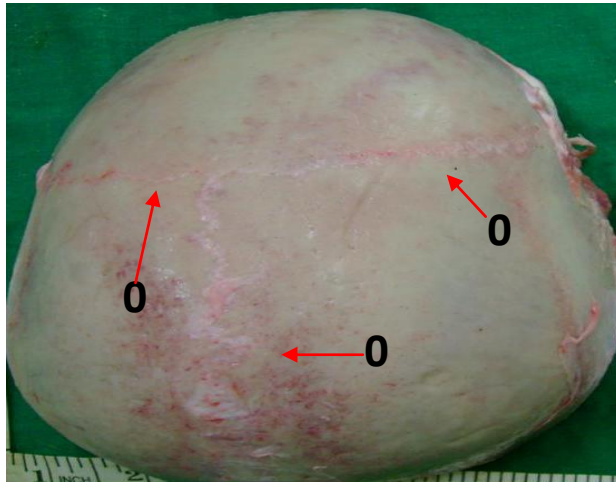
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



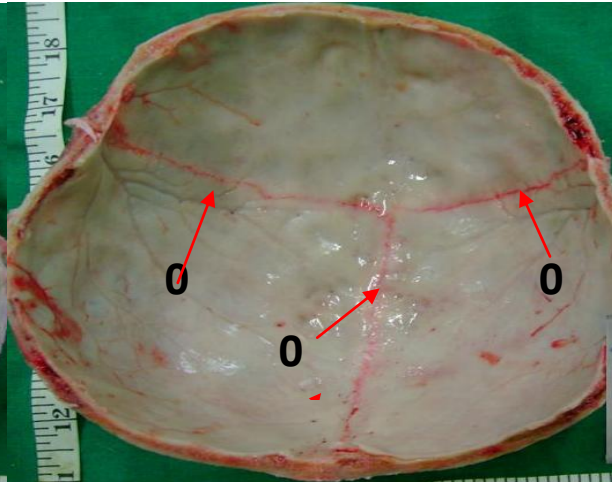
LAMDROID SUTURES (ENDOCRANIAL)

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

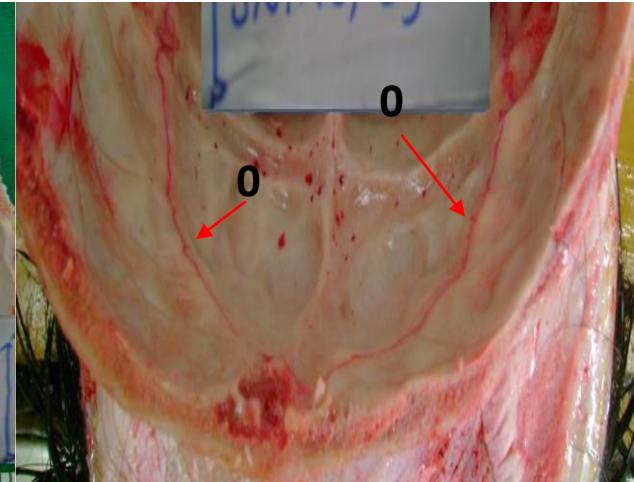
CASE-21



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

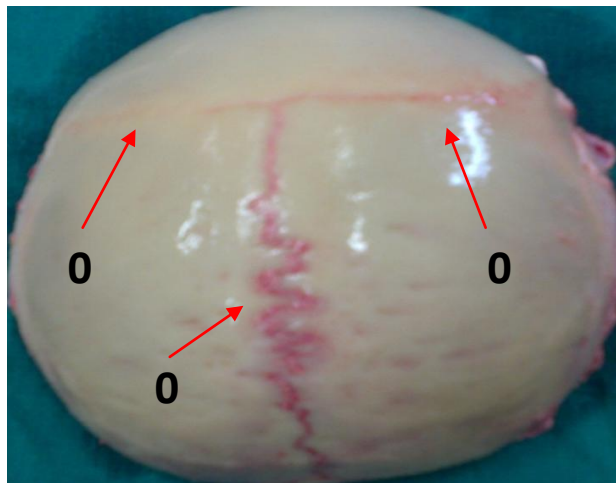


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

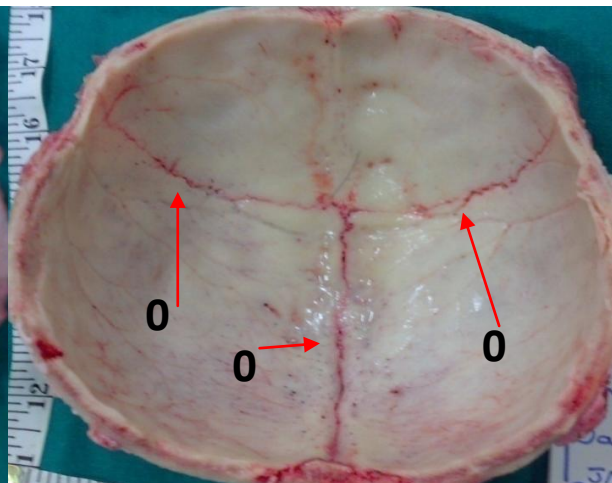


LAMDROID SUTURES (ENDOCRANIAL)

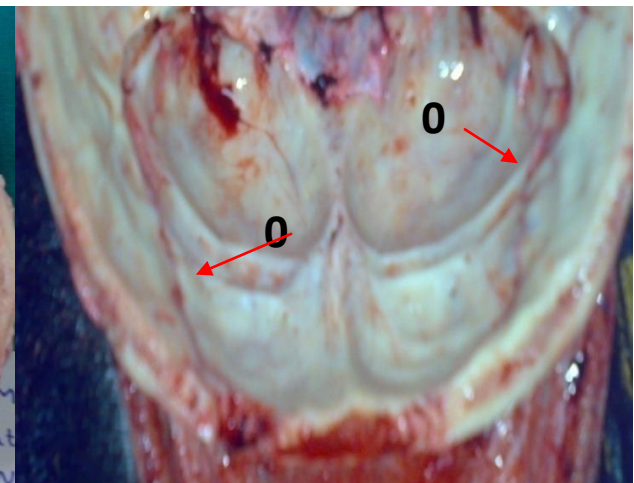
CASE-22



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



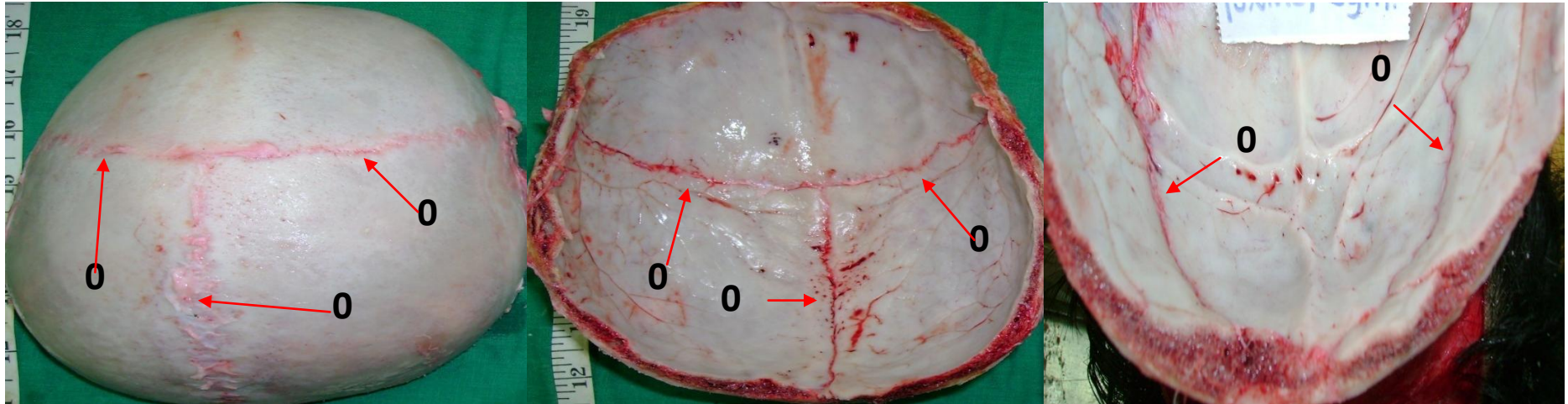
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



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

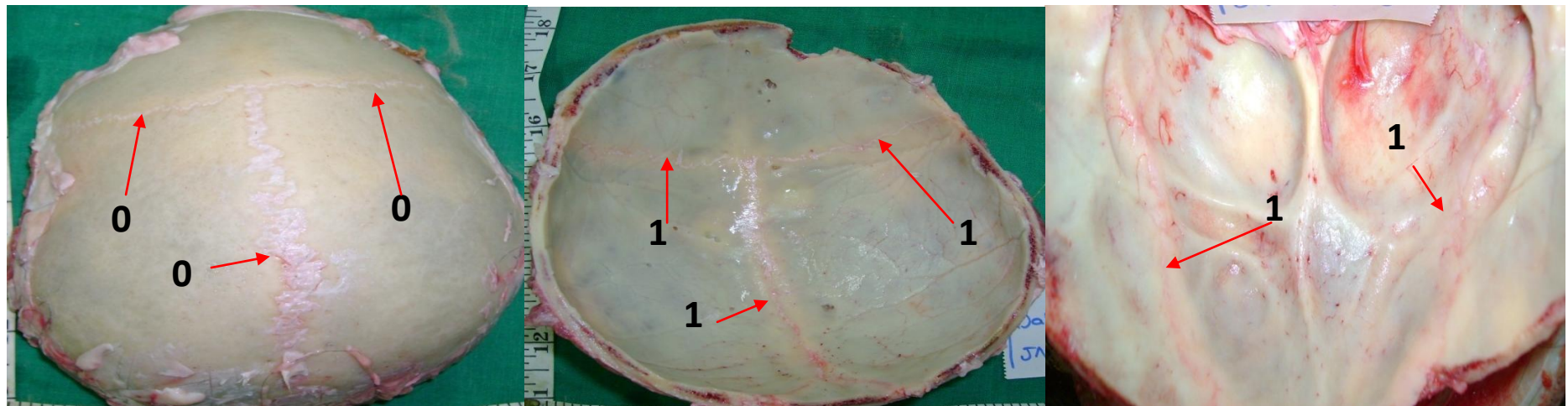


CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

LAMDOID SUTURES (ENDOCRANIAL)

CASE-24



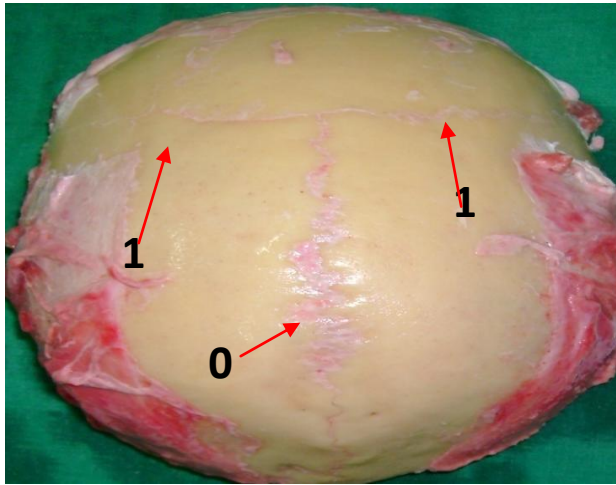
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

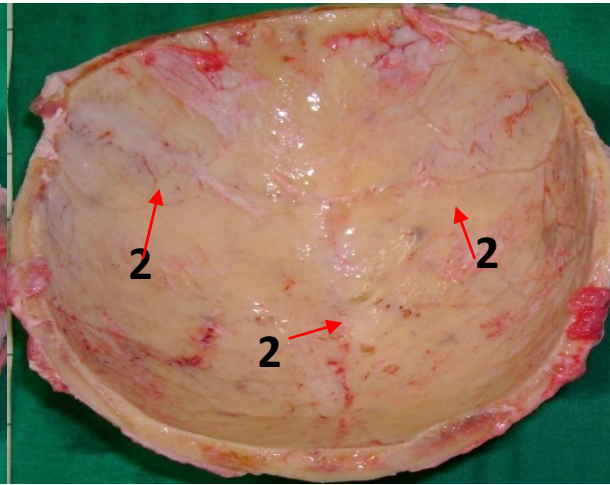
LAMDOID SUTURES (ENDOCRANIAL)

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

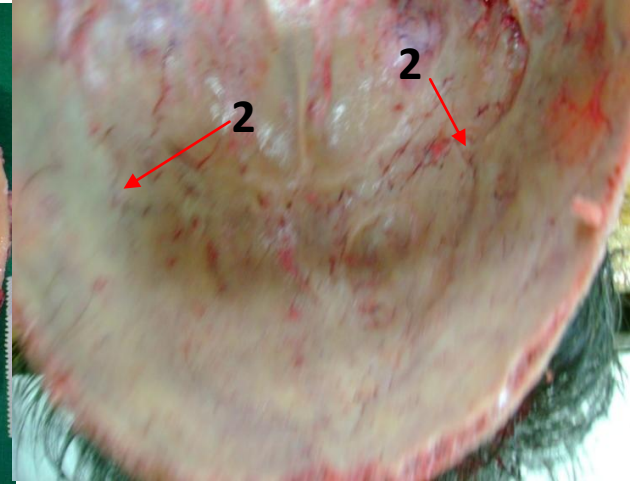
CASE-25



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

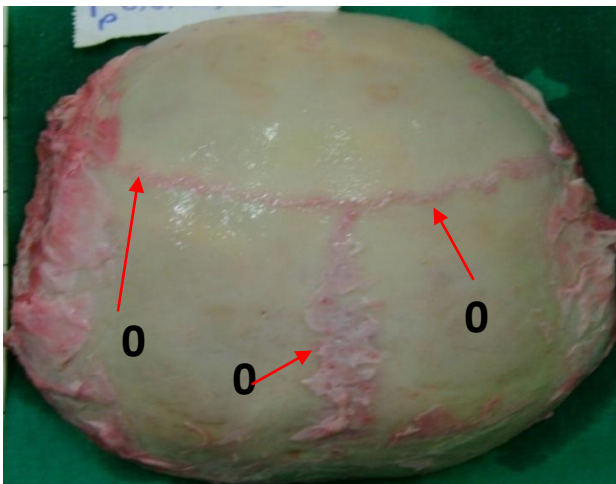


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

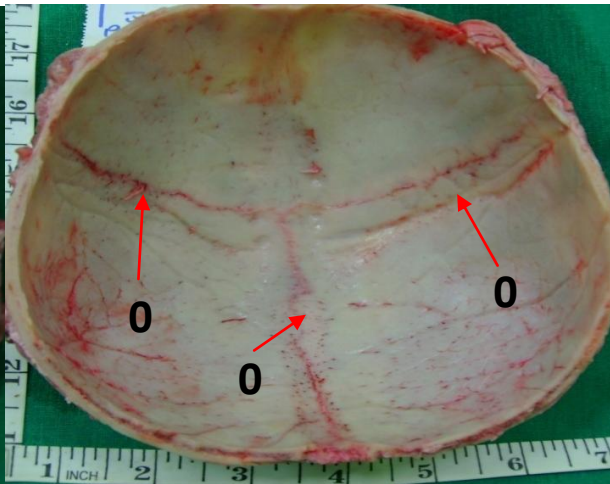


LAMDROID SUTURES (ENDOCRANIAL)

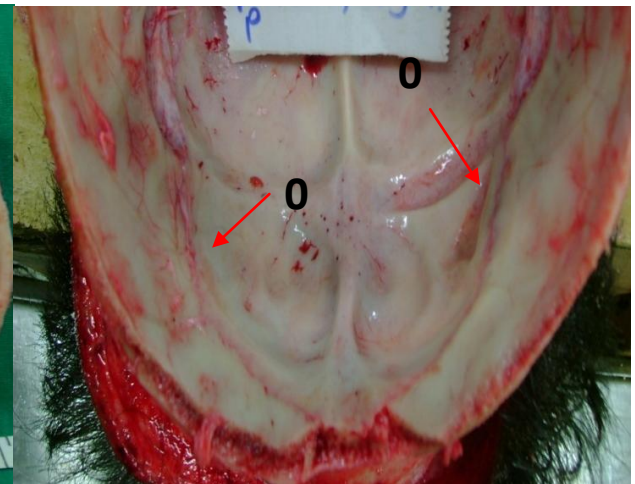
CASE-26



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



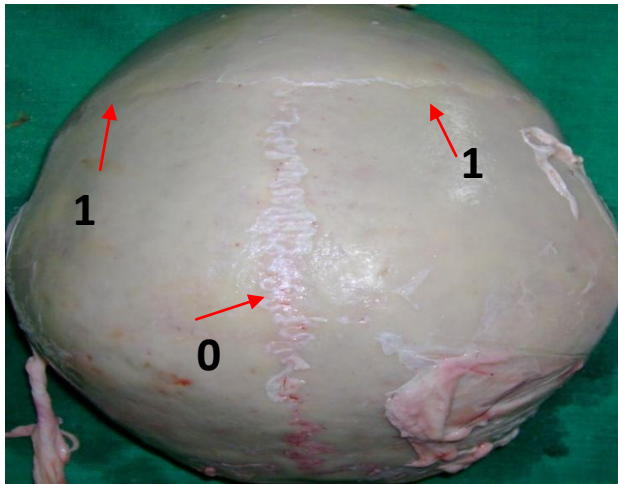
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



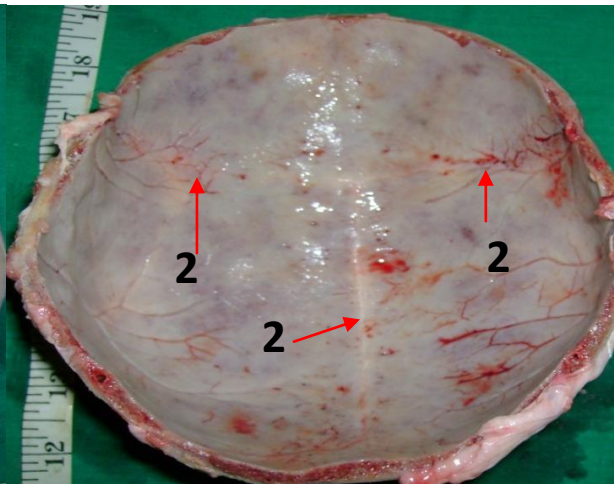
LAMDROID SUTURES (ENDOCRANIAL)

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

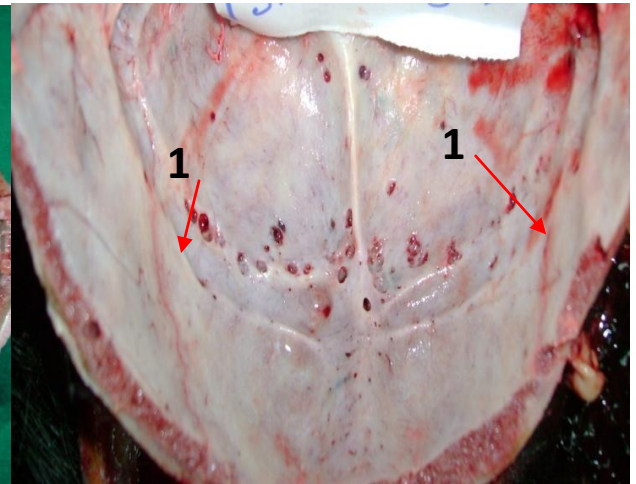
CASE-27



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

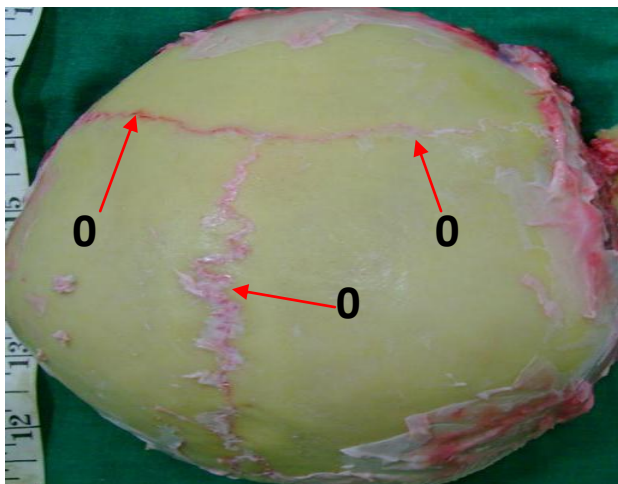


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

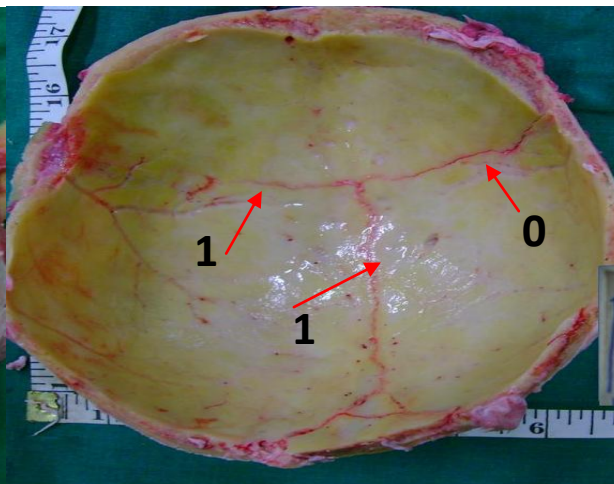


LAMDROID SUTURES (ENDOCRANIAL)

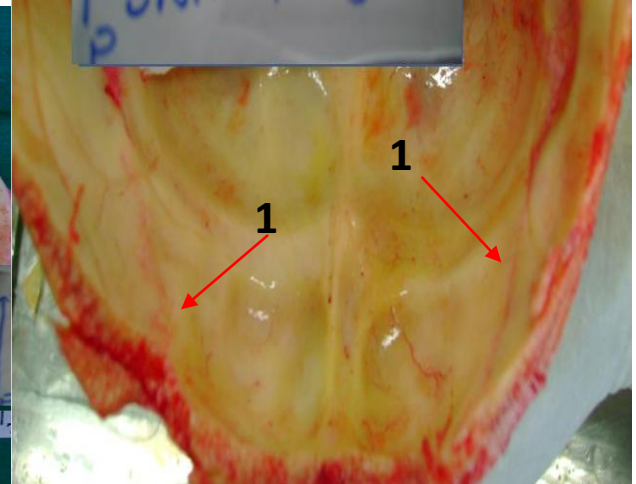
CASE-28



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



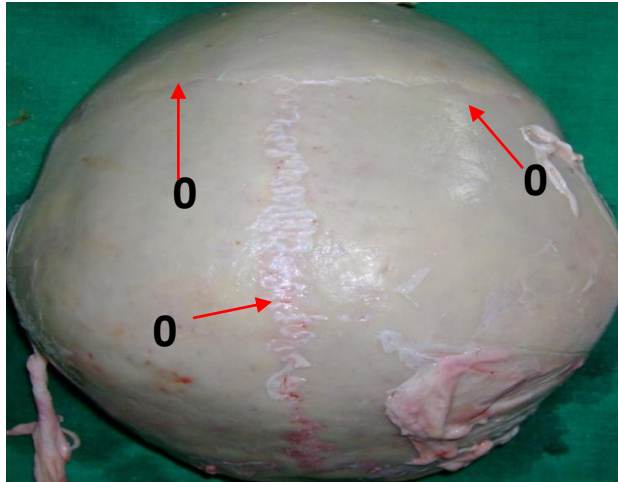
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



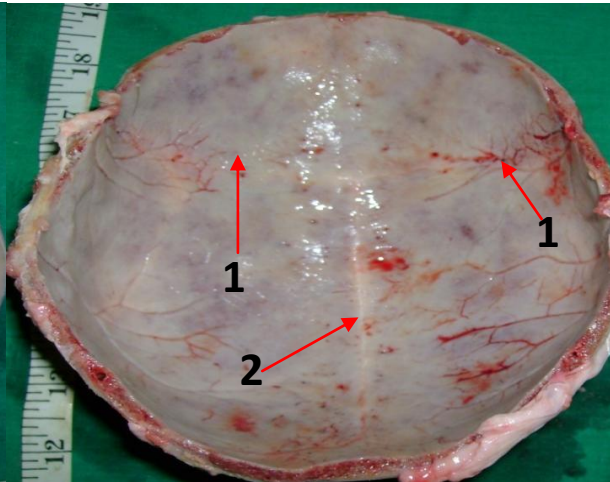
LAMDROID SUTURES (ENDOCRANIAL)

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

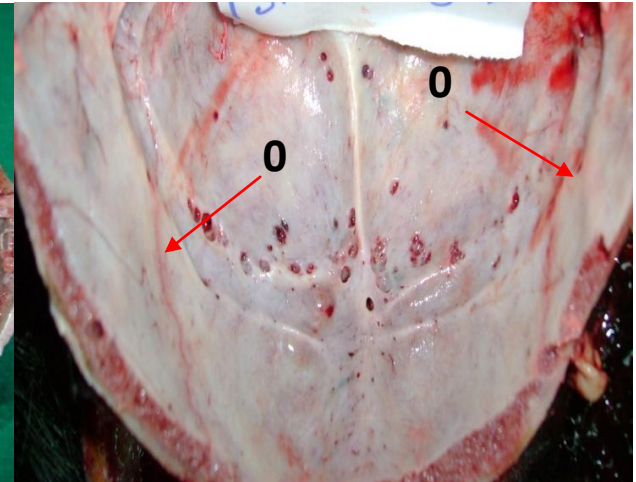
CASE-29



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

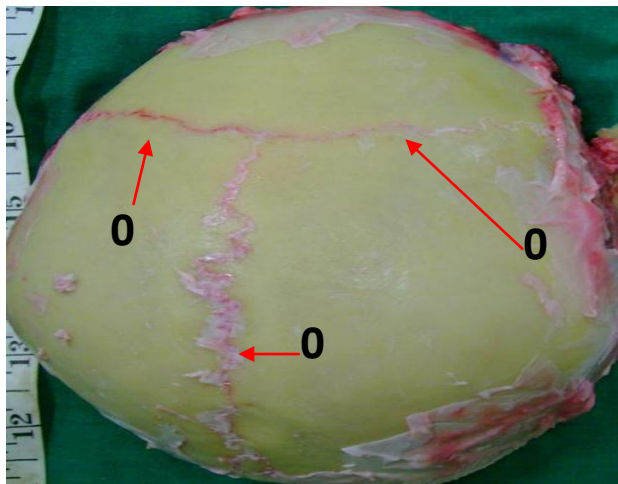


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

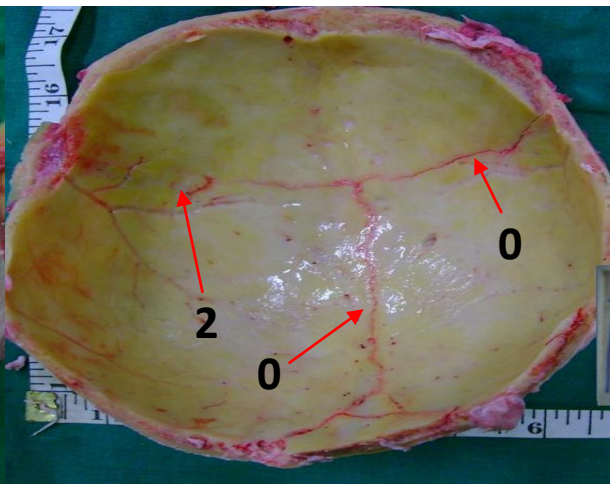


LAMDROID SUTURES (ENDOCRANIAL)

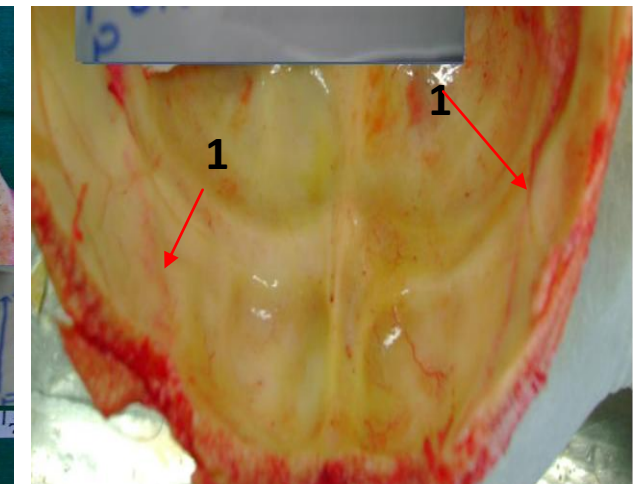
CASE-30



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



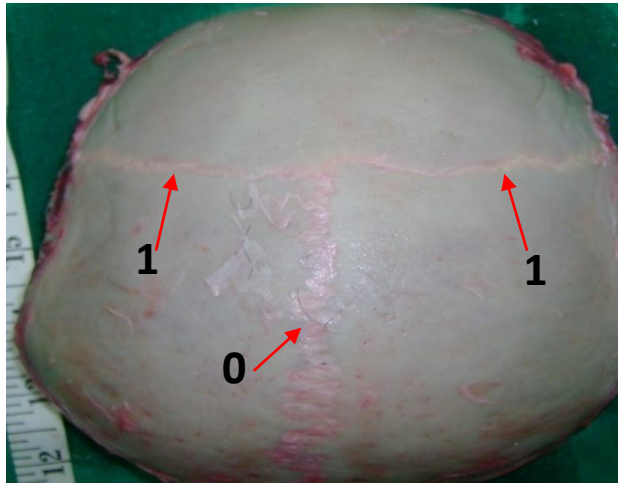
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



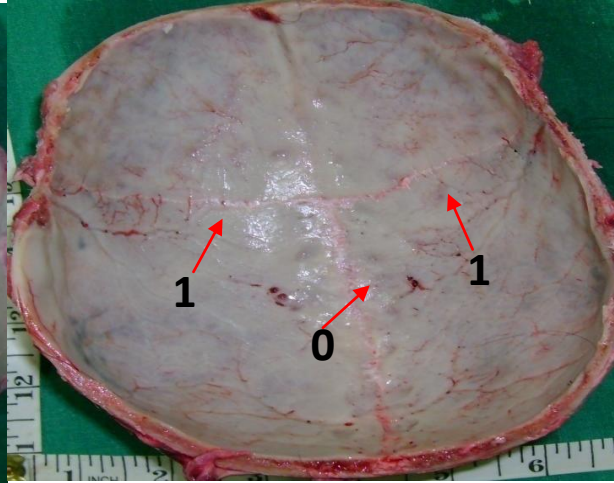
LAMDROID SUTURES (ENDOCRANIAL)

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

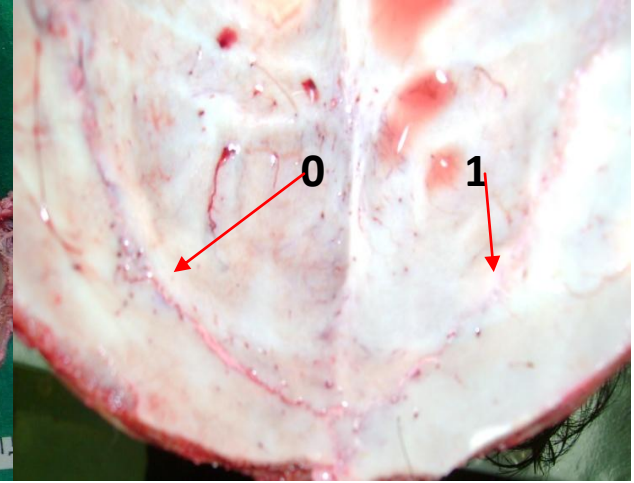
CASE-31



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

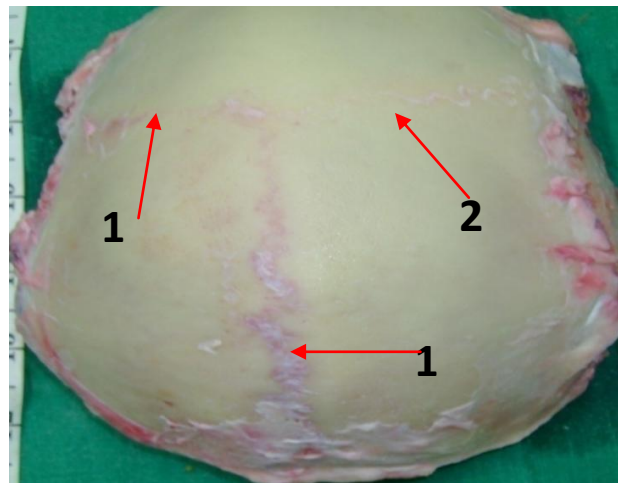


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

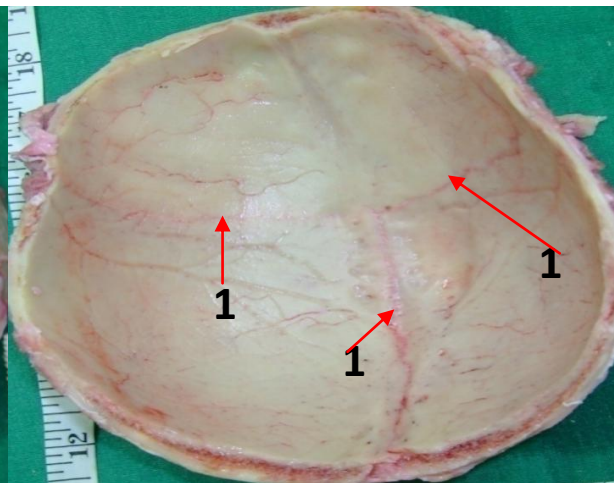


LAMDOID SUTURES (ENDOCRANIAL)

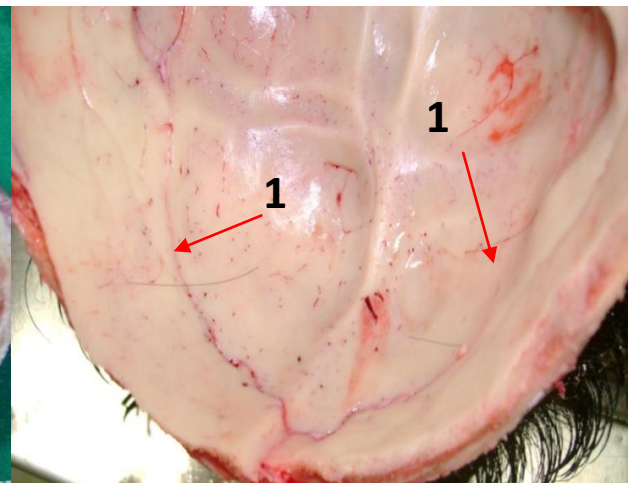
CASE-32



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



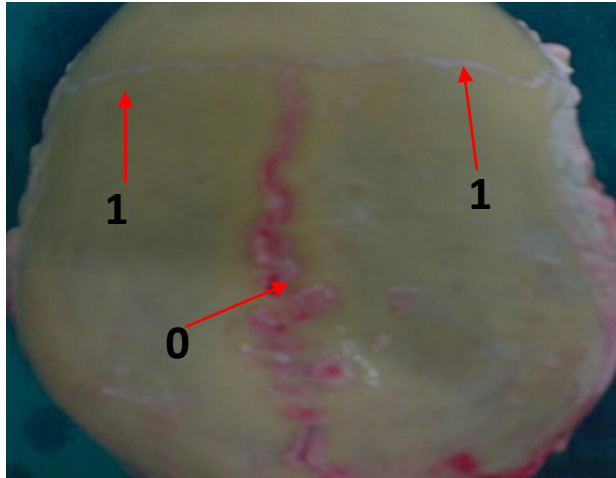
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



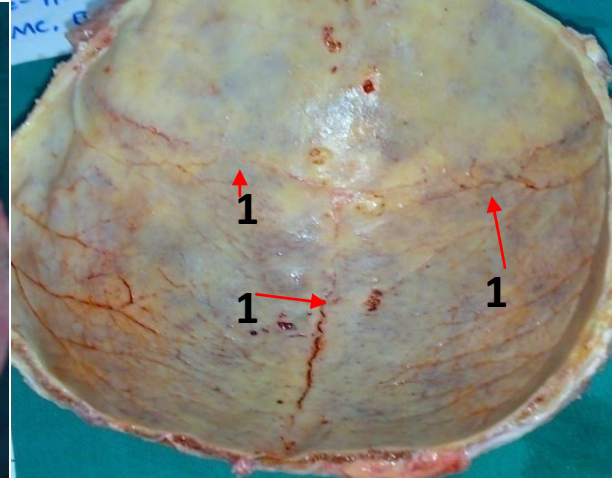
LAMDOID SUTURES (ENDOCRANIAL)

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

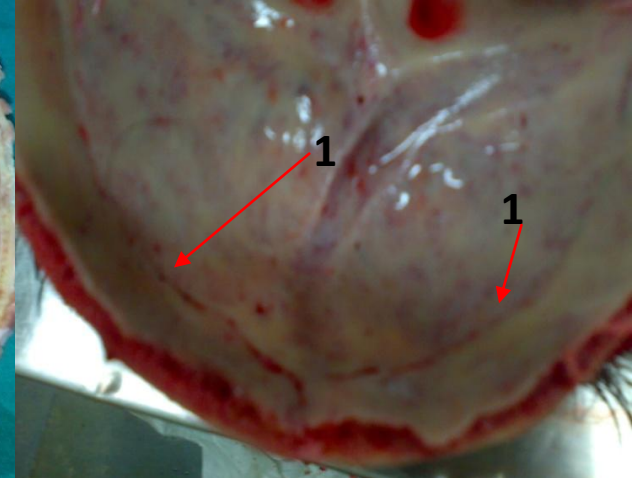
CASE-33



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

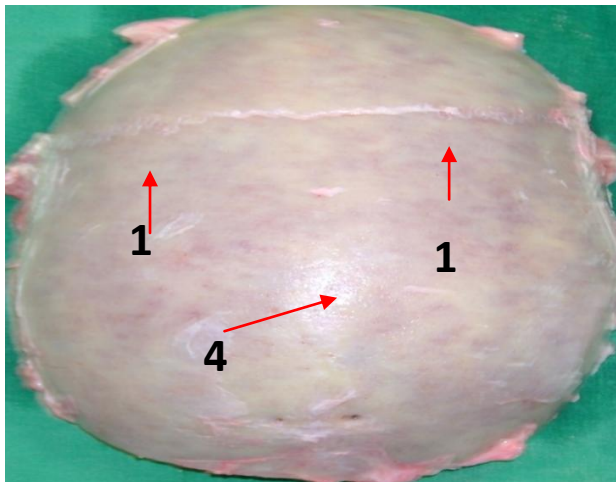


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

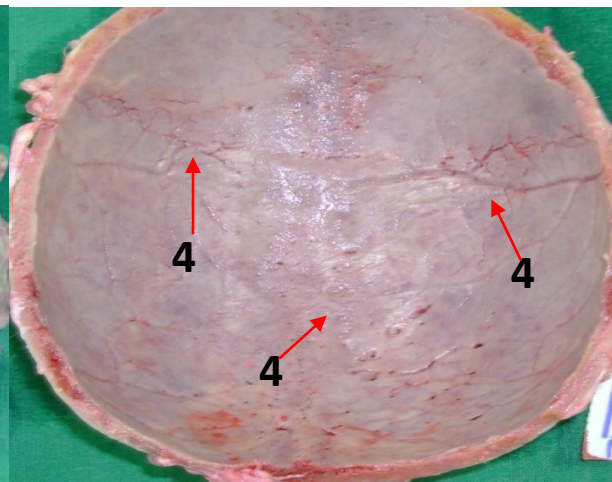


LAMDOID SUTURES (ENDOCRANIAL)

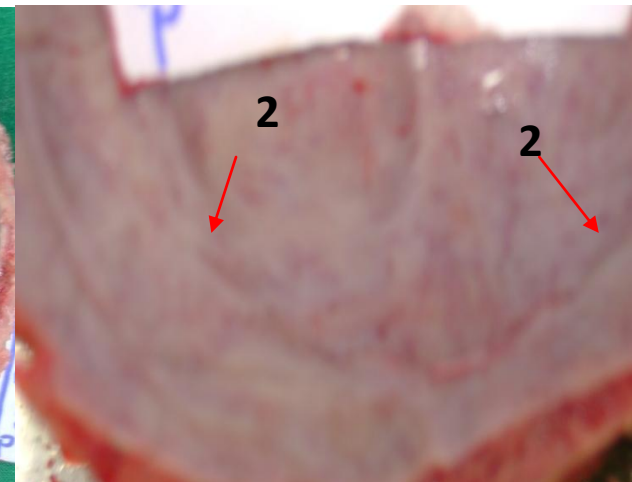
CASE-34



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



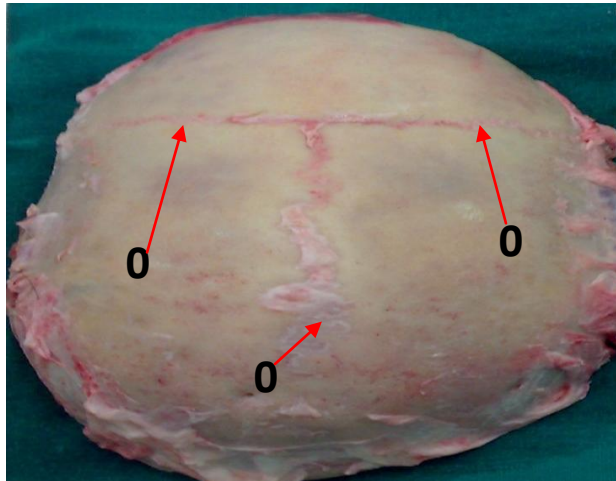
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



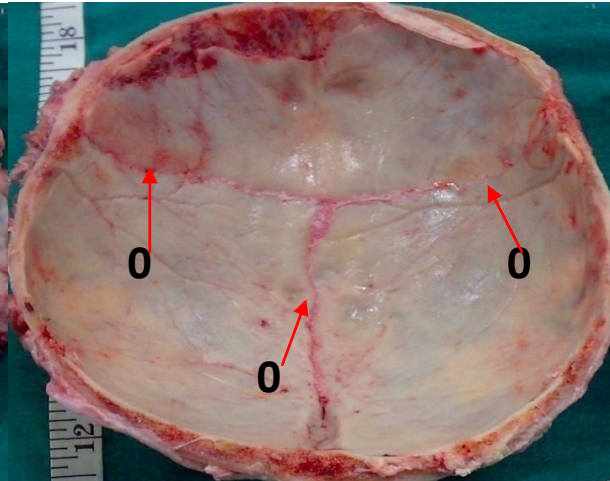
LAMDOID SUTURES (ENDOCRANIAL)

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

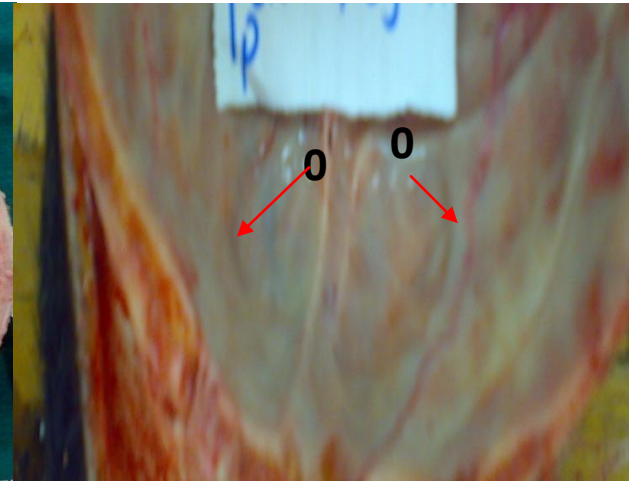
CASE-35



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

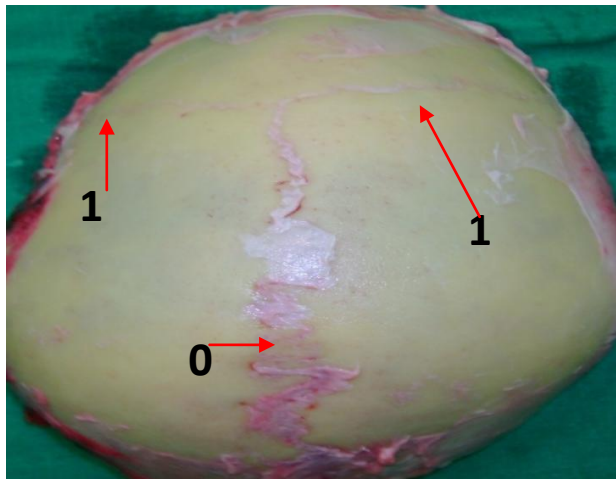


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

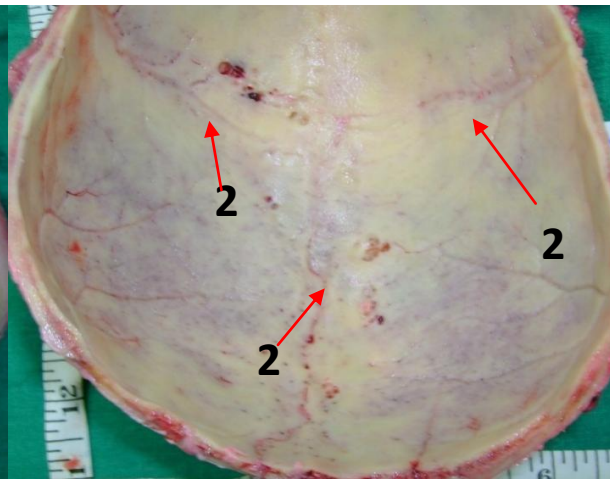


LAMDROID SUTURES (ENDOCRANIAL)

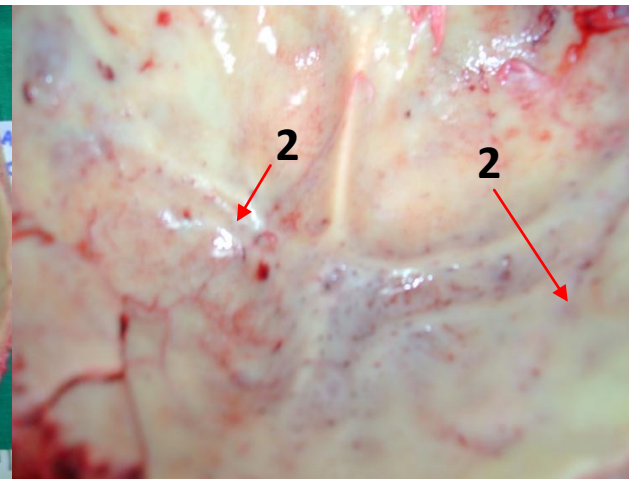
CASE-36



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



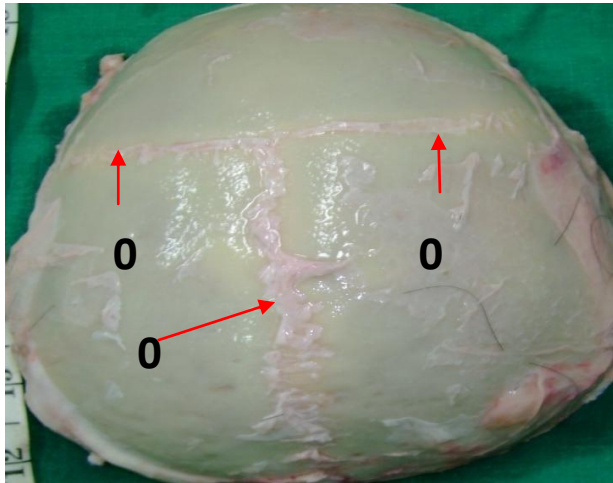
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



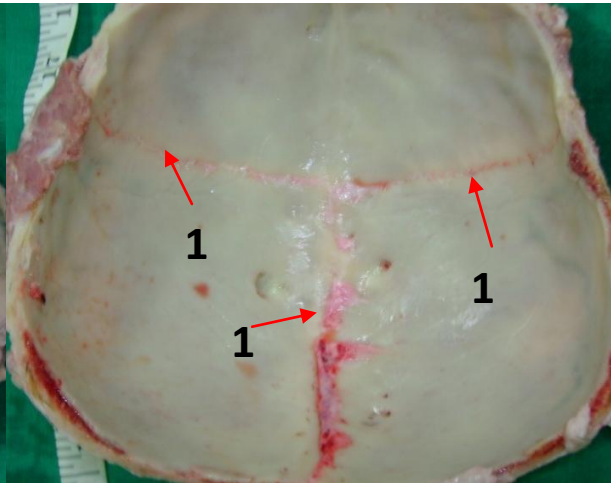
LAMDROID SUTURES (ENDOCRANIAL)

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

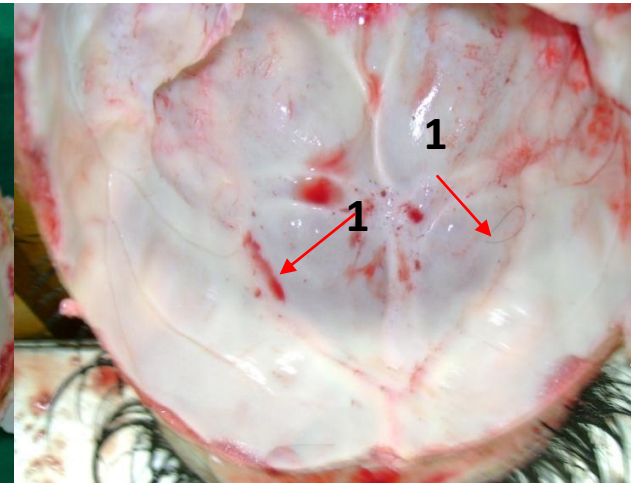
CASE-37



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

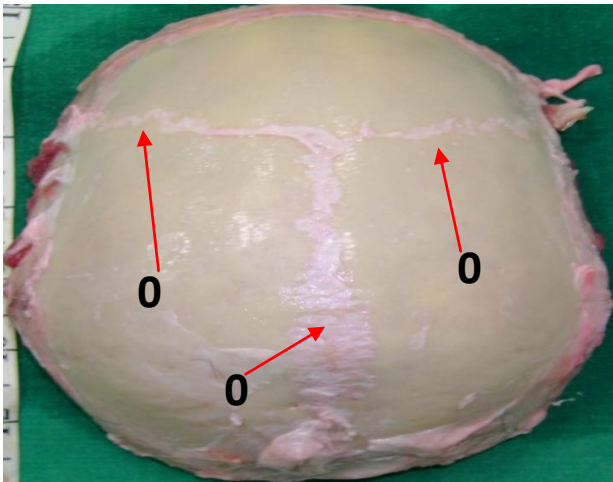


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

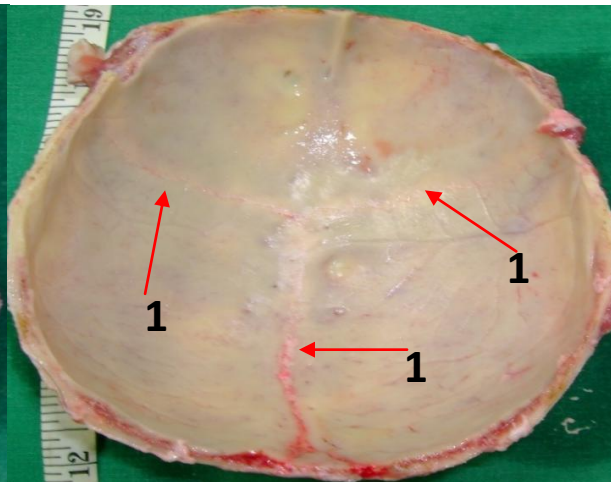


LAMDROID SUTURES (ENDOCRANIAL)

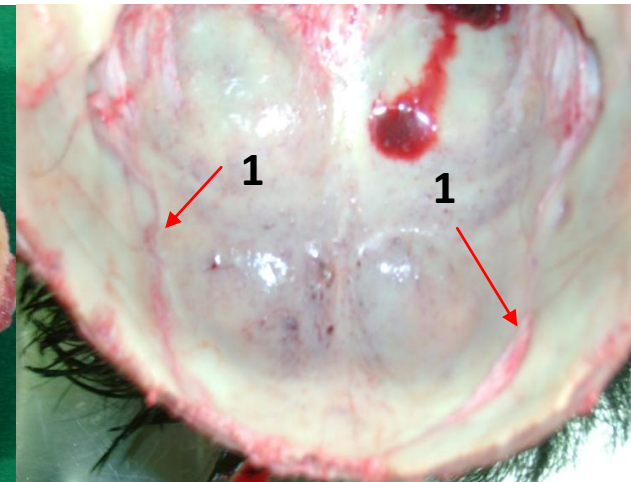
CASE-38



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



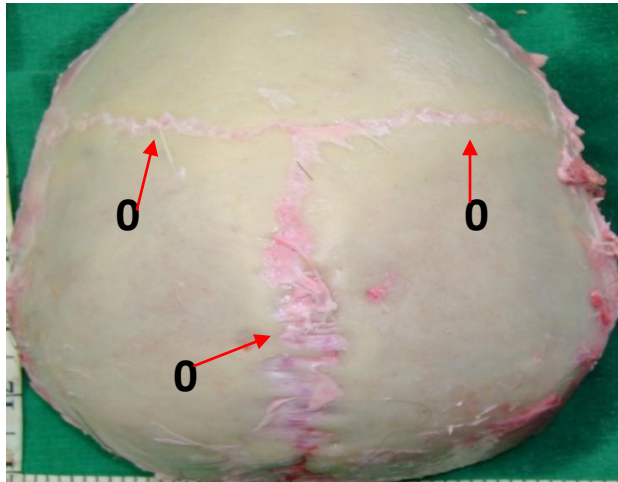
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



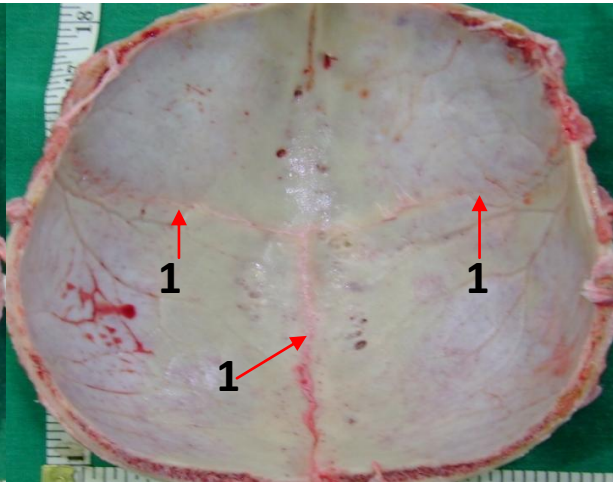
LAMDROID SUTURES (ENDOCRANIAL)

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

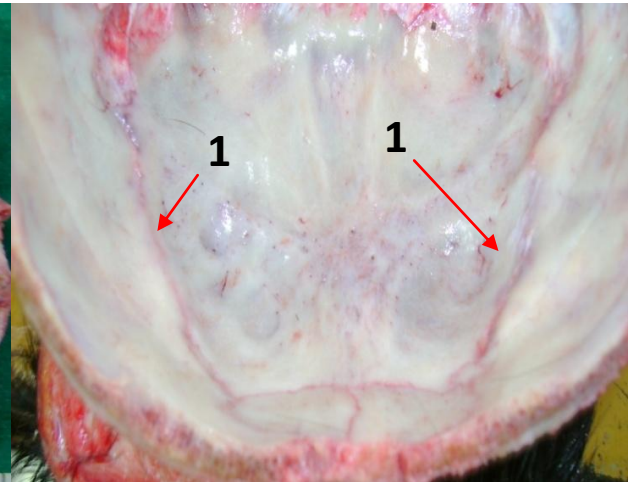
CASE-39



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

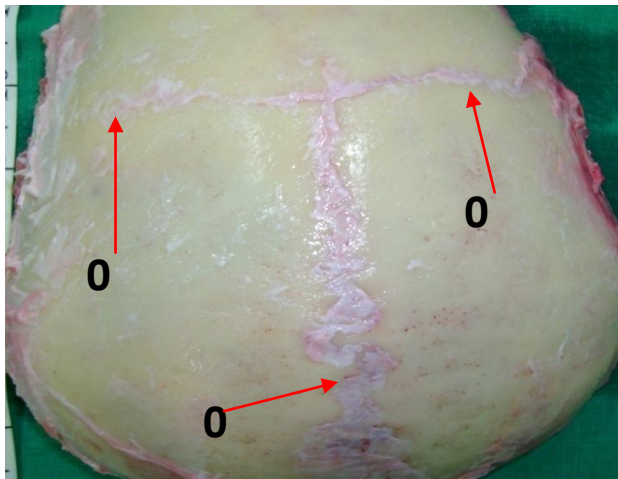


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

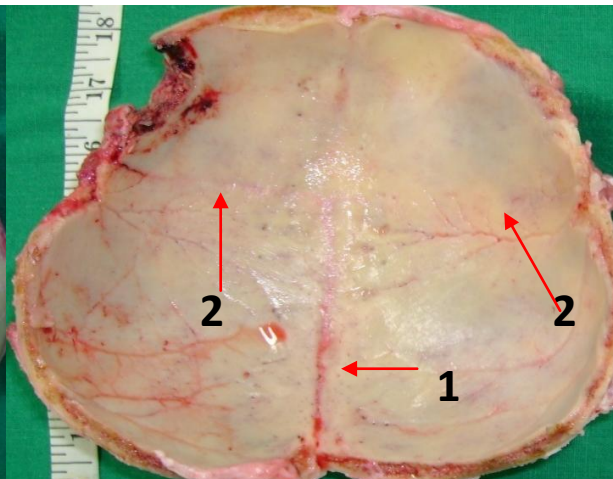


LAMDOID SUTURES (ENDOCRANIAL)

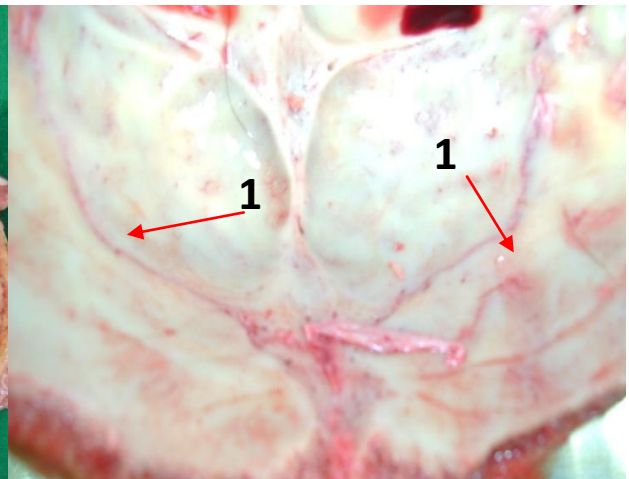
CASE-40



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



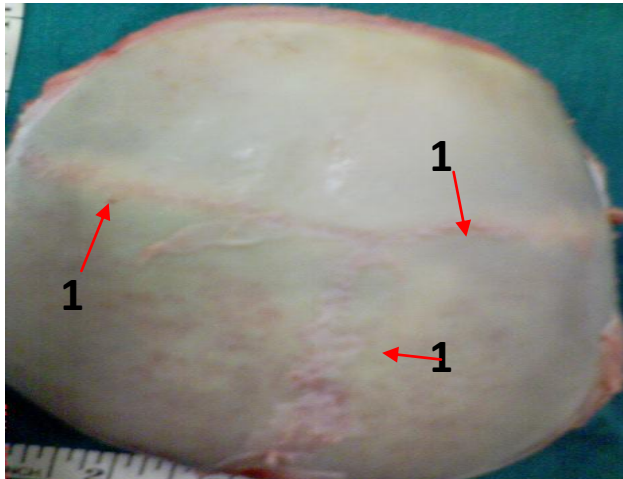
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



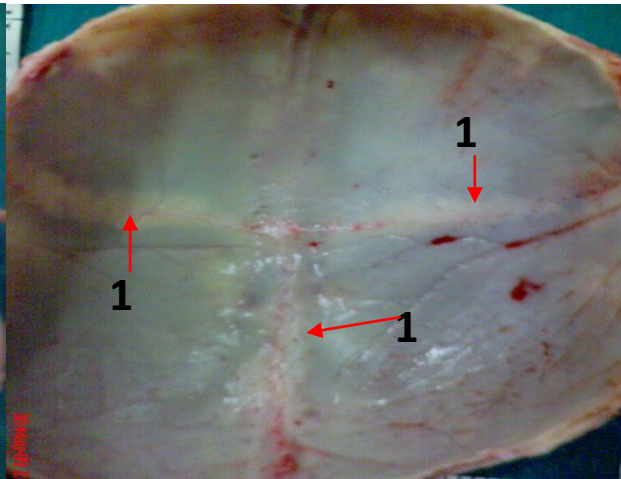
LAMDOID SUTURES (ENDOCRANIAL)

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

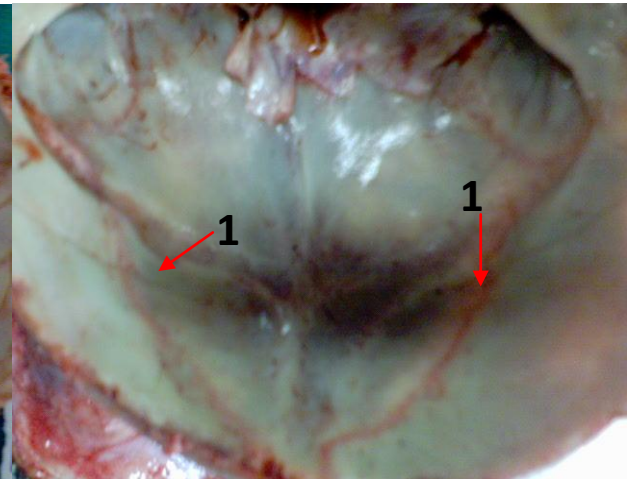
CASE-41



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

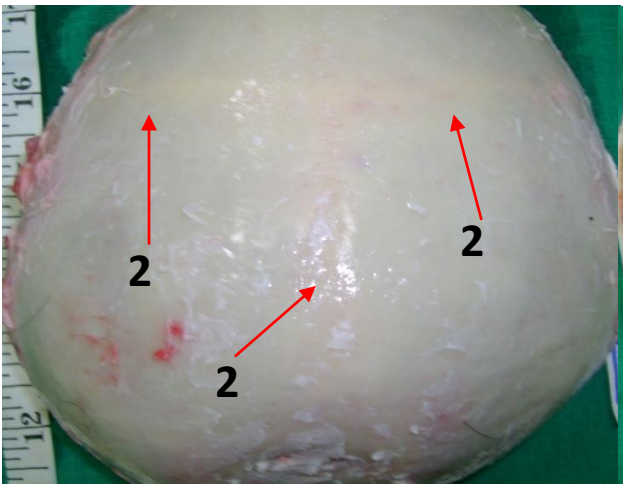


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

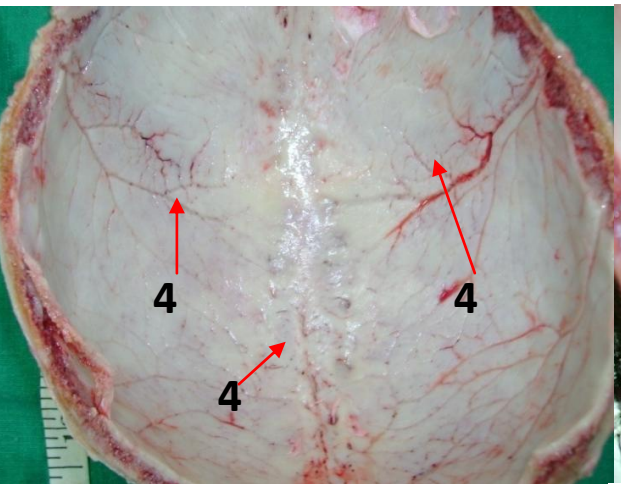


LAMDOID SUTURES (ENDOCRANIAL)

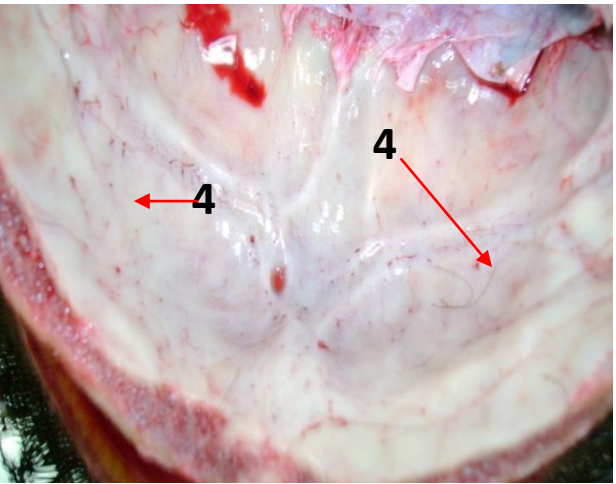
CASE-42



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



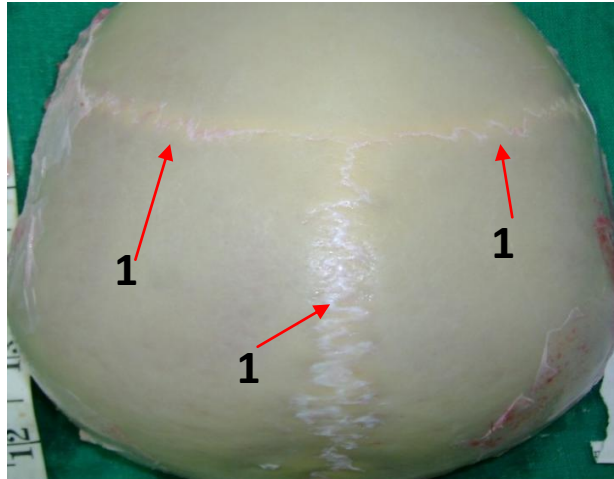
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



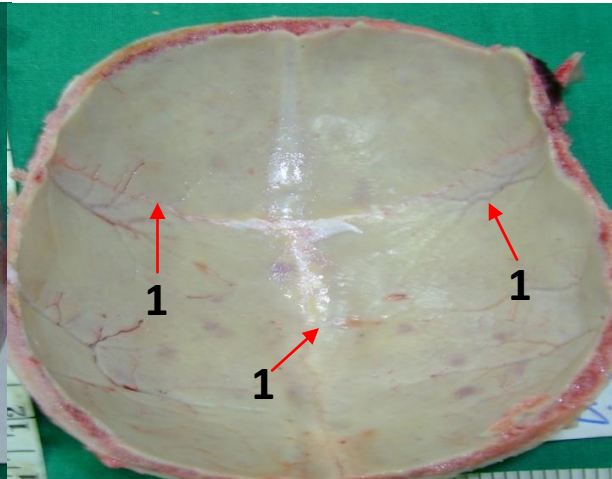
LAMDOID SUTURES (ENDOCRANIAL)

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

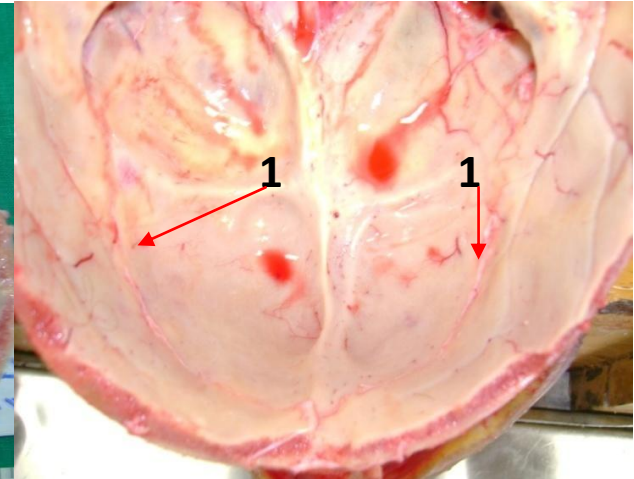
CASE-43



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

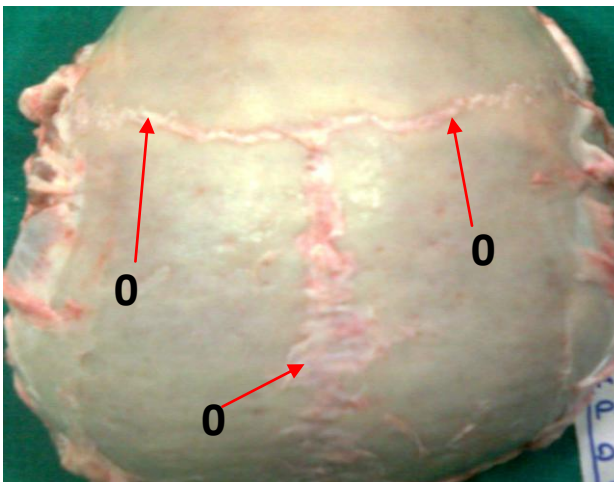


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

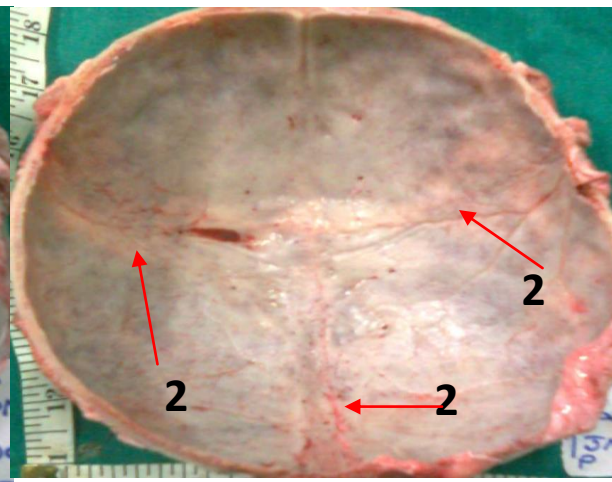


LAMDROID SUTURES (ENDOCRANIAL)

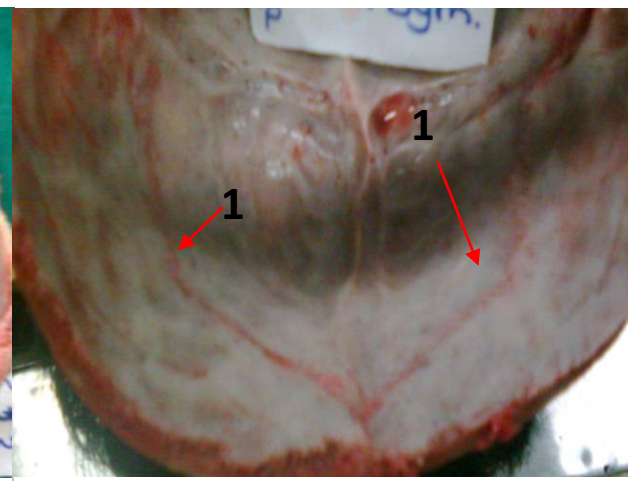
CASE-44



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



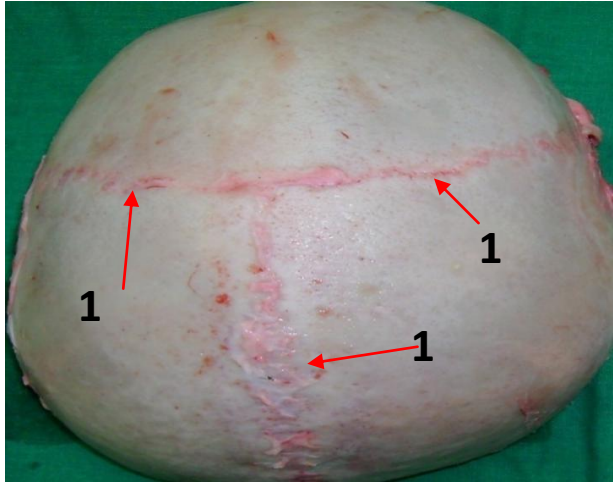
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



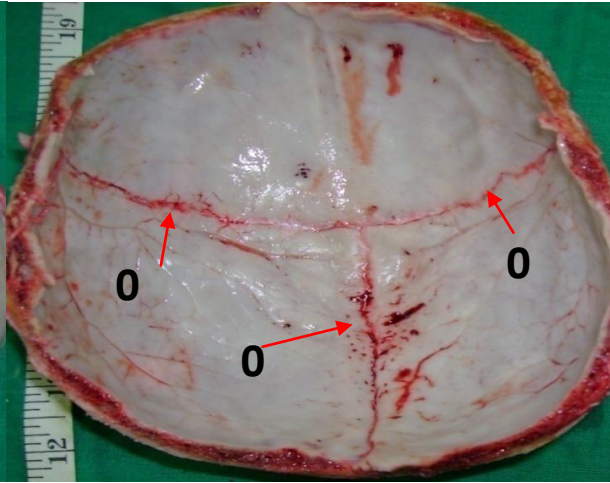
LAMDROID SUTURES (ENDOCRANIAL)

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

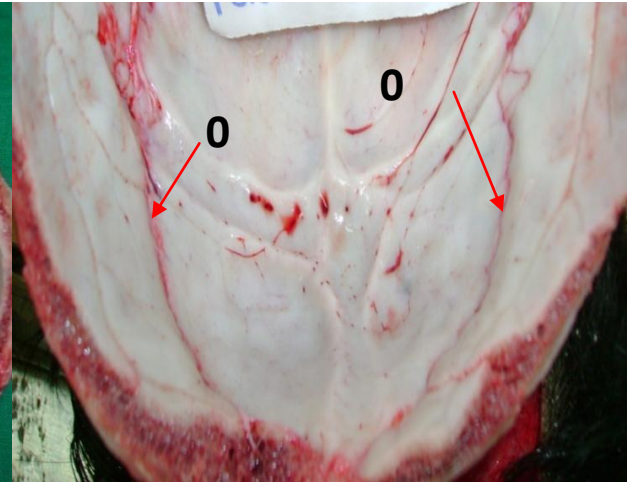
CASE-45



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

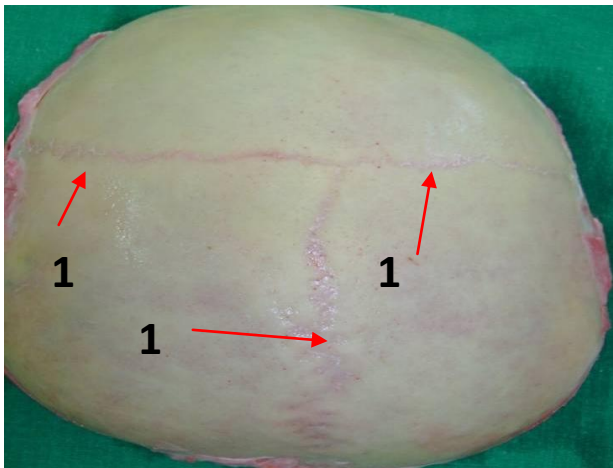


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

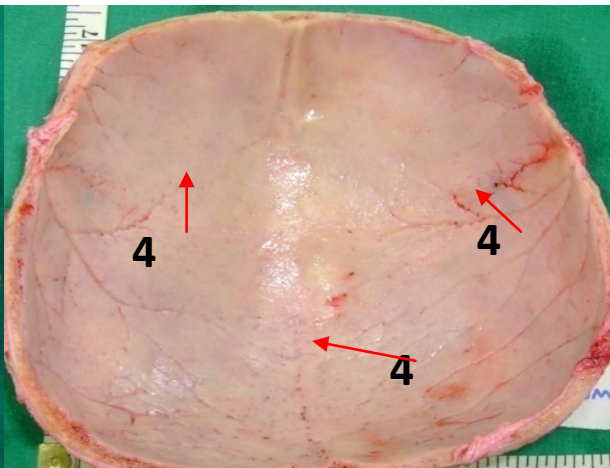


LAMDOID SUTURES (ENDOCRANIAL)

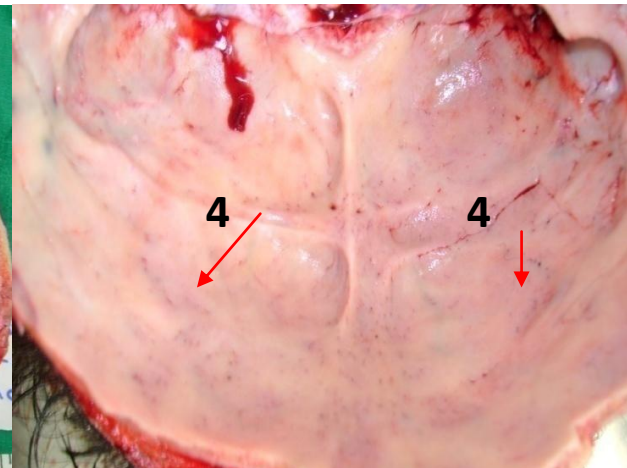
CASE-46



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



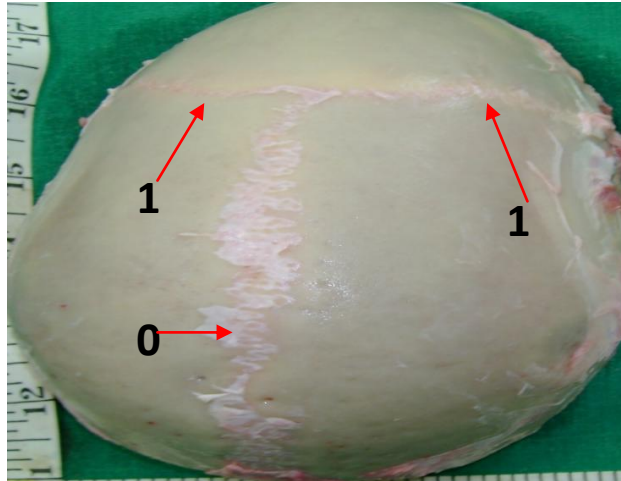
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



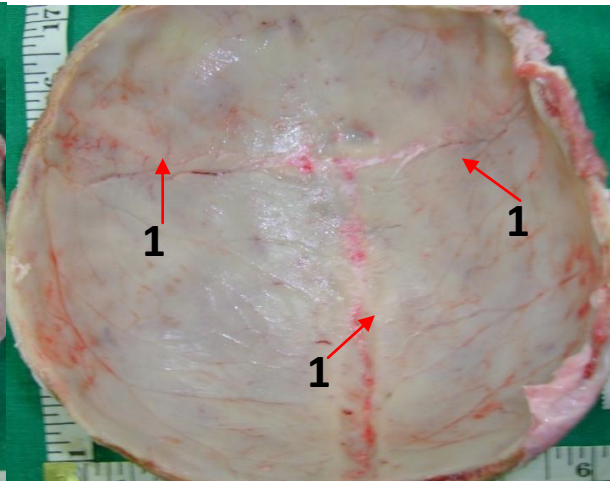
LAMDOID SUTURES (ENDOCRANIAL)

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

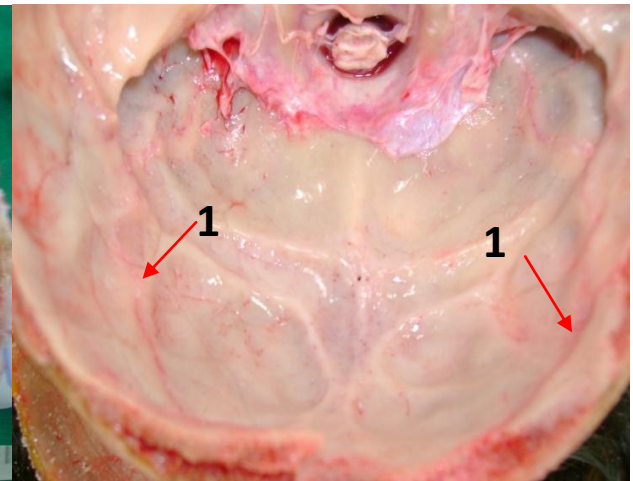
CASE-47



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

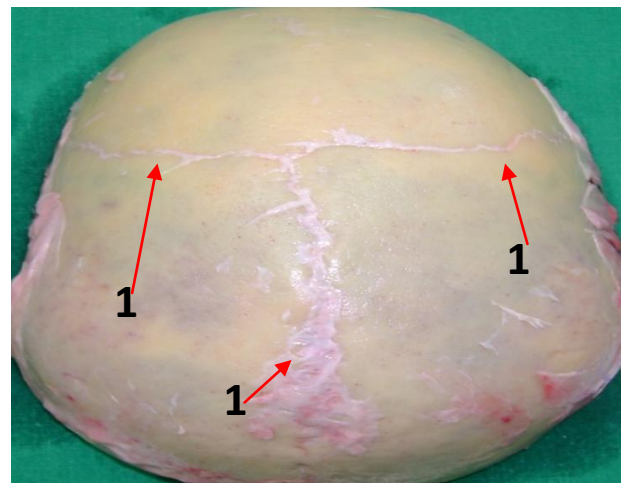


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

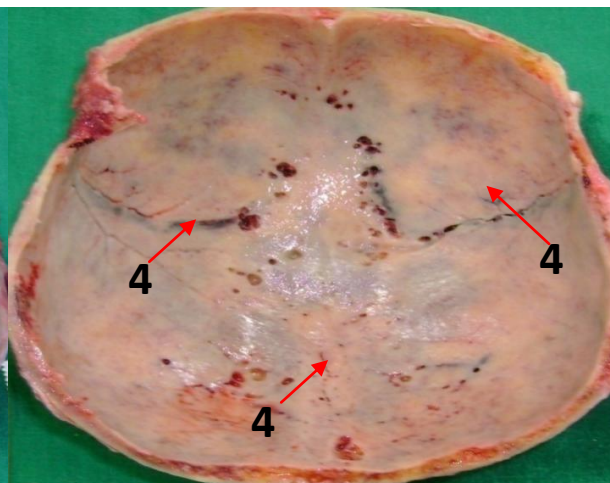


LAMDROID SUTURES (ENDOCRANIAL)

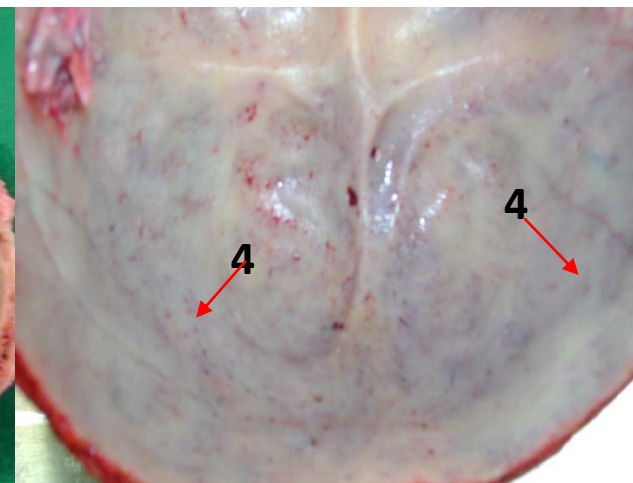
CASE-48



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



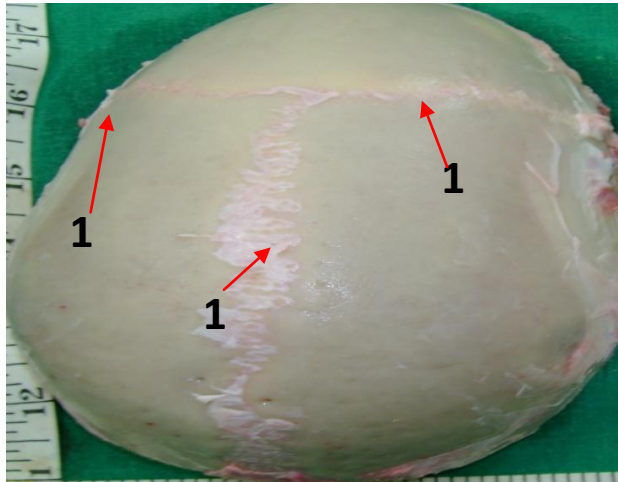
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



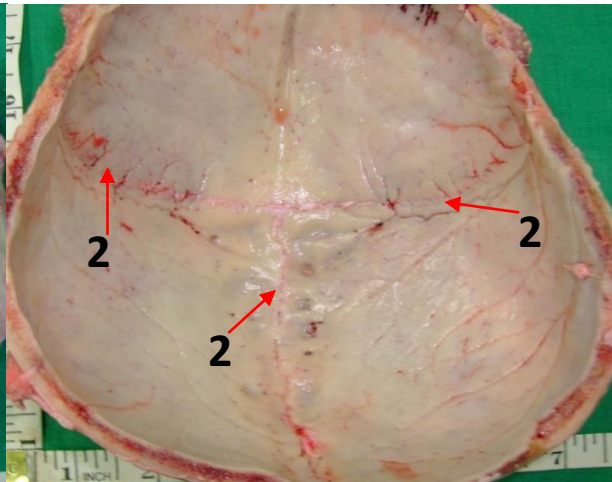
LAMDROID SUTURES (ENDOCRANIAL)

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

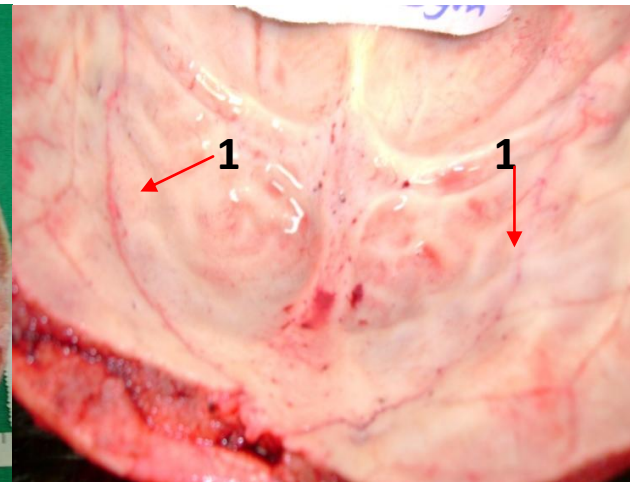
CASE-49



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

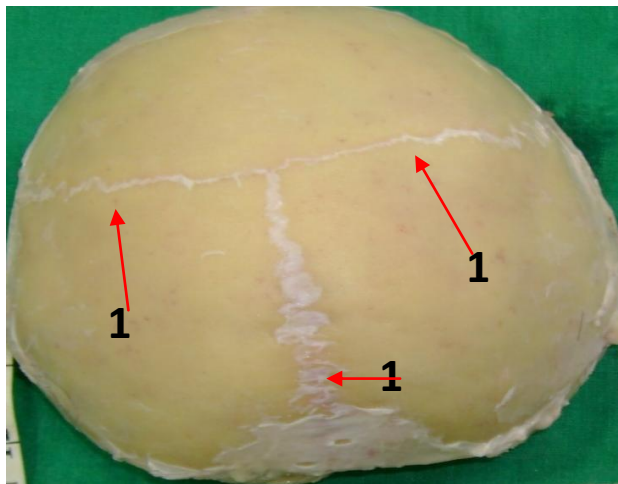


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

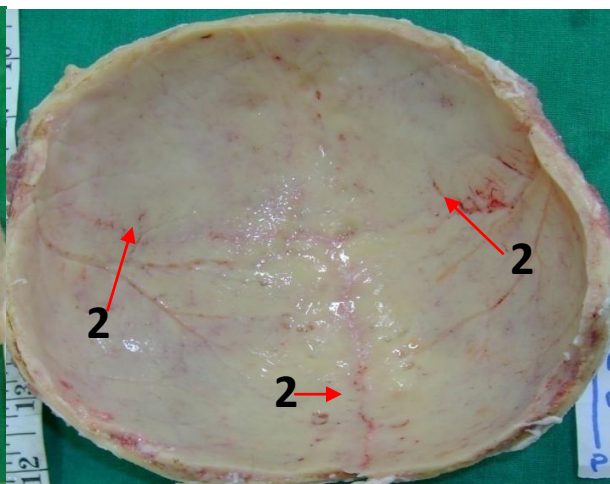


LAMDOID SUTURES (ENDOCRANIAL)

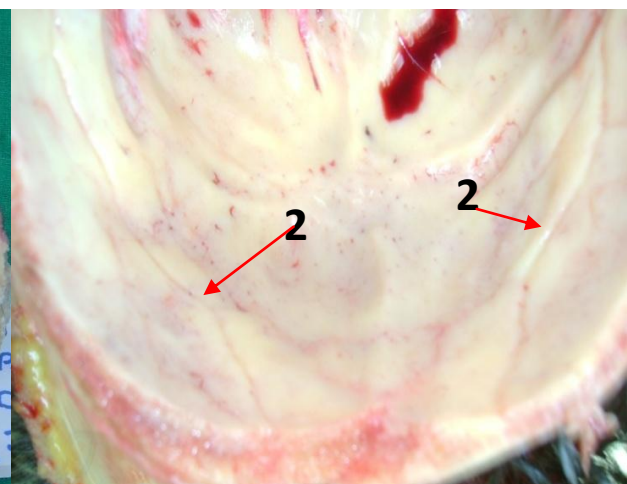
CASE-50



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



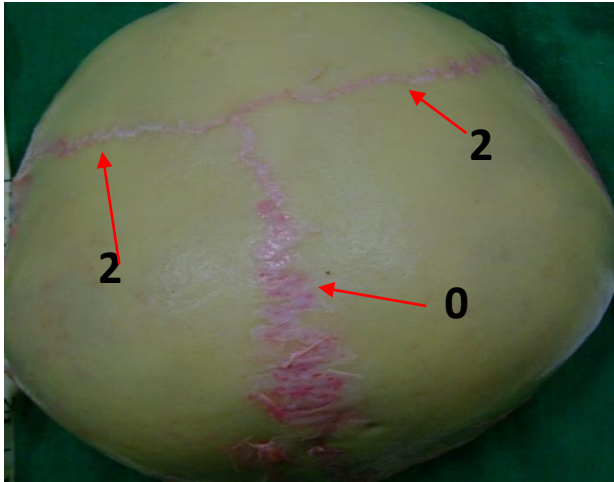
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



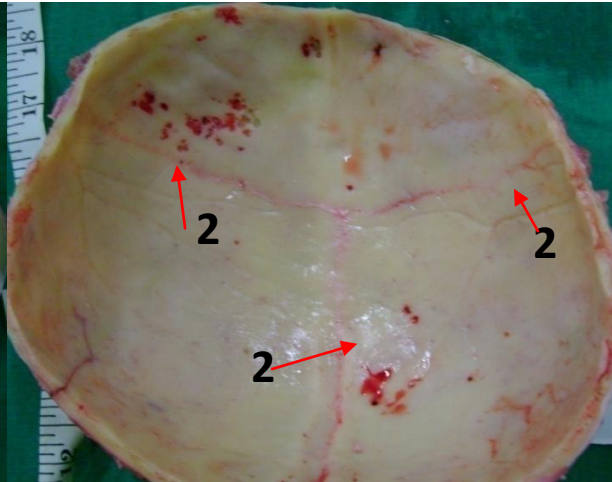
LAMDOID SUTURES (ENDOCRANIAL)

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

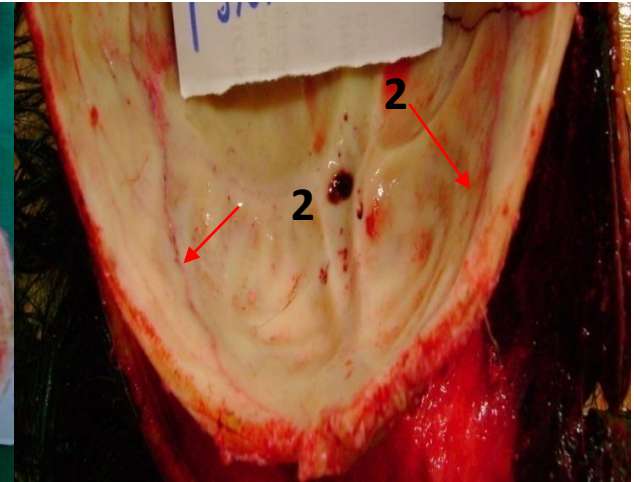
CASE-51



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

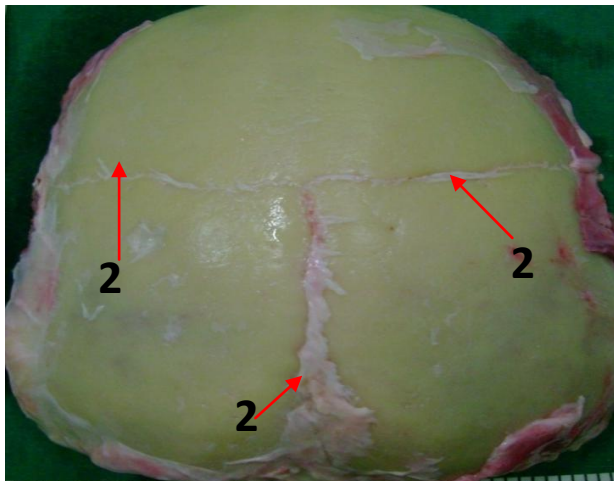


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

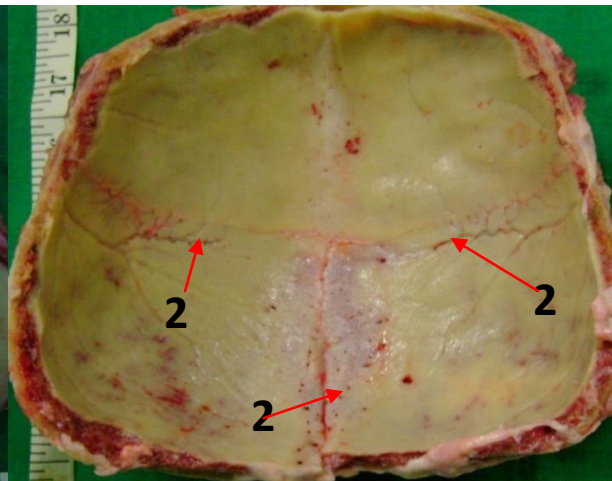


LAMDROID SUTURES (ENDOCRANIAL)

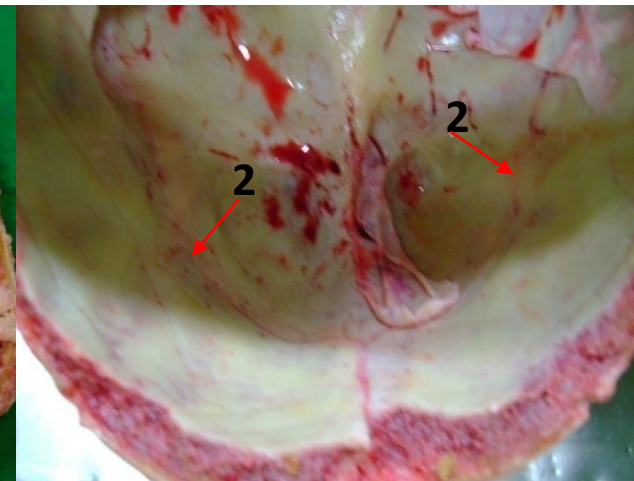
CASE-52



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



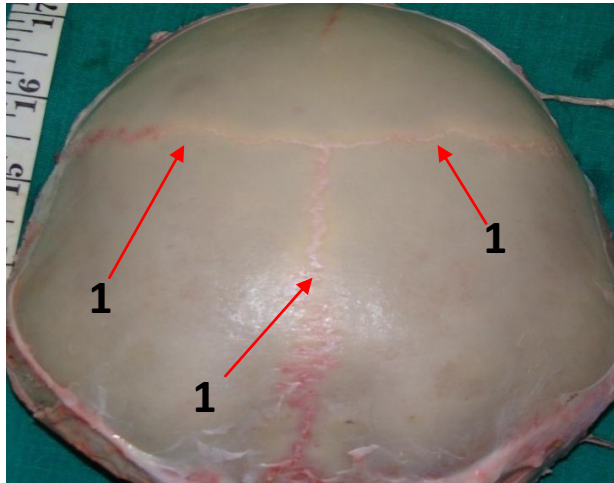
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



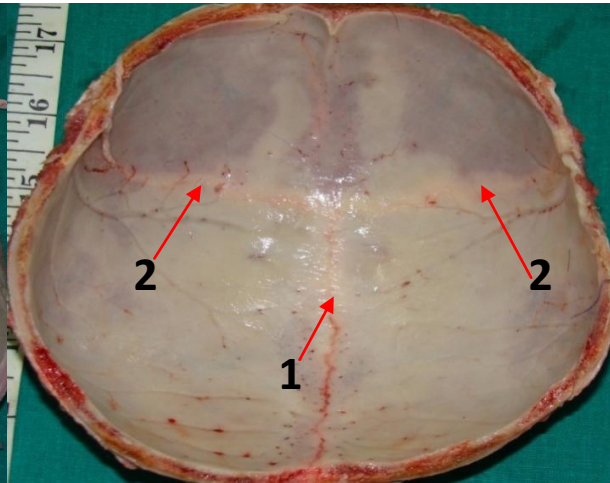
LAMDROID SUTURES (ENDOCRANIAL)

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

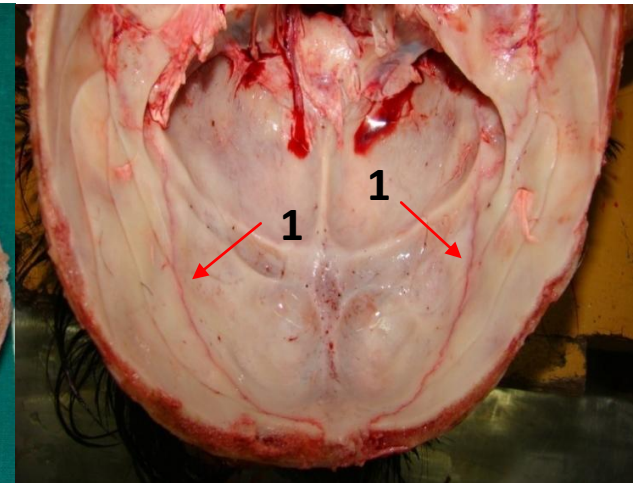
CASE-53



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

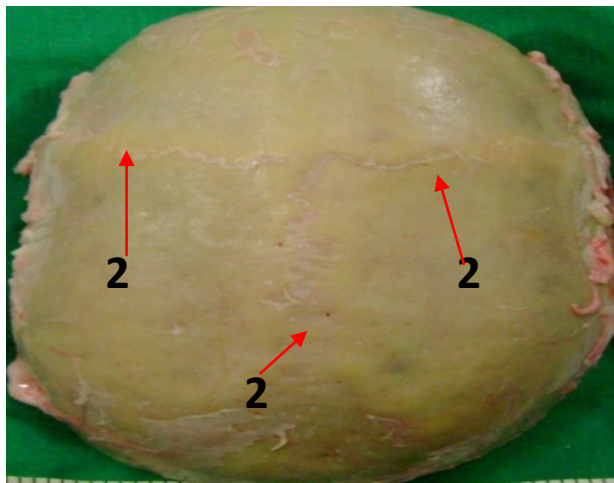


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

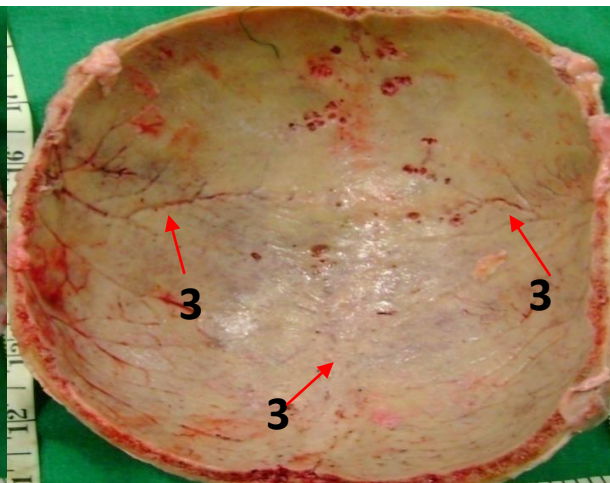


LAMDROID SUTURES (ENDOCRANIAL)

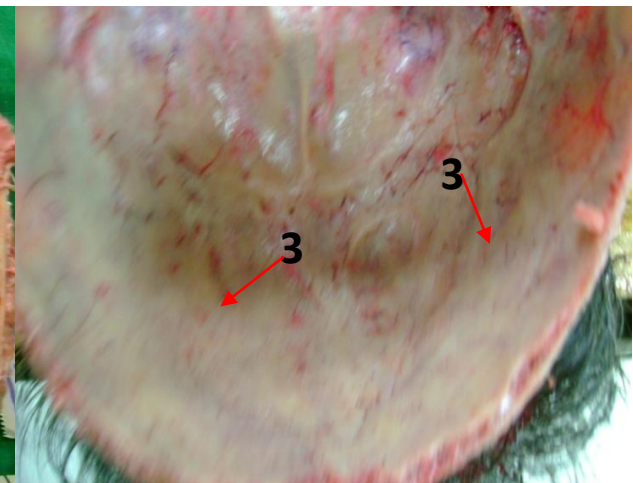
CASE-54



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



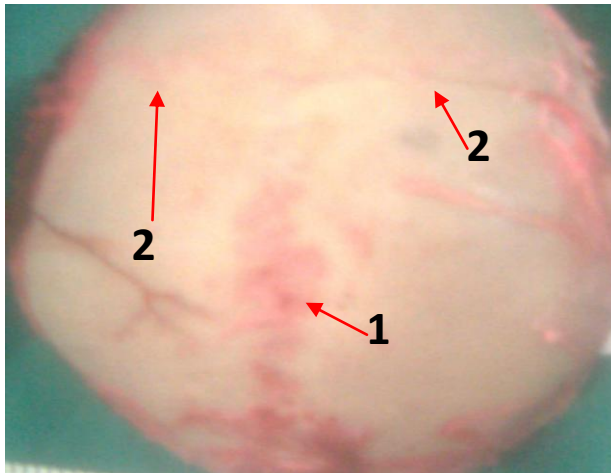
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



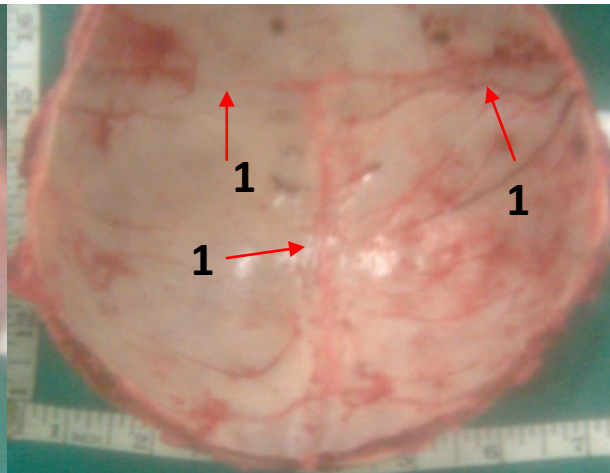
LAMDROID SUTURES (ENDOCRANIAL)

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

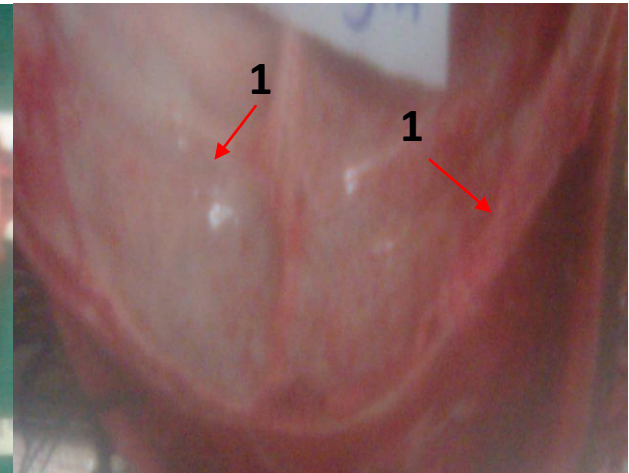
CASE-55



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

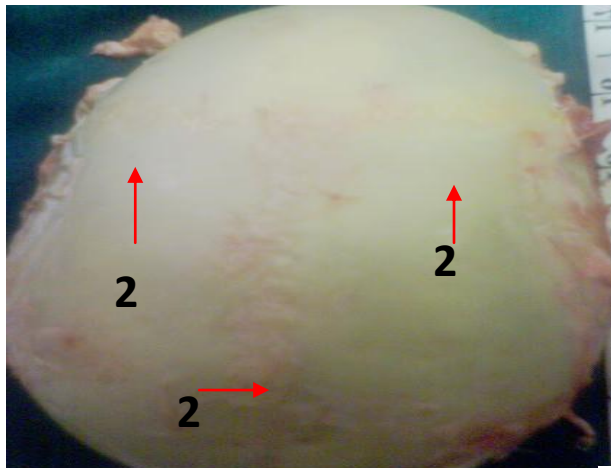


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

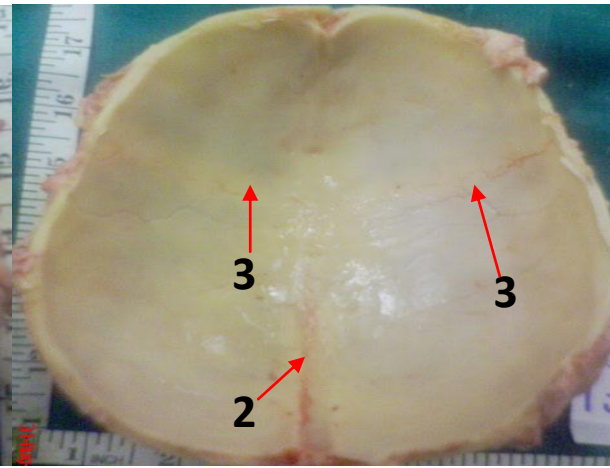


LAMDOID SUTURES (ENDOCRANIAL)

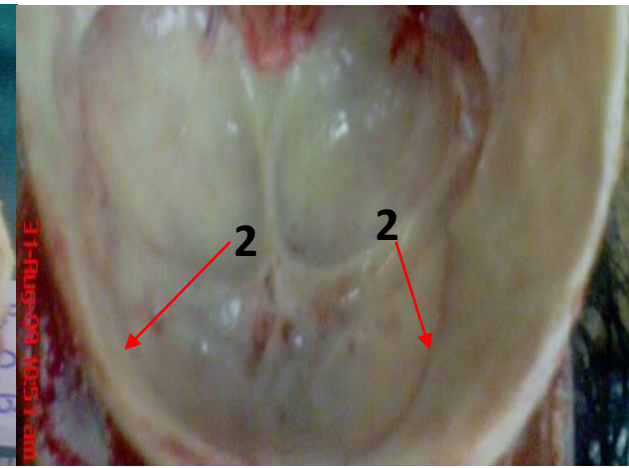
CASE-56



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



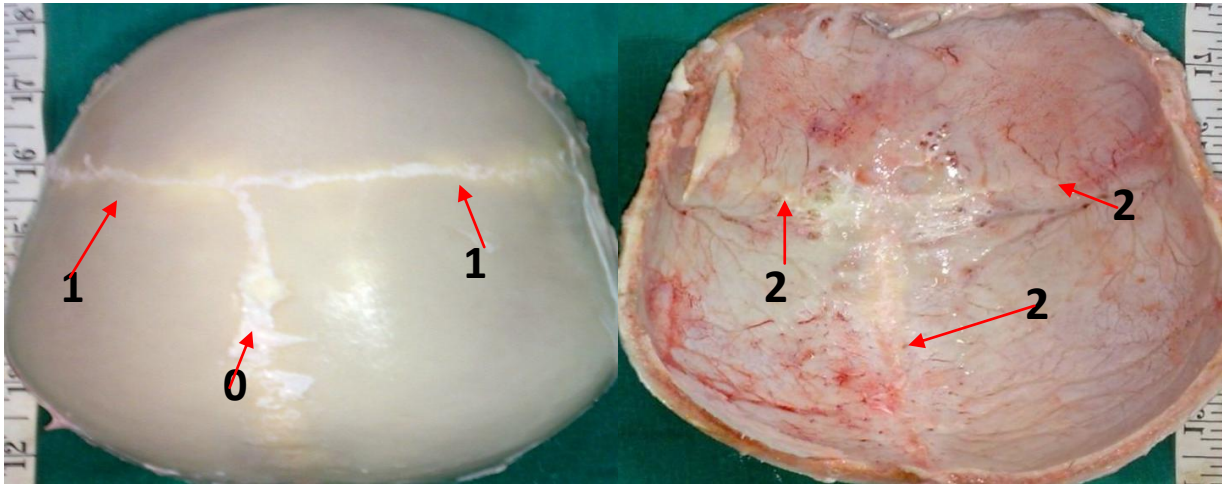
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDOID SUTURES (ENDOCRANIAL)

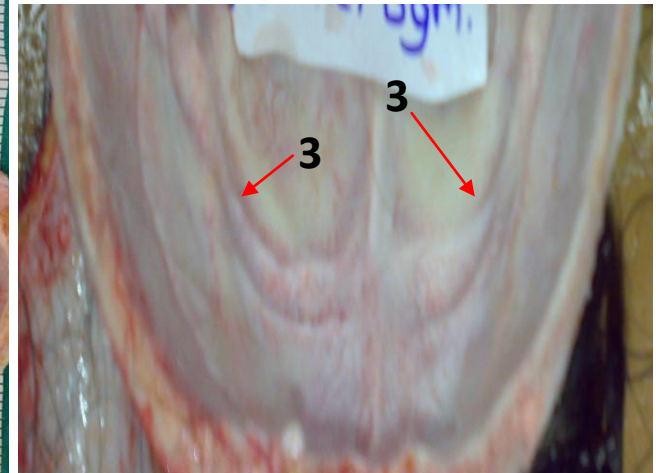
0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-57



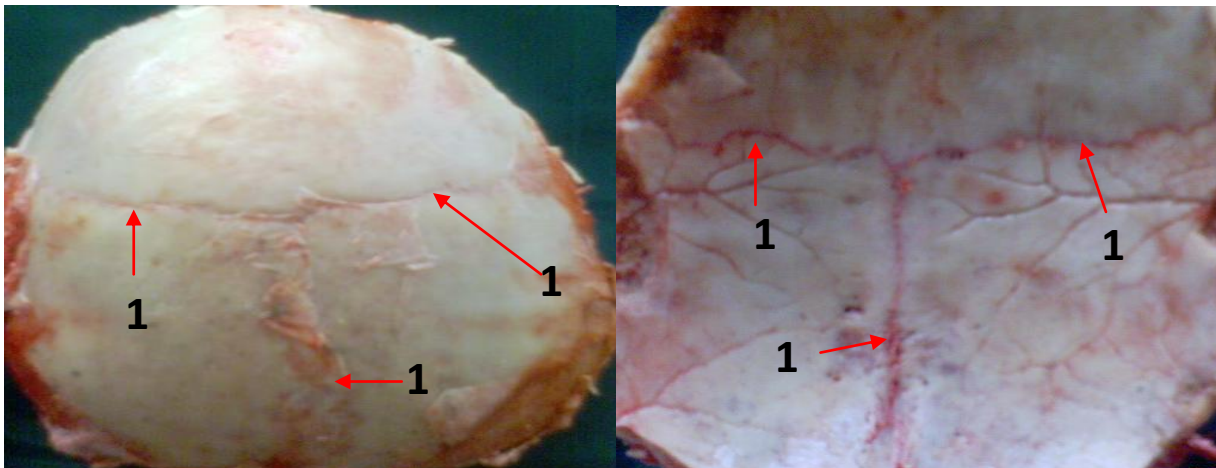
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



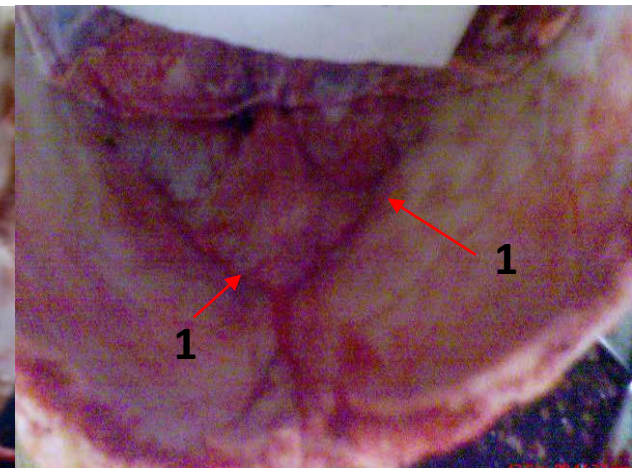
LAMDROID SUTURES (ENDOCRANIAL)

CASE-58



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

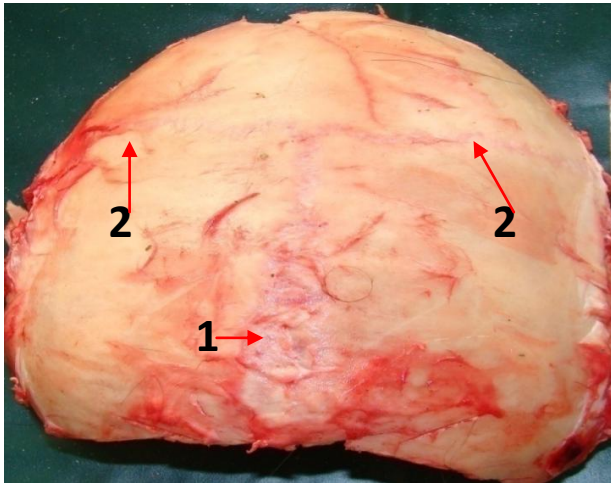
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



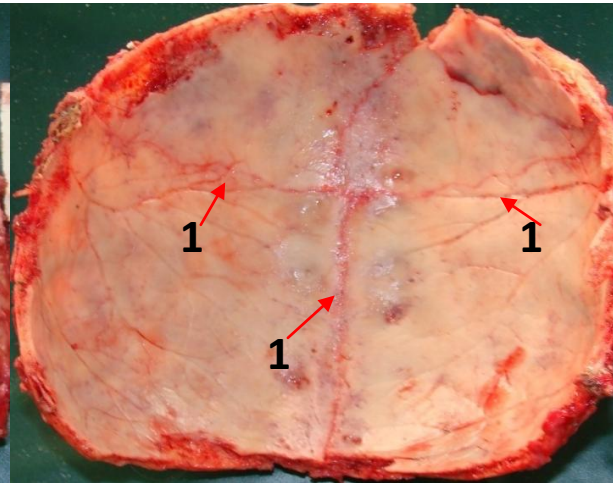
LAMDROID SUTURES (ENDOCRANIAL)

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

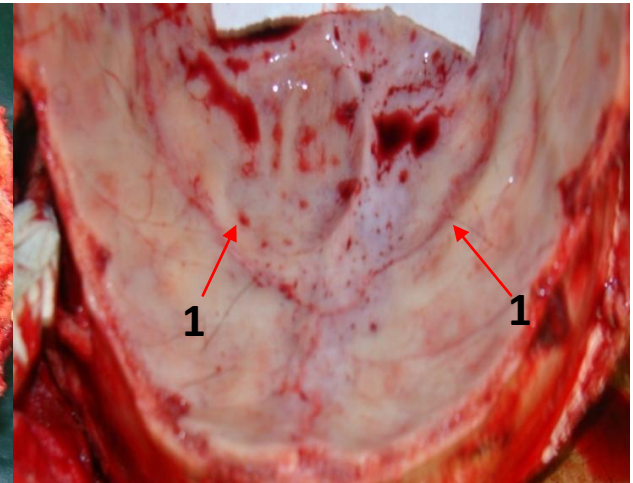
CASE-59



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

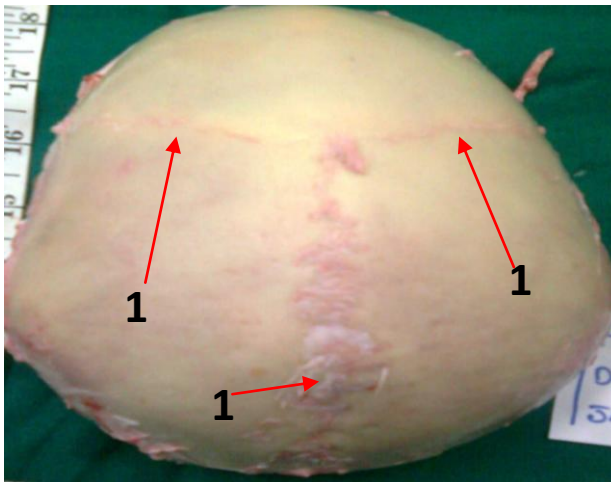


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

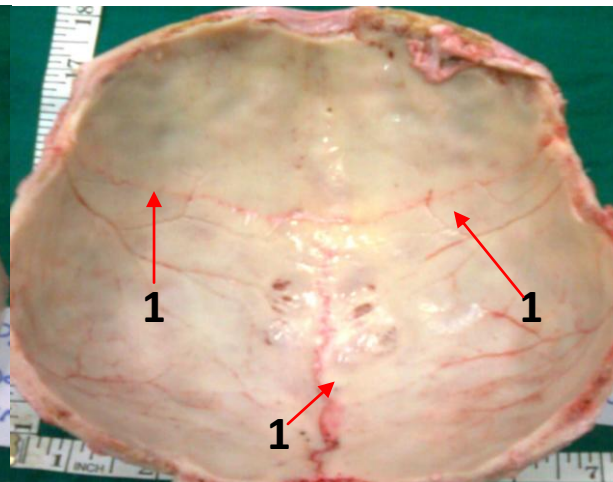


LAMDROID SUTURES (ENDOCRANIAL)

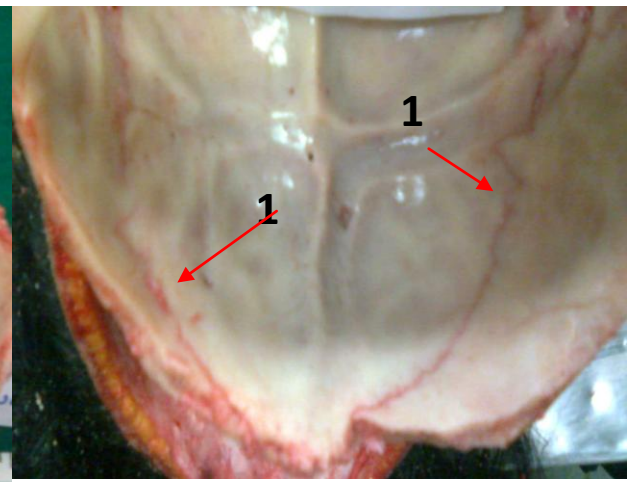
CASE-60



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



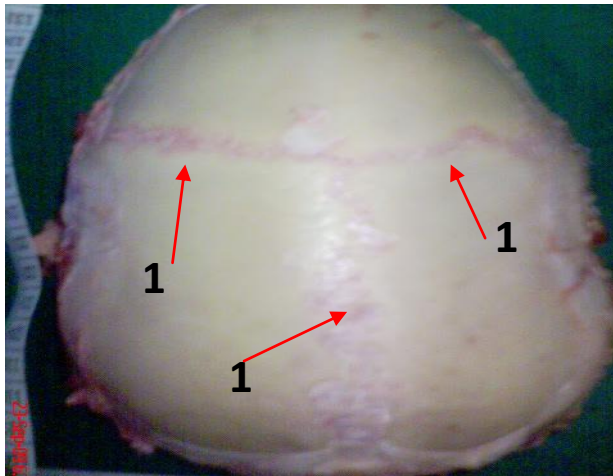
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



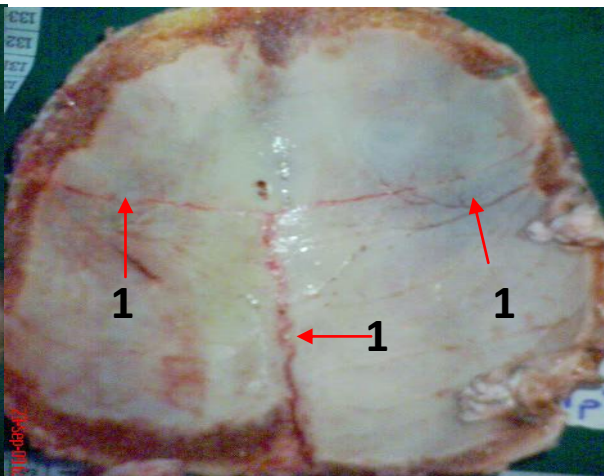
LAMDROID SUTURES (ENDOCRANIAL)

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

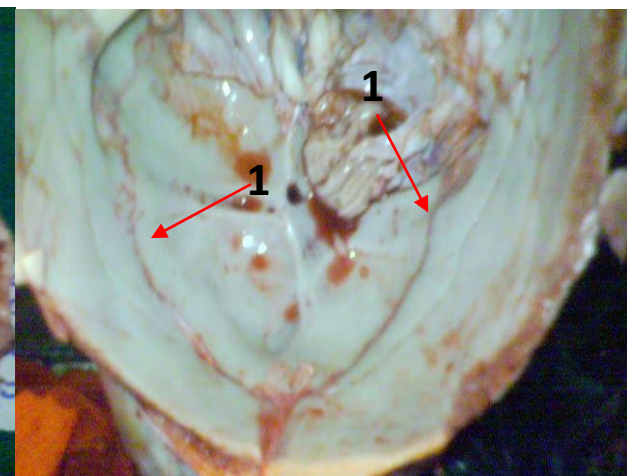
CASE-61



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

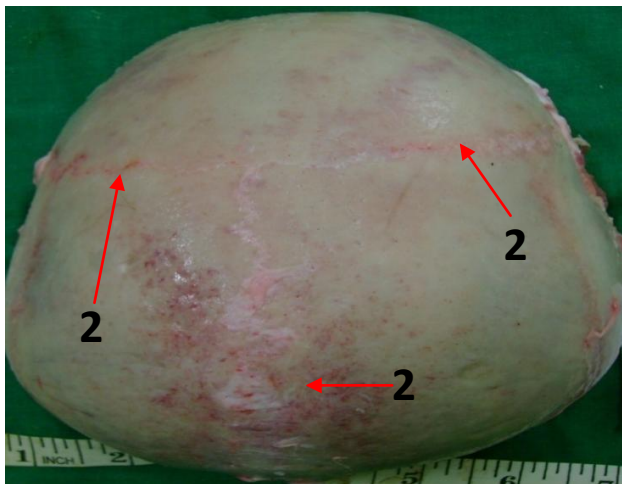


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

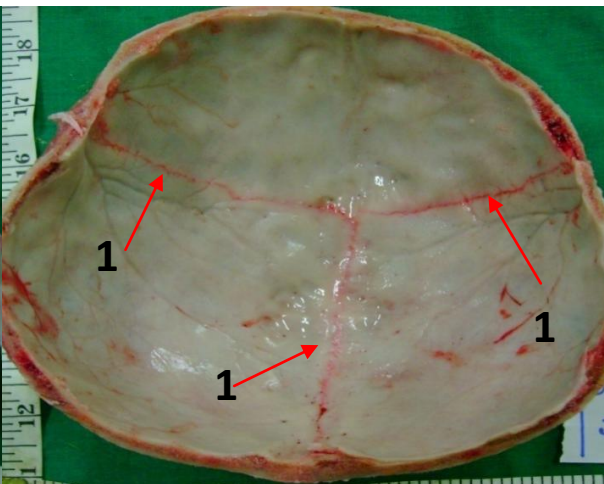


LAMDOID SUTURES (ENDOCRANIAL)

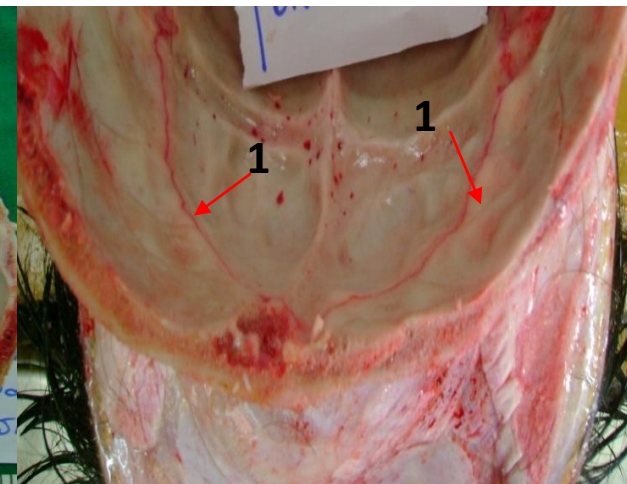
CASE-62



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



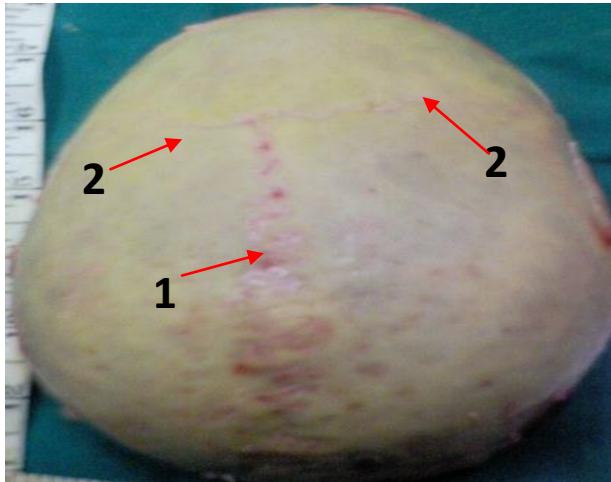
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



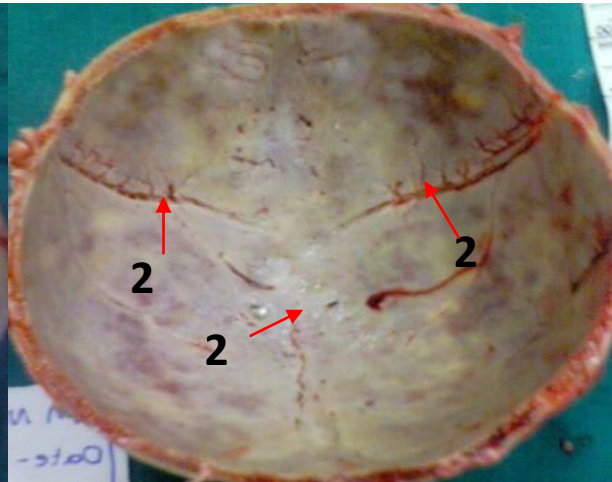
LAMDOID SUTURES (ENDOCRANIAL)

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

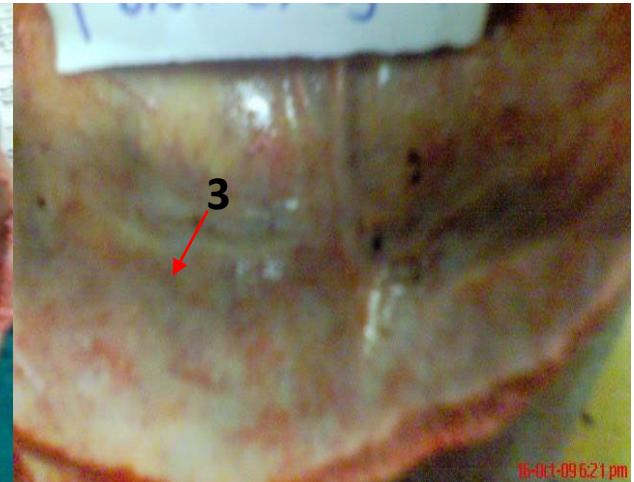
CASE-63



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

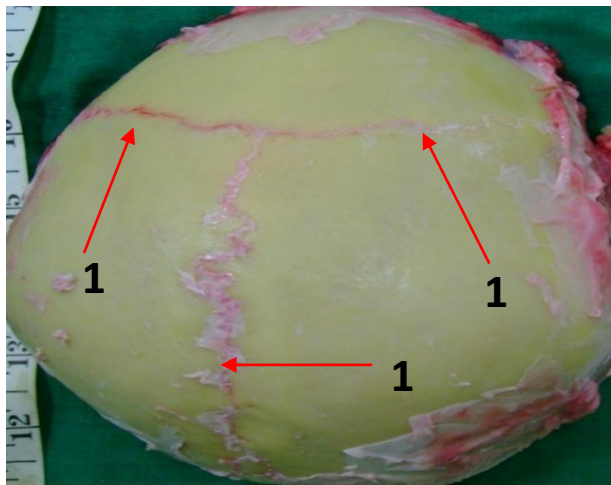


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

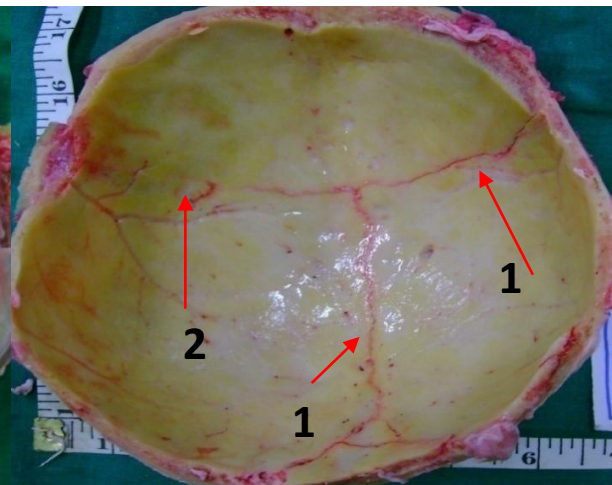


LAMDOID SUTURES (ENDOCRANIAL)

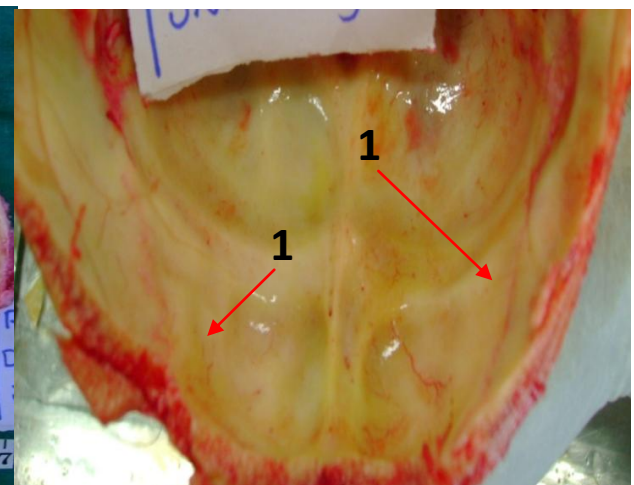
CASE-64



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



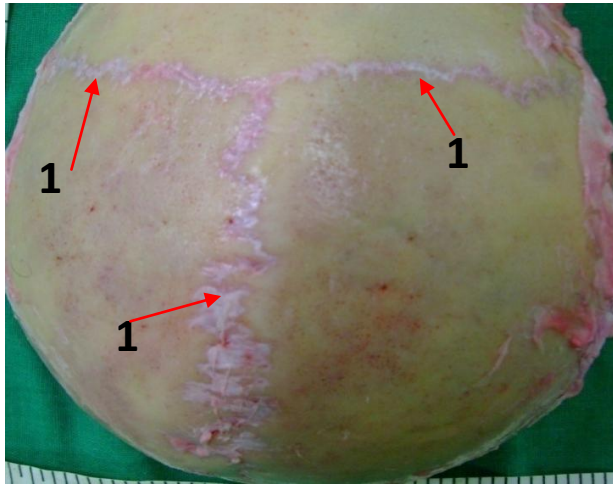
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



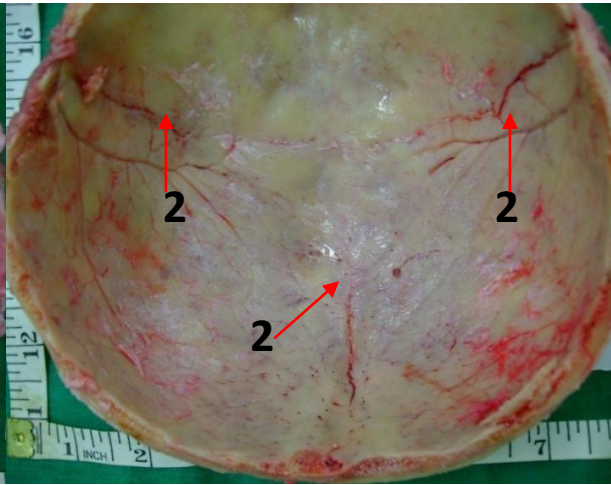
LAMDOID SUTURES (ENDOCRANIAL)

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

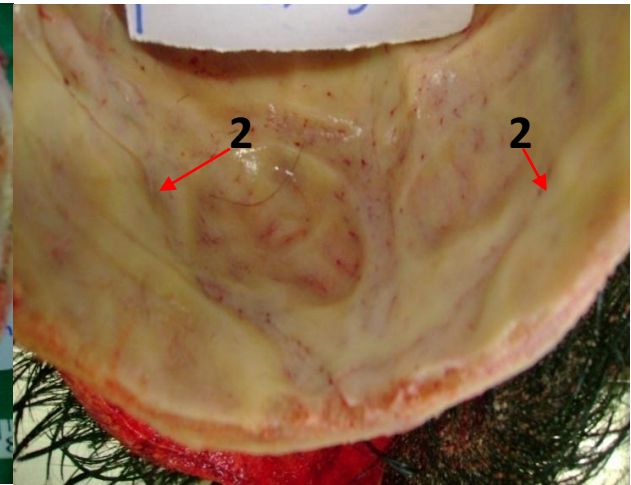
CASE-65



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

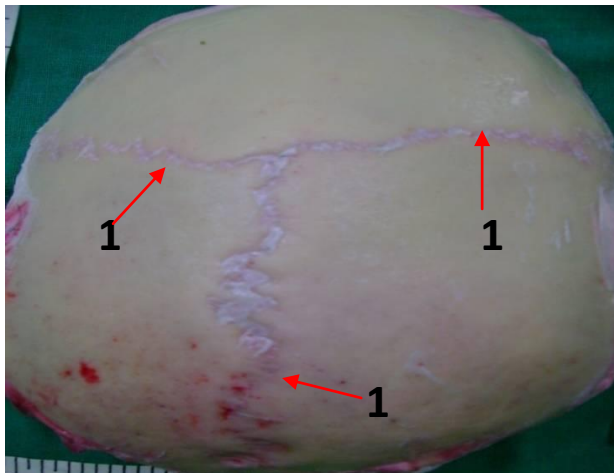


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

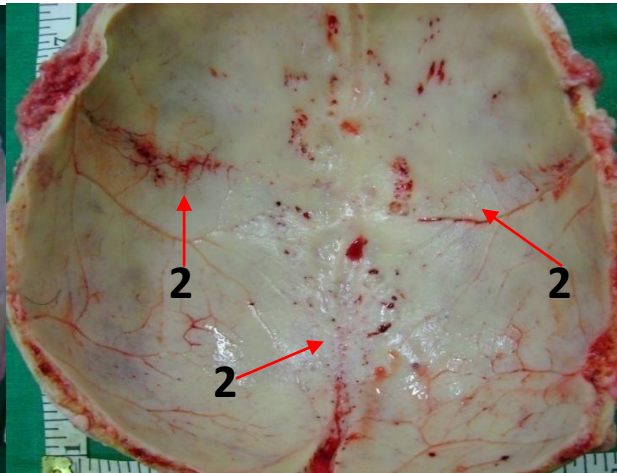


LAMDOID SUTURES (ENDOCRANIAL)

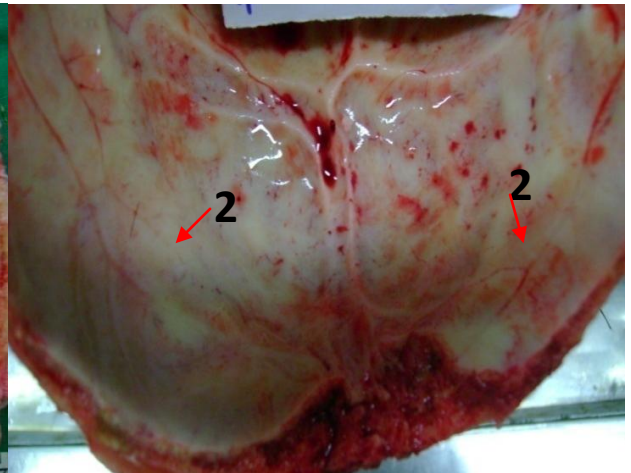
CASE-66



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



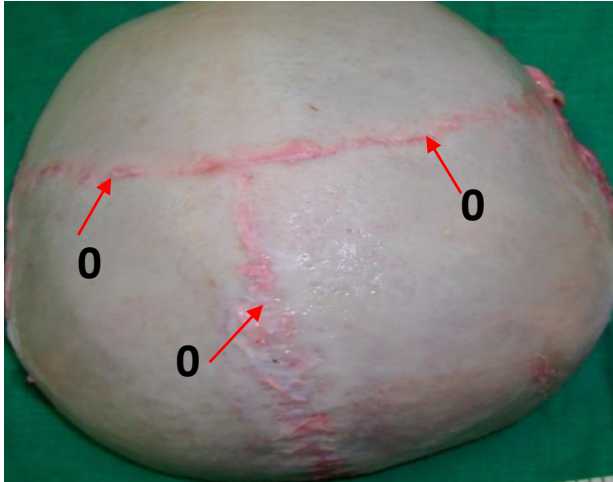
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



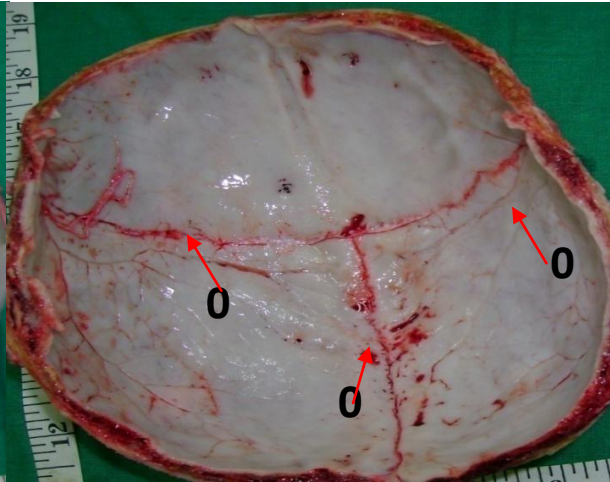
LAMDOID SUTURES (ENDOCRANIAL)

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

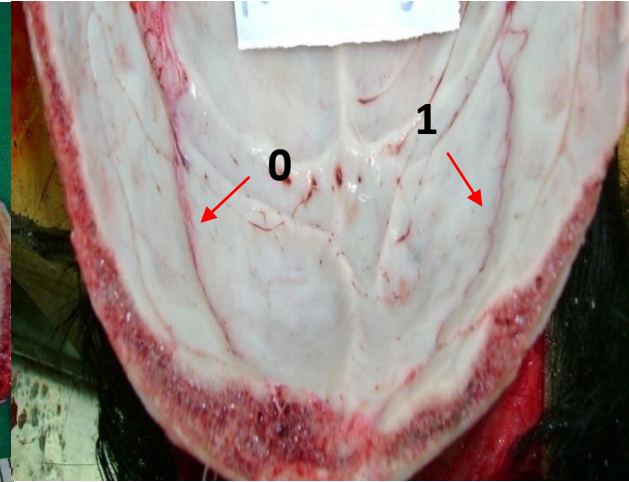
CASE-67



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

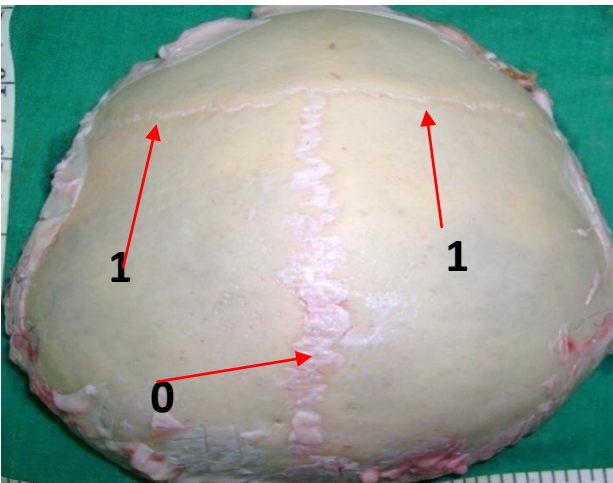


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

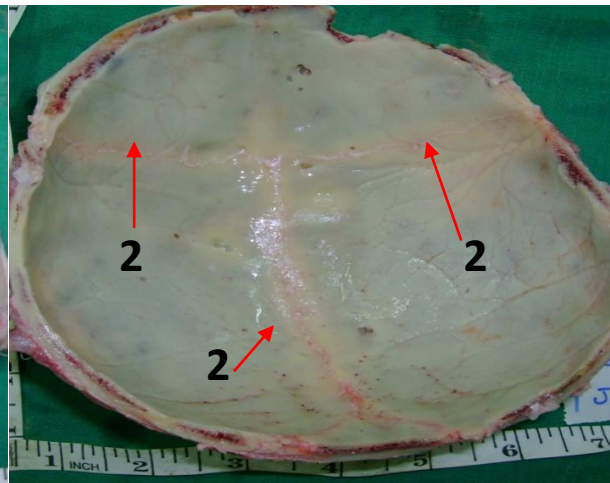


LAMDOID SUTURES (ENDOCRANIAL)

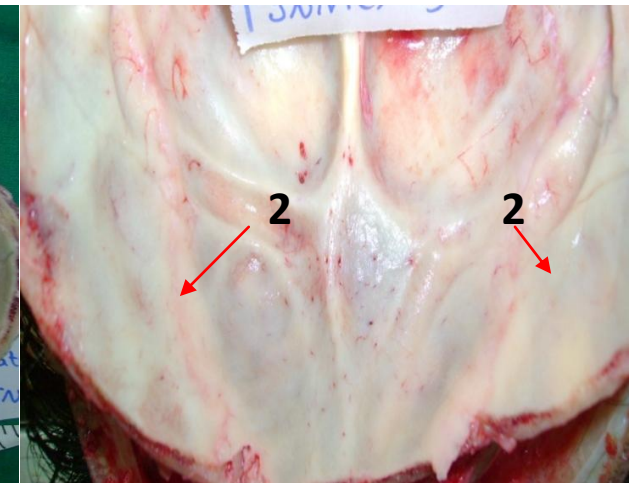
CASE-68



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



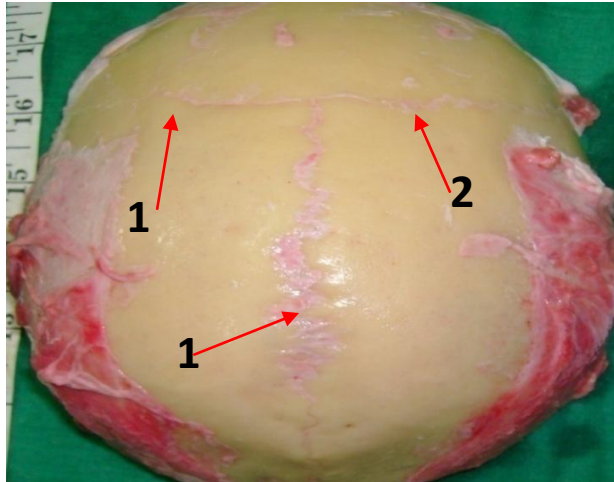
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



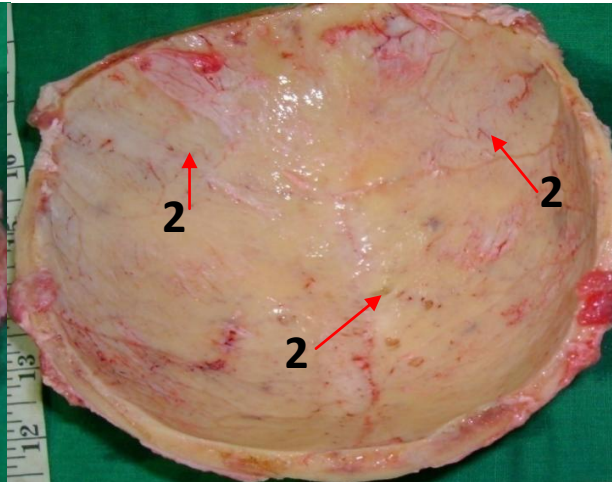
LAMDOID SUTURES (ENDOCRANIAL)

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

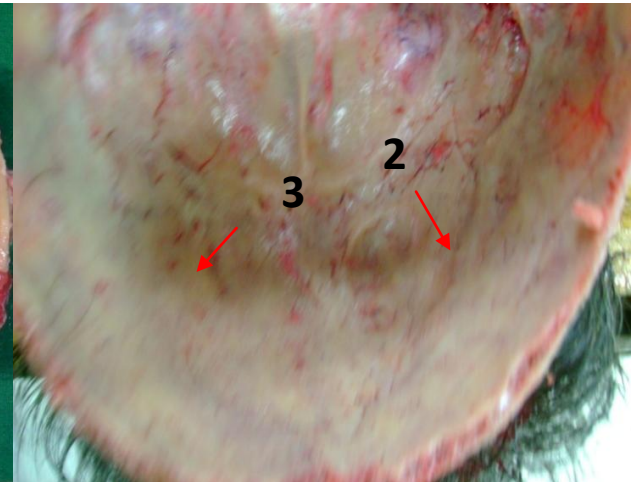
CASE-69



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

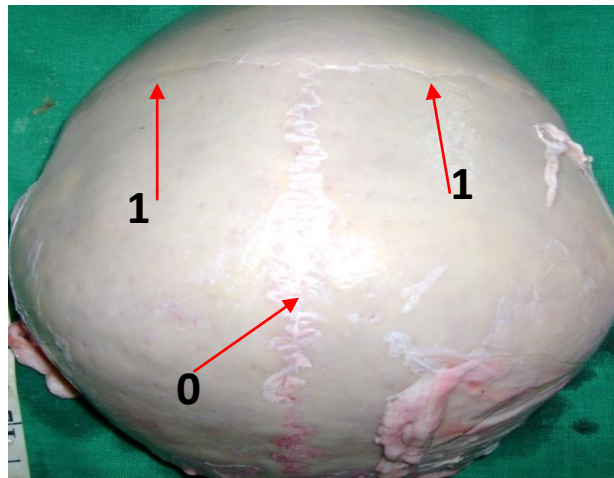


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

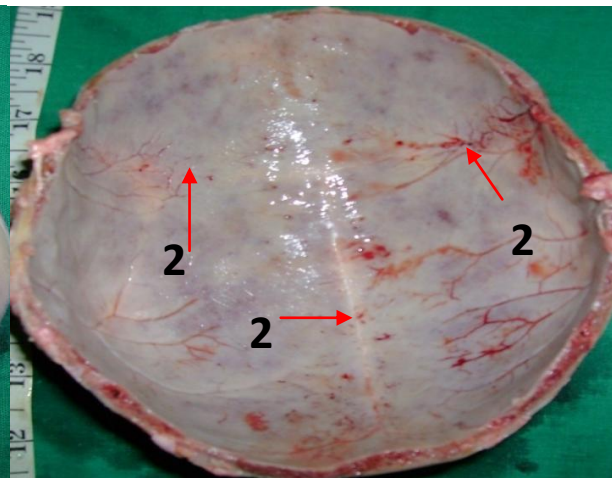


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

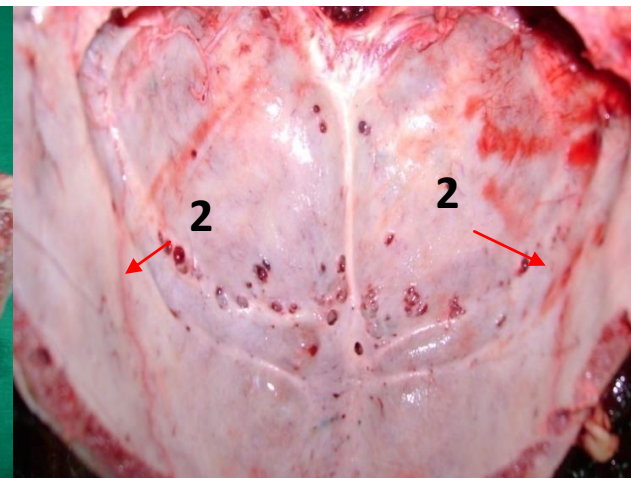
CASE-70



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



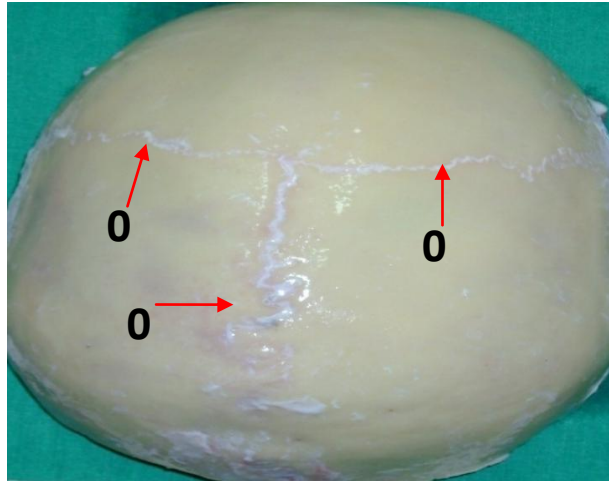
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



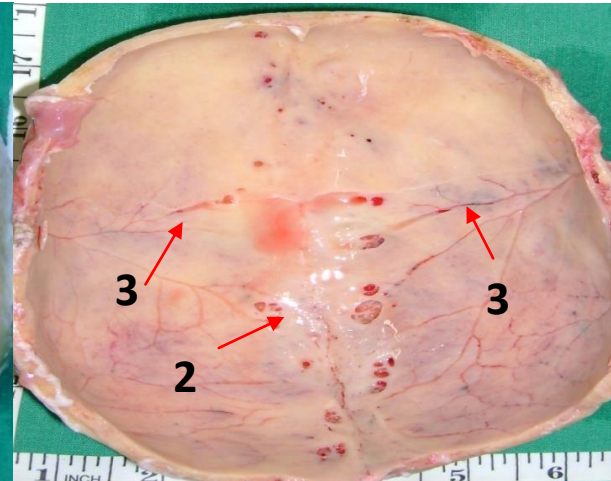
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

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

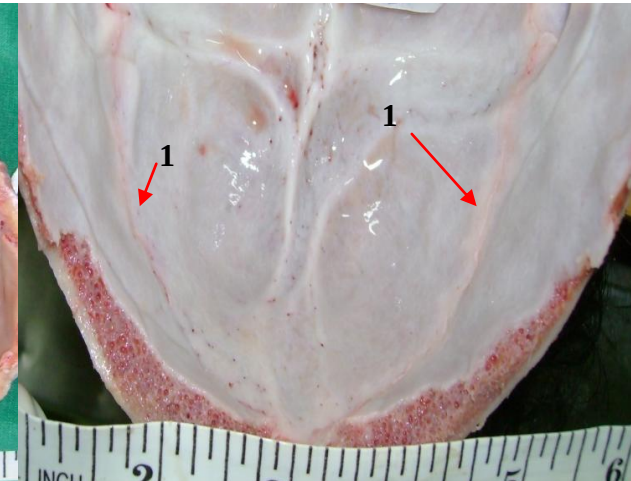
CASE-71



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

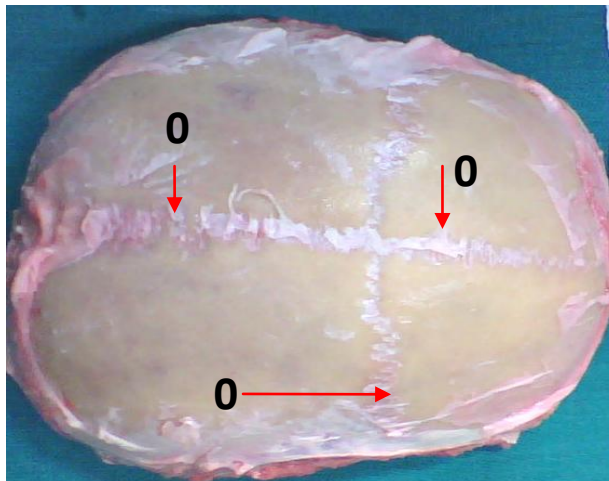


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

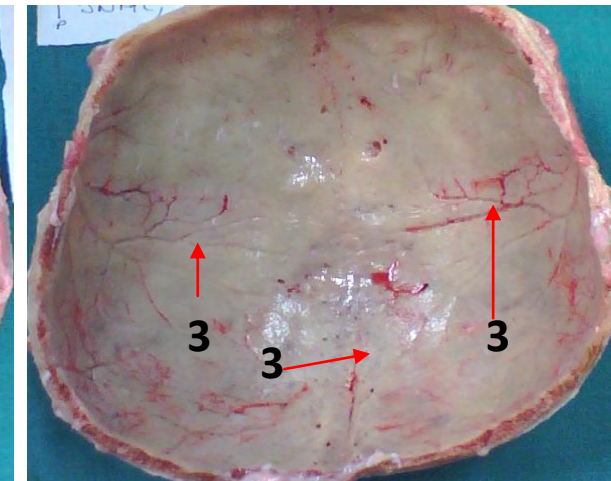


LAMDROID SUTURES (ENDOCRANIAL)

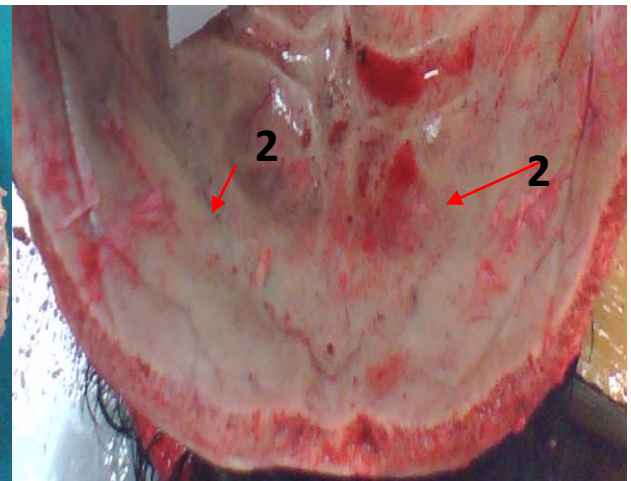
CASE-72



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



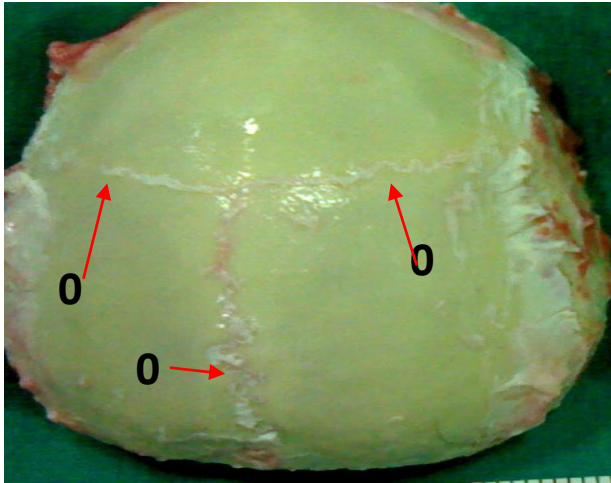
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



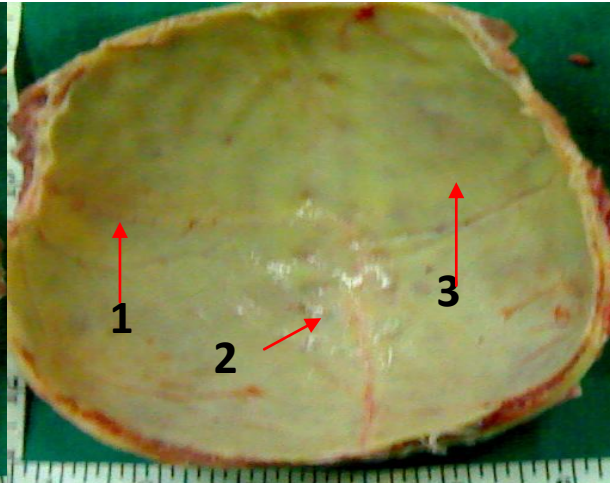
LAMDROID SUTURES (ENDOCRANIAL)

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

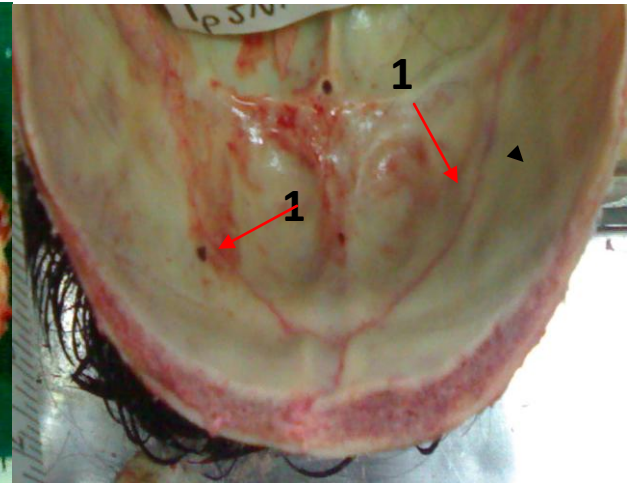
CASE-73



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

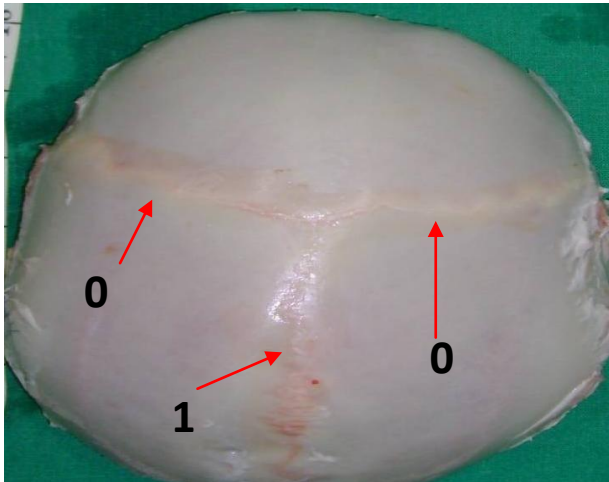


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

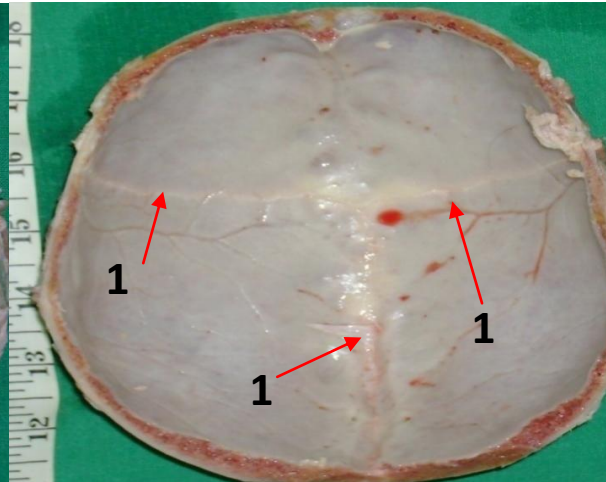


LAMDOID SUTURES (ENDOCRANIAL)

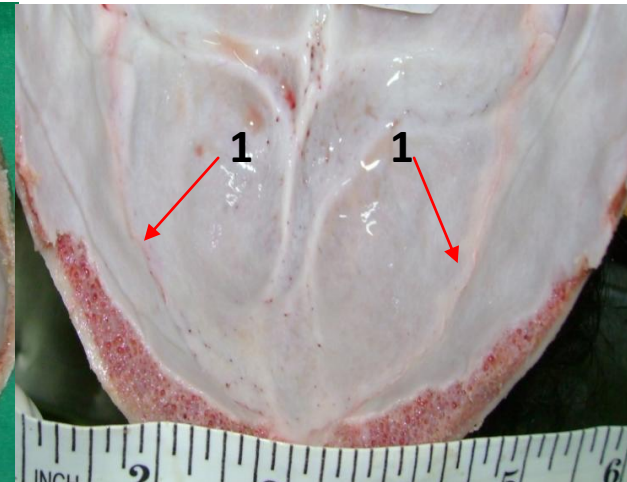
CASE-74



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



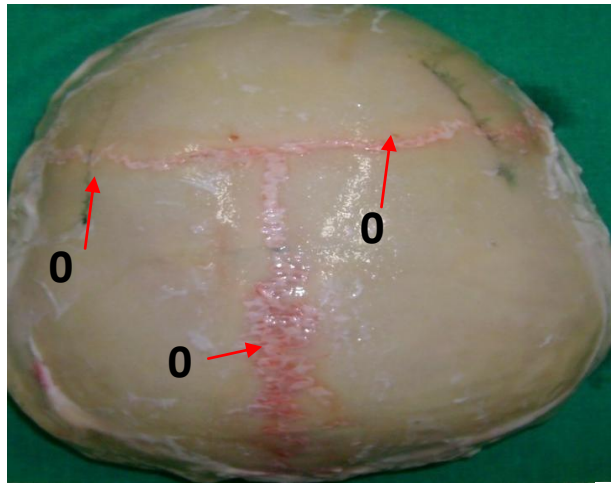
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



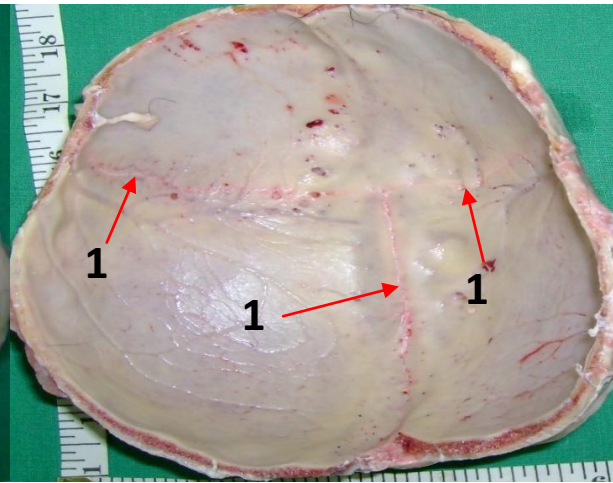
LAMDOID SUTURES (ENDOCRANIAL)

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

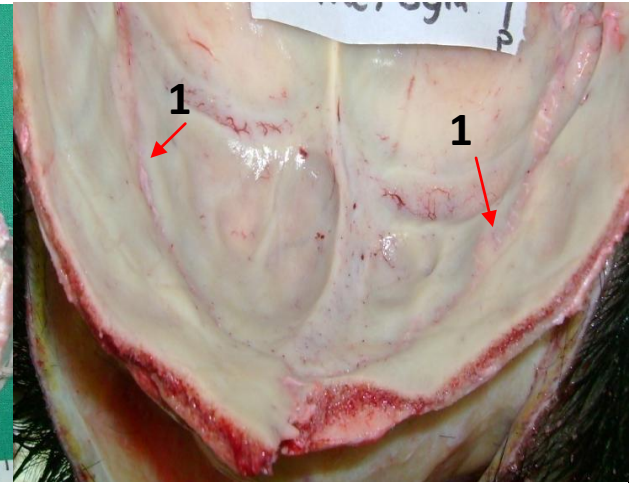
CASE-75



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

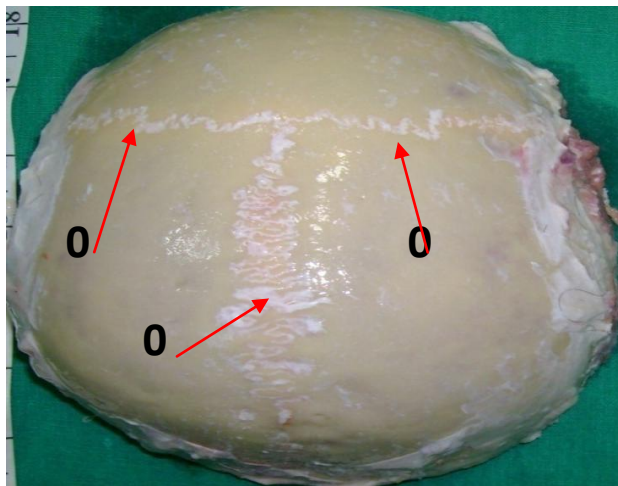


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

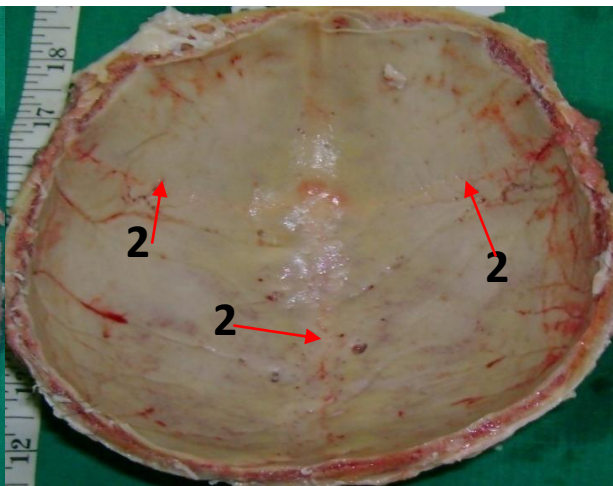


LAMDROID SUTURES (ENDOCRANIAL)

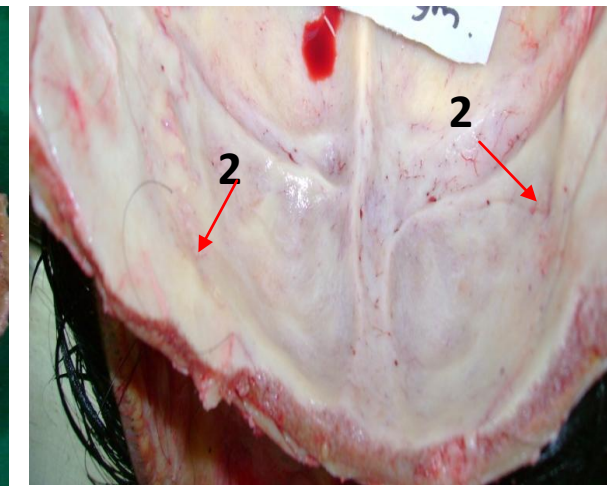
CASE-76



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



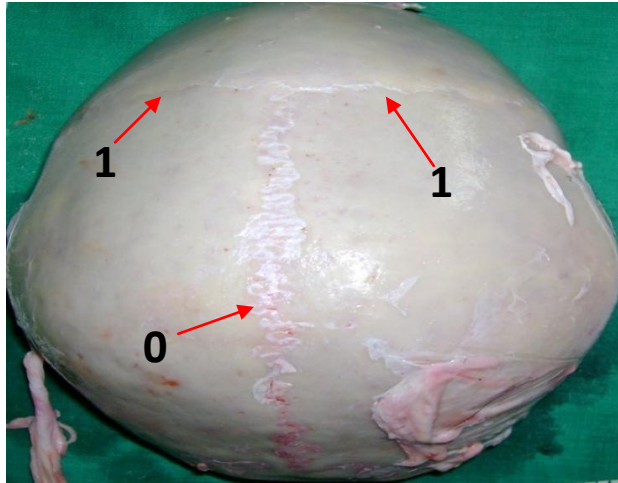
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



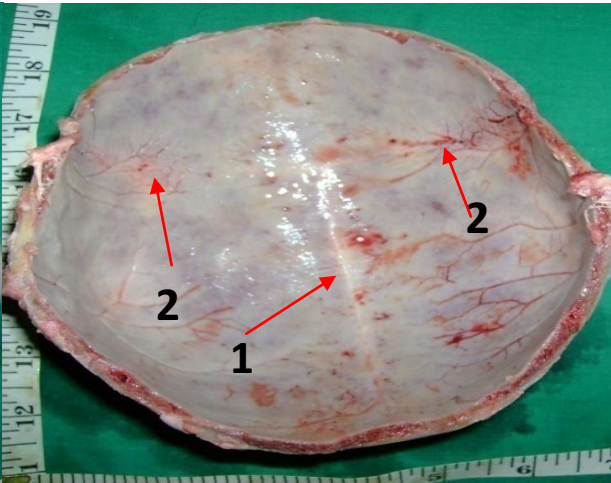
LAMDROID SUTURES (ENDOCRANIAL)

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

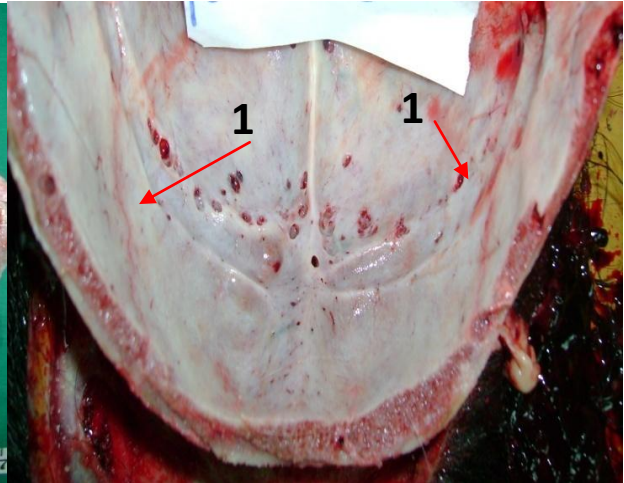
CASE-77



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

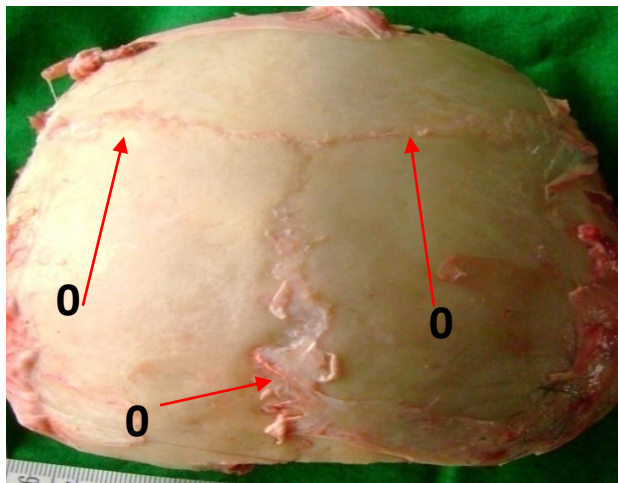


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

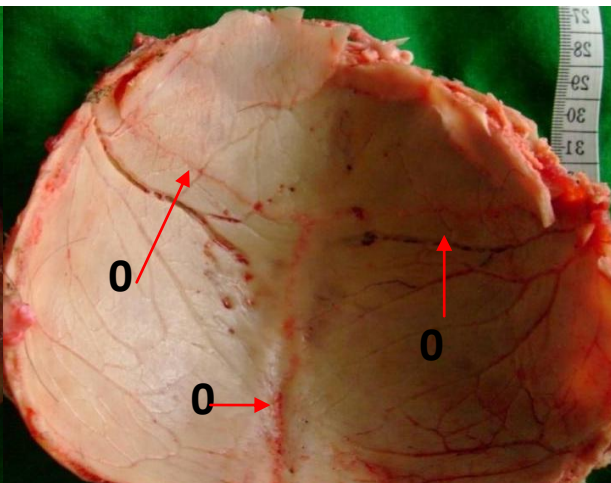


LAMDROID SUTURES (ENDOCRANIAL)

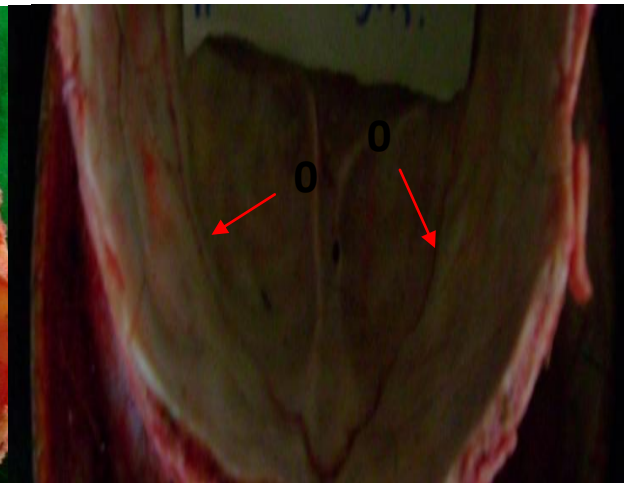
CASE-78



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



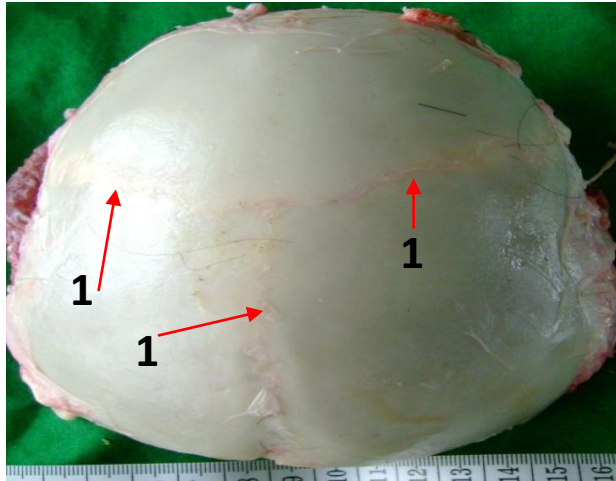
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



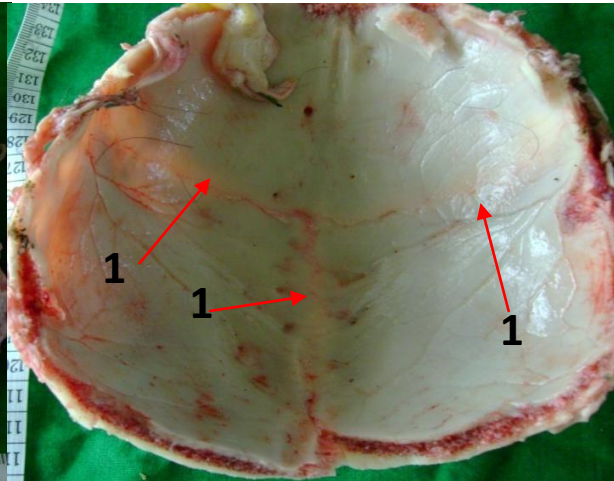
LAMDROID SUTURES (ENDOCRANIAL)

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

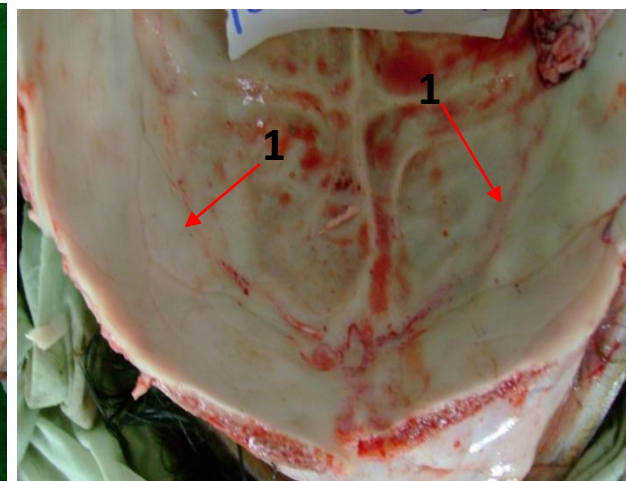
CASE-79



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

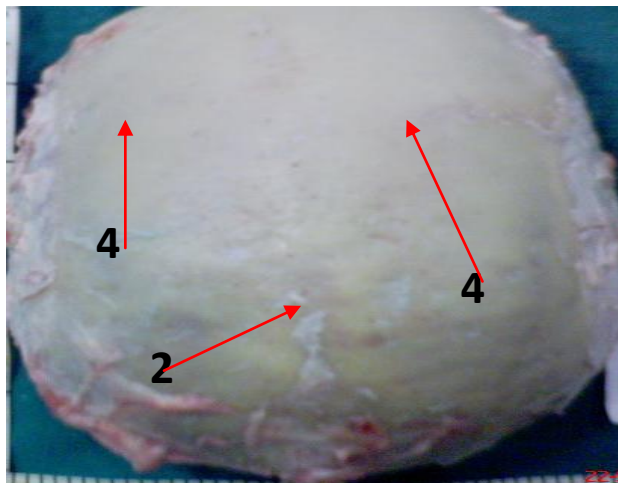


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

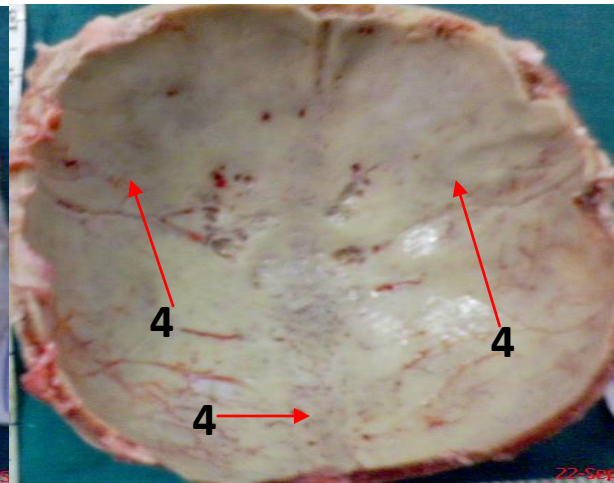


LAMDROID SUTURES (ENDOCRANIAL)

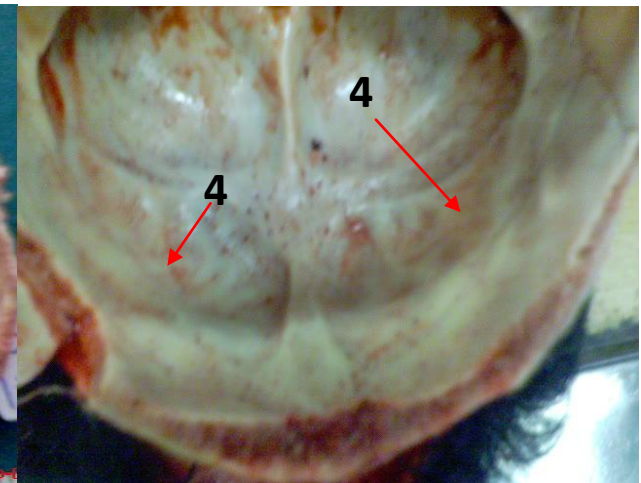
CASE-80



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



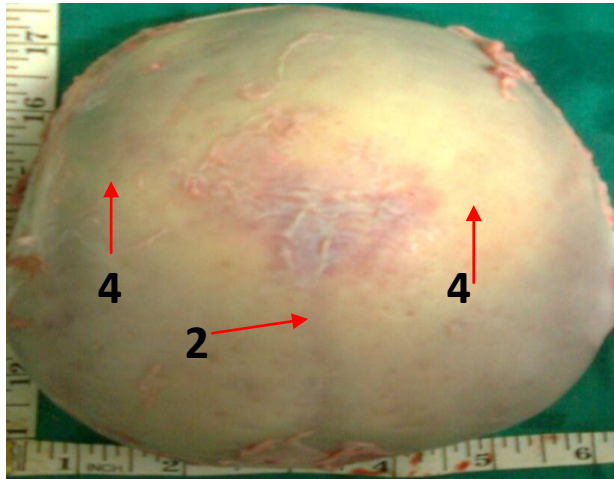
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



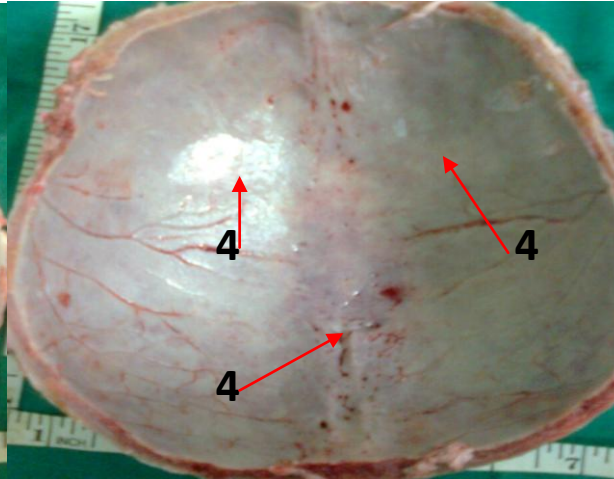
LAMDROID SUTURES (ENDOCRANIAL)

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

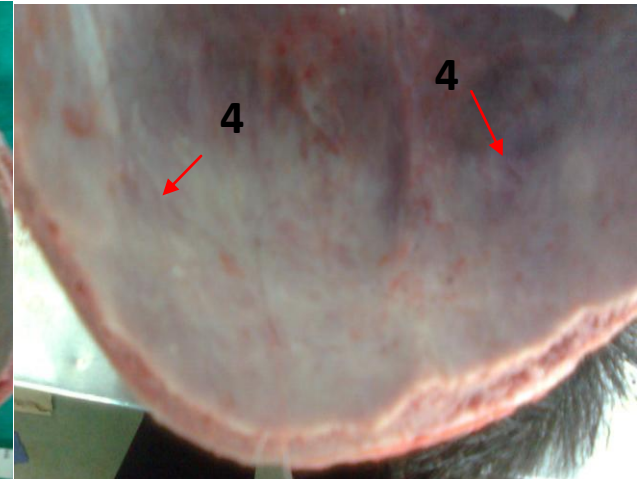
CASE-81



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

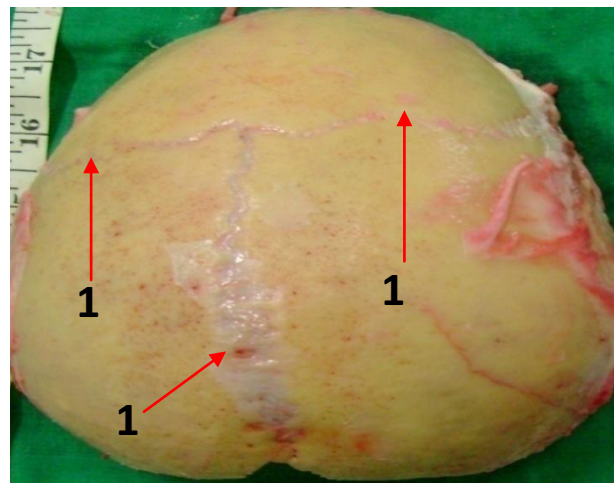


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

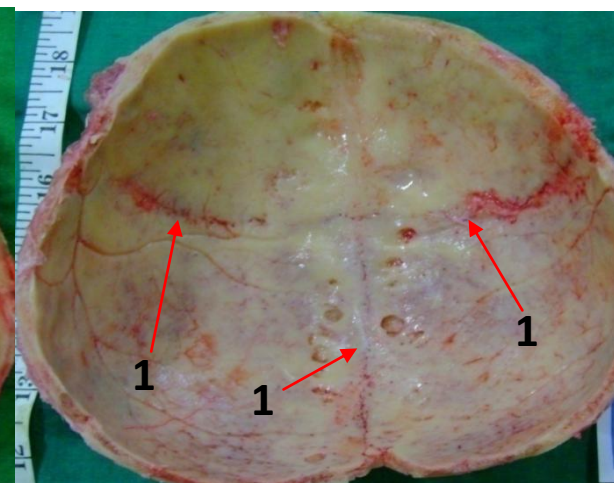


LAMDROID SUTURES (ENDOCRANIAL)

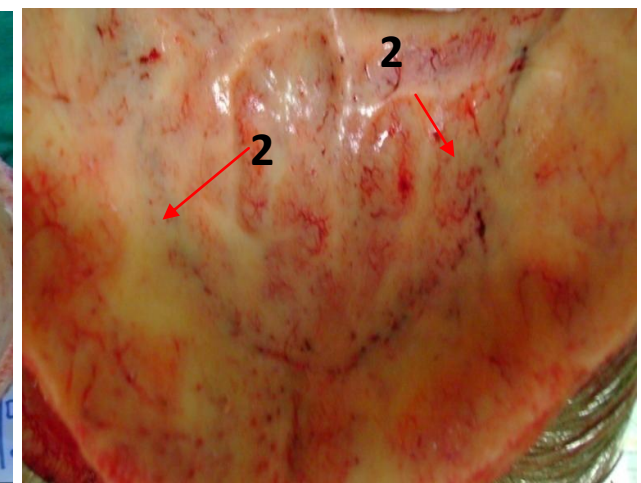
CASE-82



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



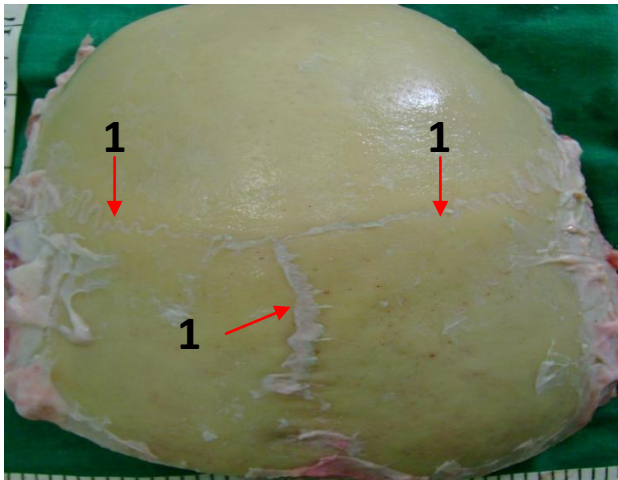
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



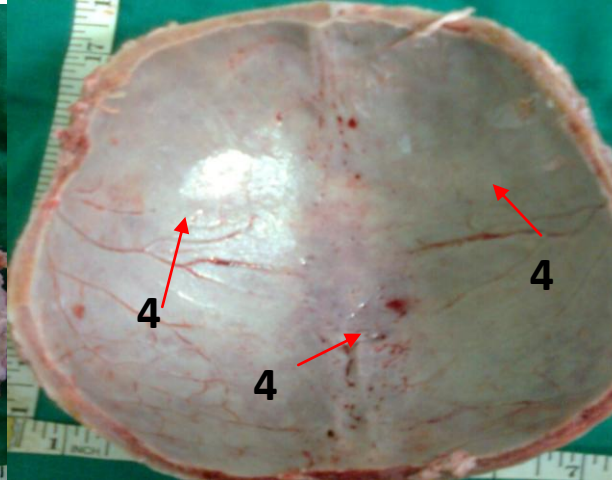
LAMDROID SUTURES (ENDOCRANIAL)

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

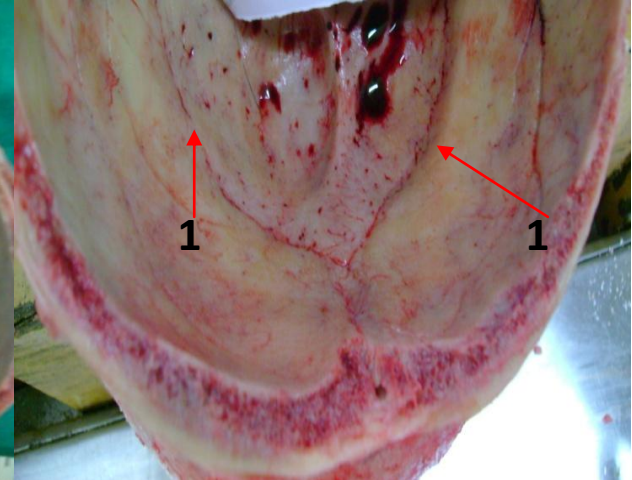
CASE-83



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

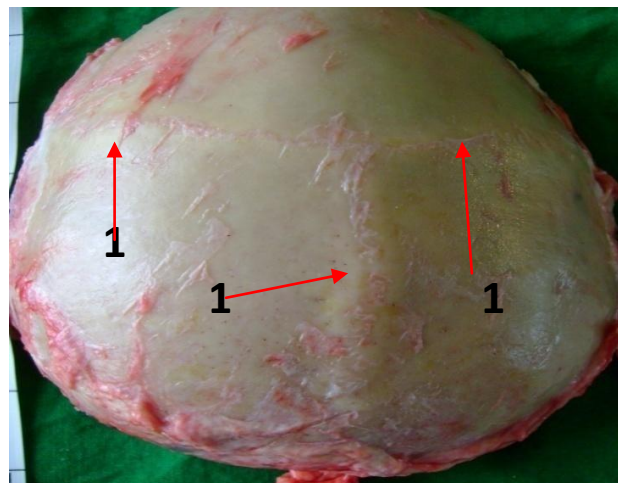


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

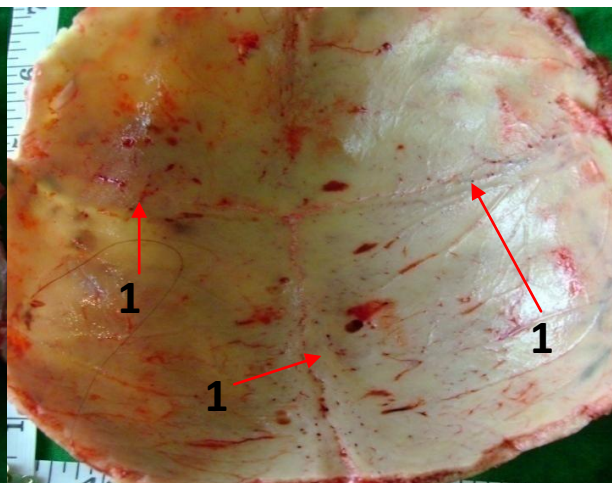


LAMDROID SUTURES (ENDOCRANIAL)

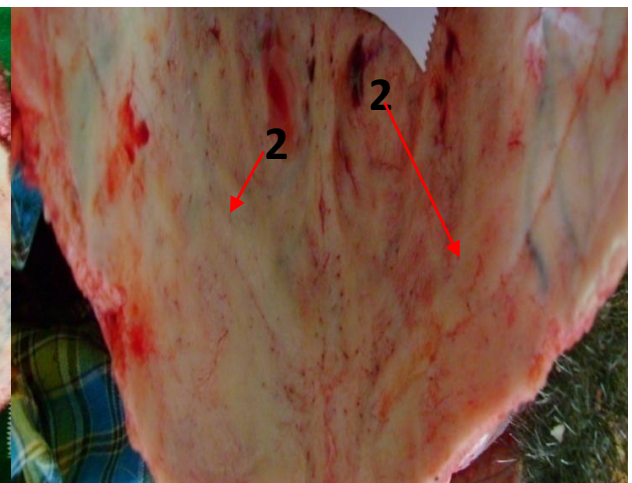
CASE-84



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



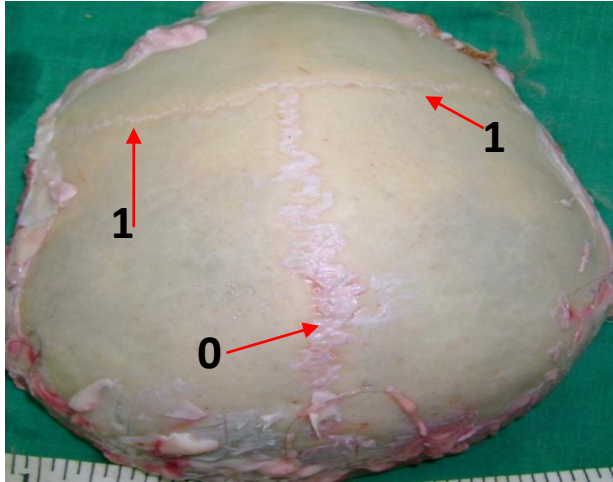
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



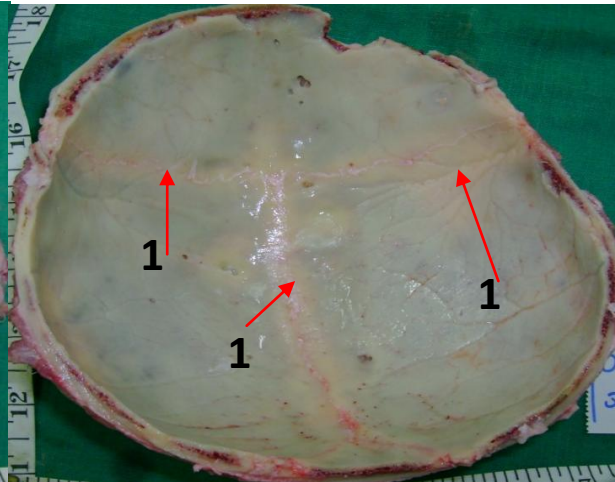
LAMDROID SUTURES (ENDOCRANIAL)

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

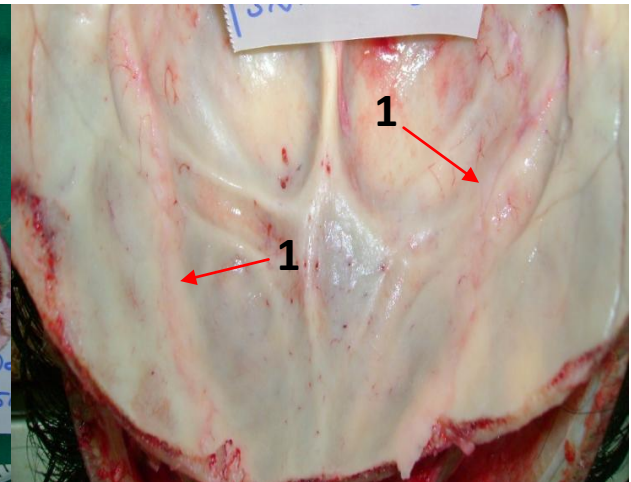
CASE-85



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

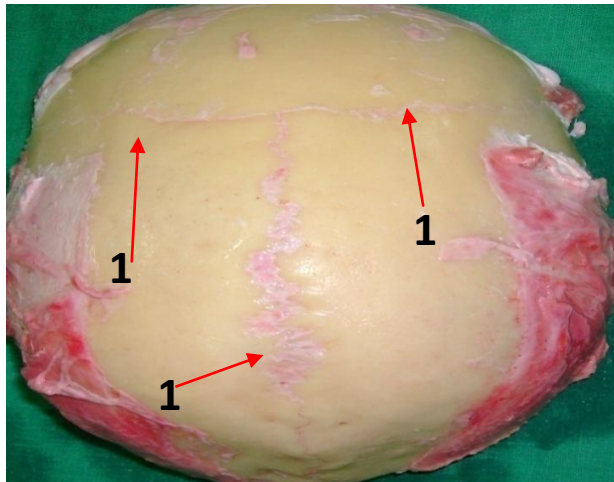


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

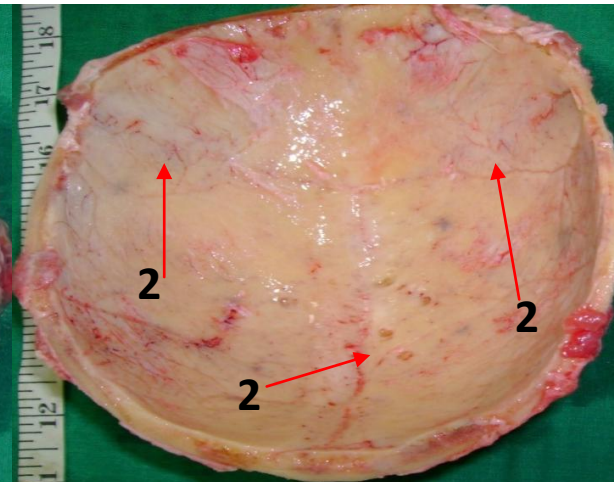


LAMDOID SUTURES (ENDOCRANIAL)

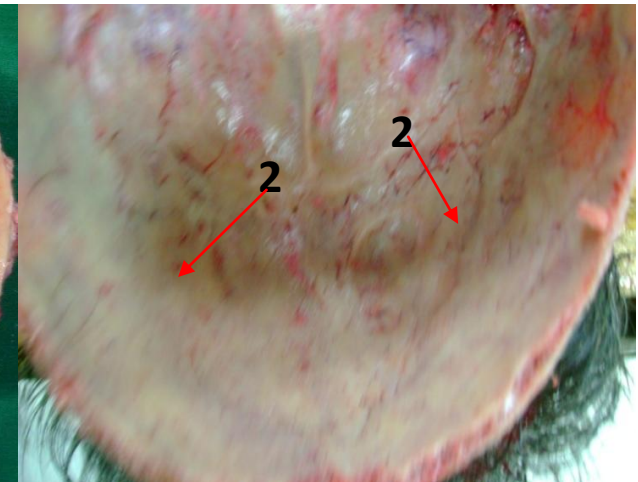
CASE-86



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



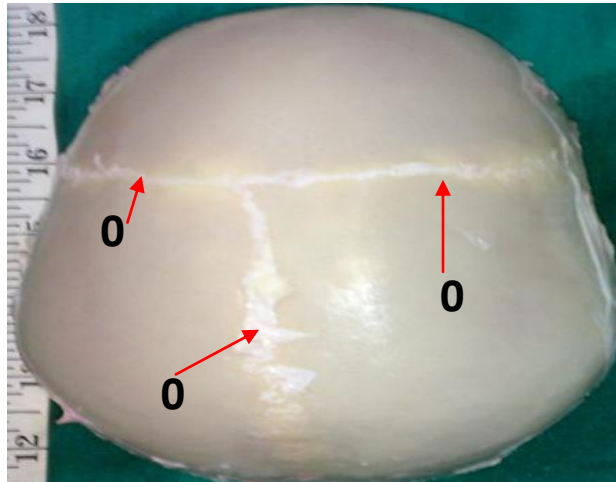
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



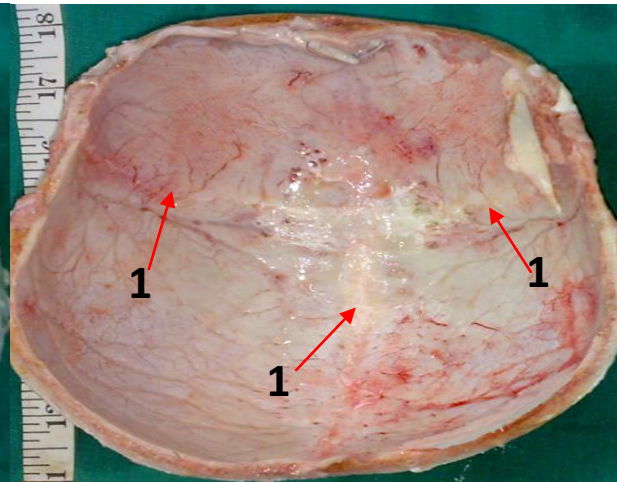
LAMDOID SUTURES (ENDOCRANIAL)

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

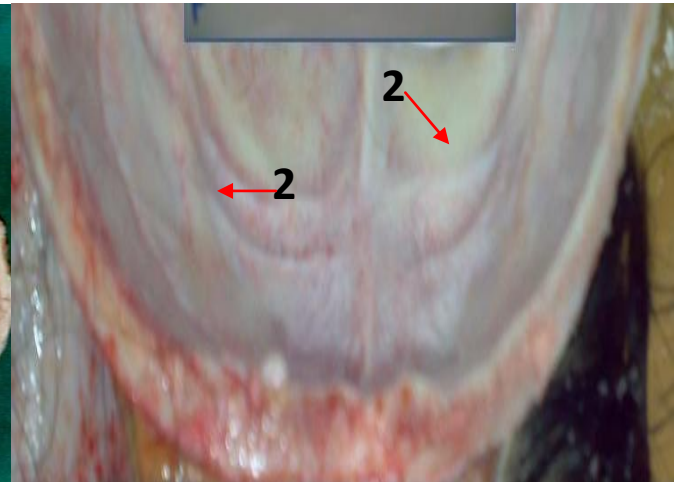
CASE-87



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

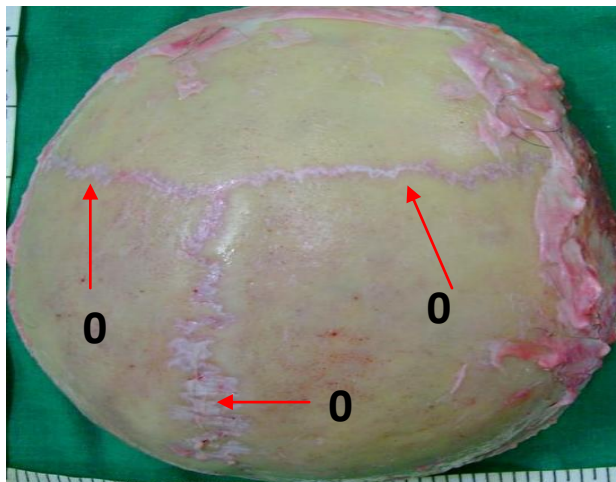


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

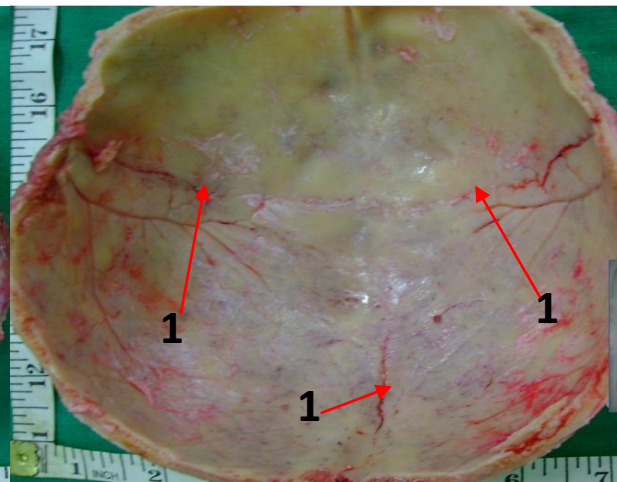


LAMDROID SUTURES (ENDOCRANIAL)

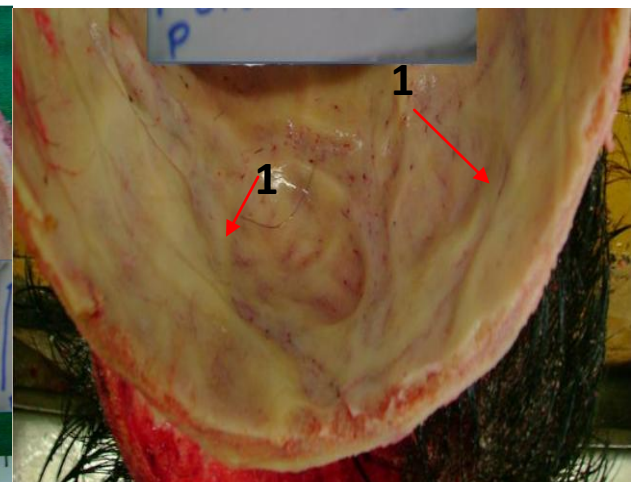
CASE-88



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



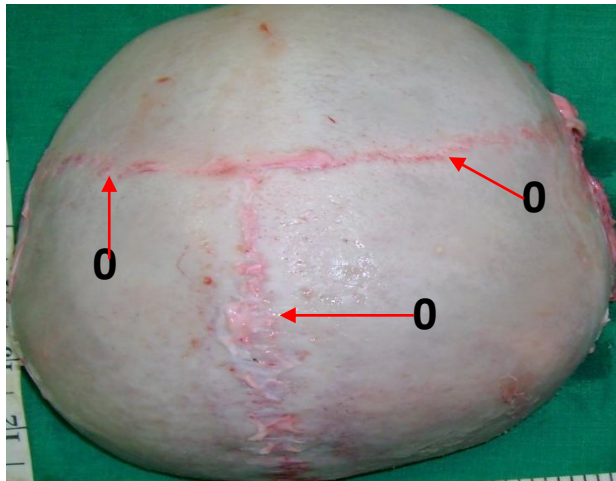
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



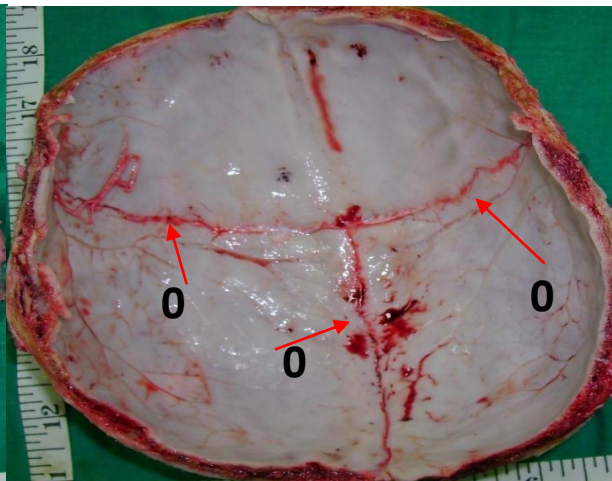
LAMDROID SUTURES (ENDOCRANIAL)

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

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CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

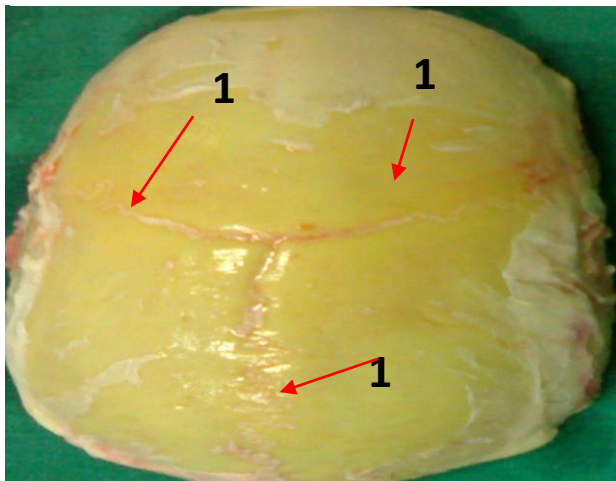


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

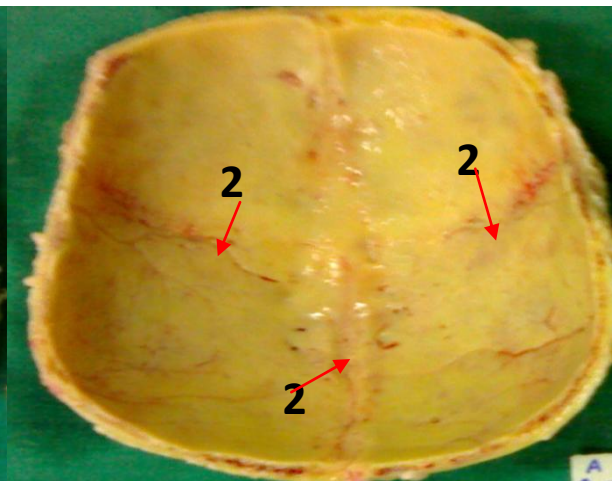


LAMDROID SUTURES (ENDOCRANIAL)

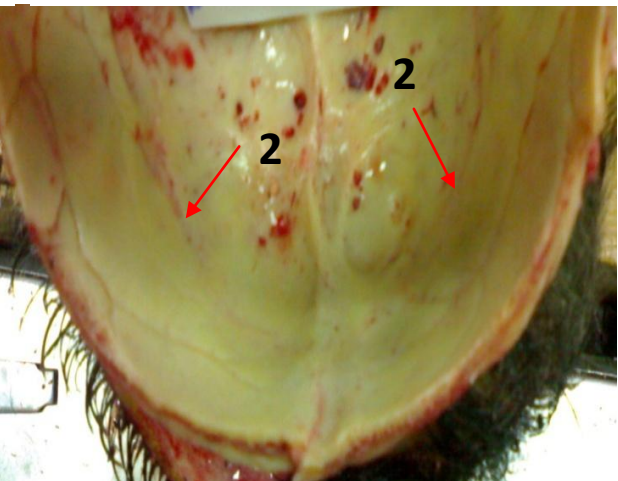
CASE-90



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



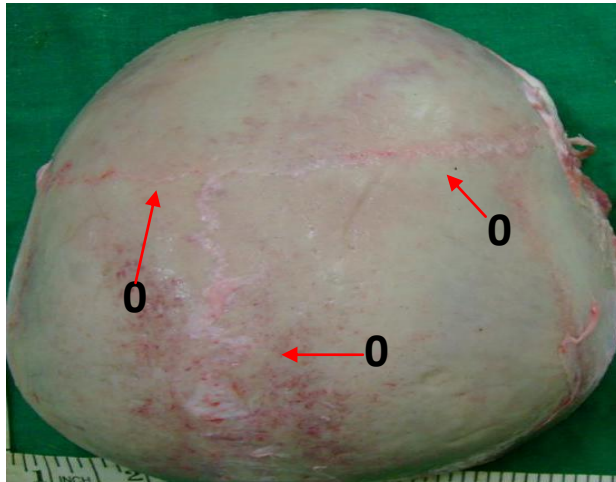
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



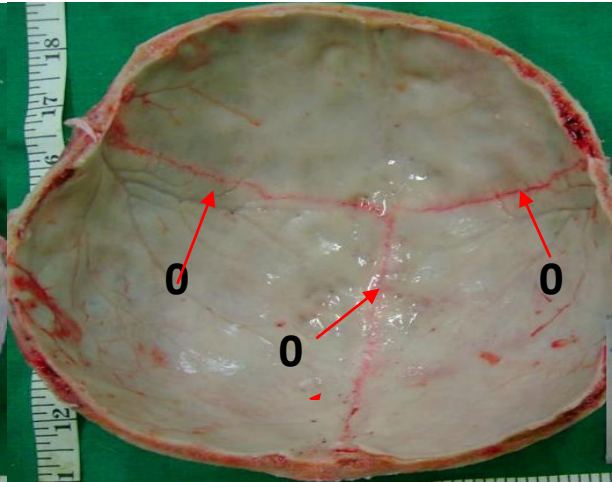
LAMDROID SUTURES (ENDOCRANIAL)

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

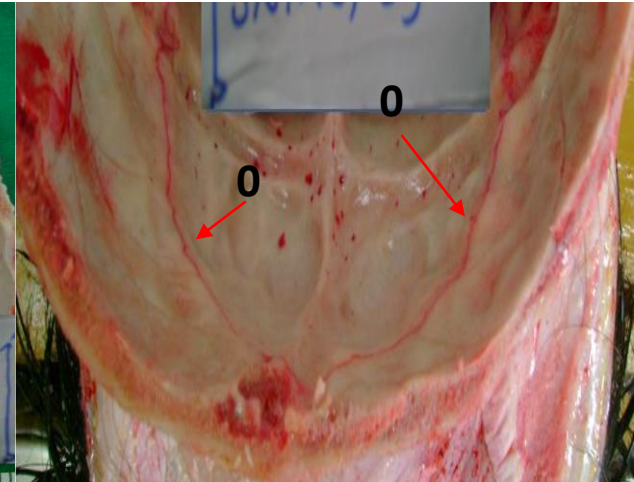
CASE-91



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

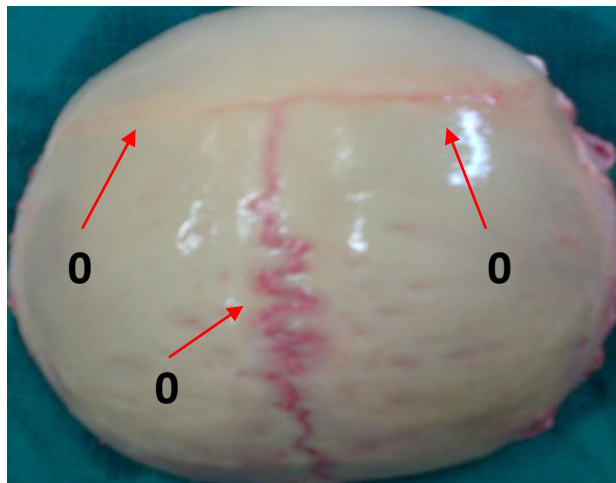


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

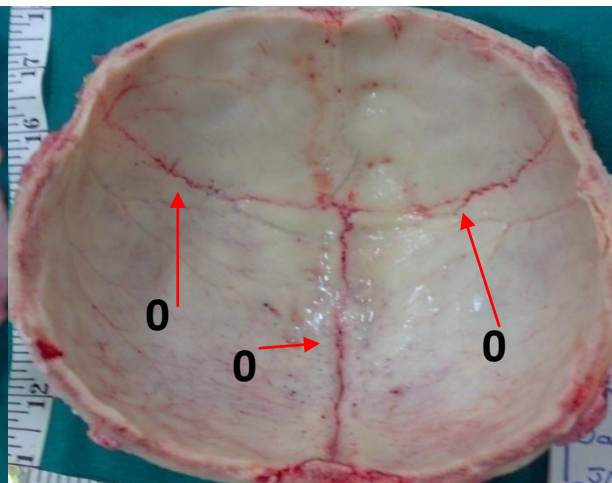


LAMDROID SUTURES (ENDOCRANIAL)

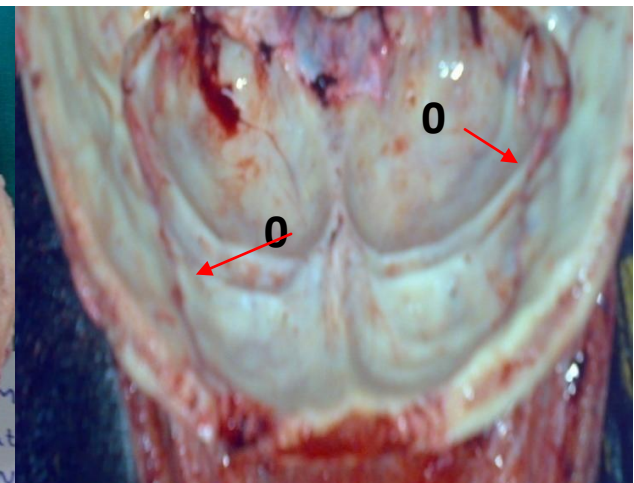
CASE-92



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



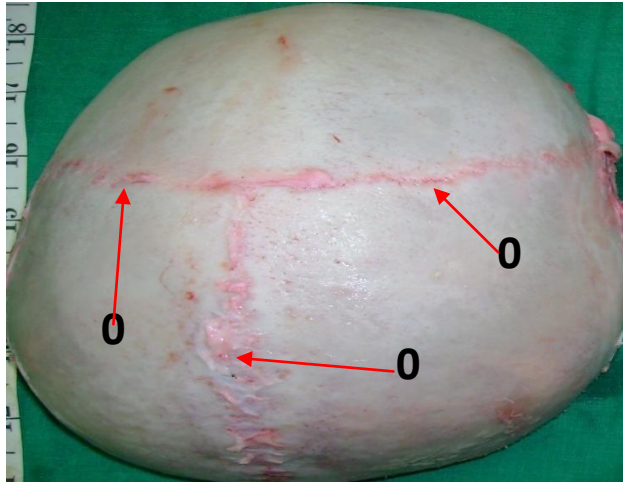
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



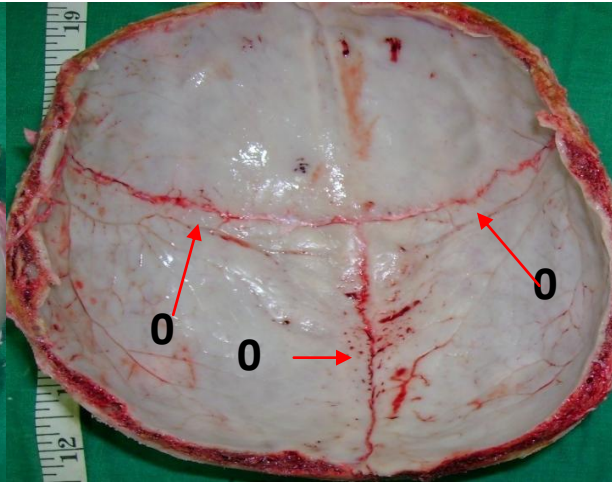
LAMDROID SUTURES (ENDOCRANIAL)

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

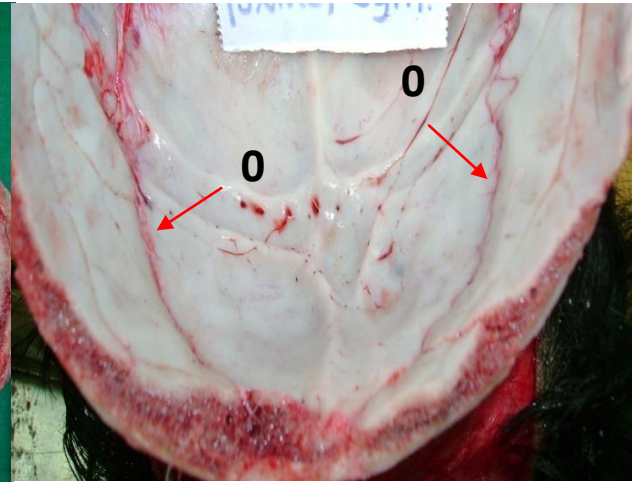
CASE-93



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

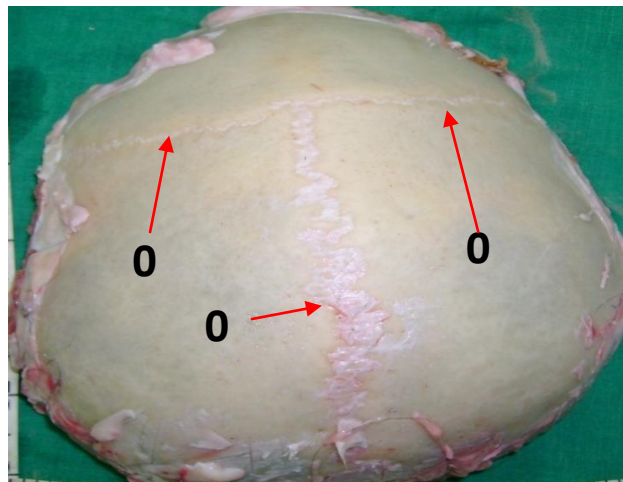


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

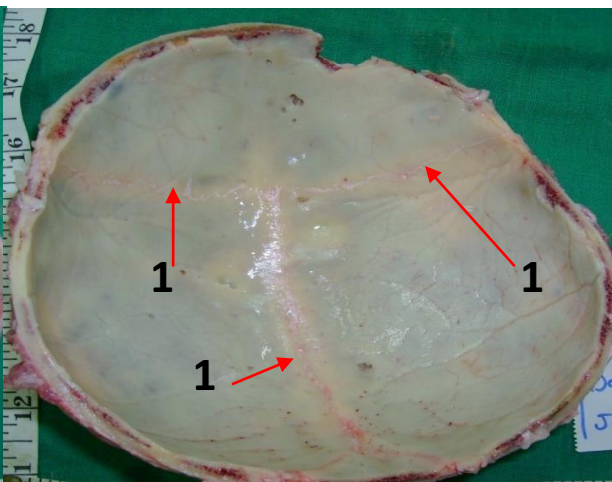


LAMDOID SUTURES (ENDOCRANIAL)

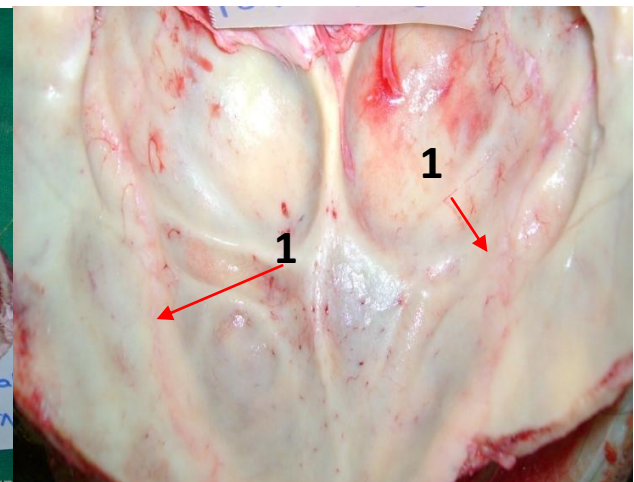
CASE-94



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



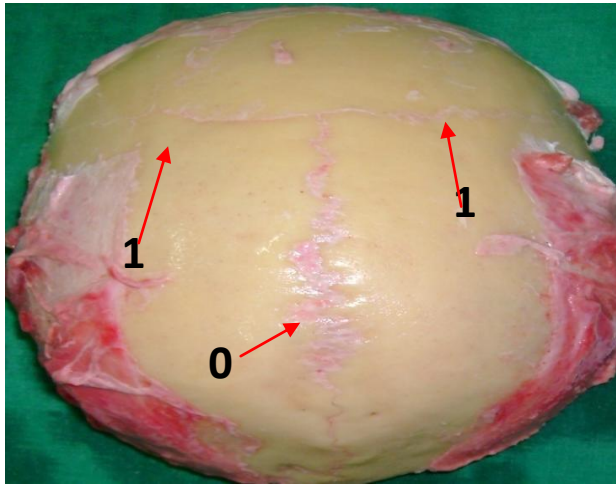
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



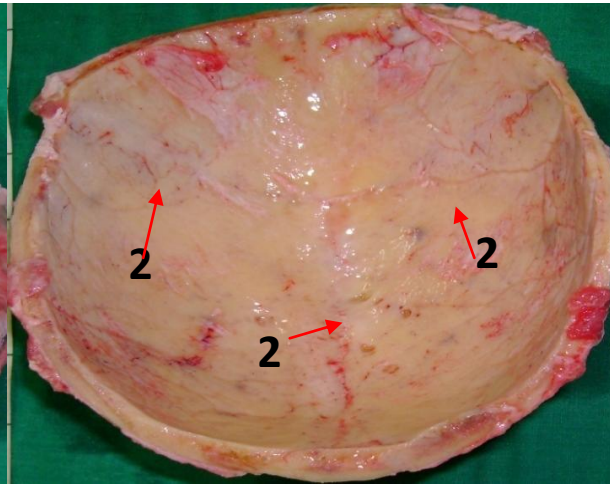
LAMDOID SUTURES (ENDOCRANIAL)

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

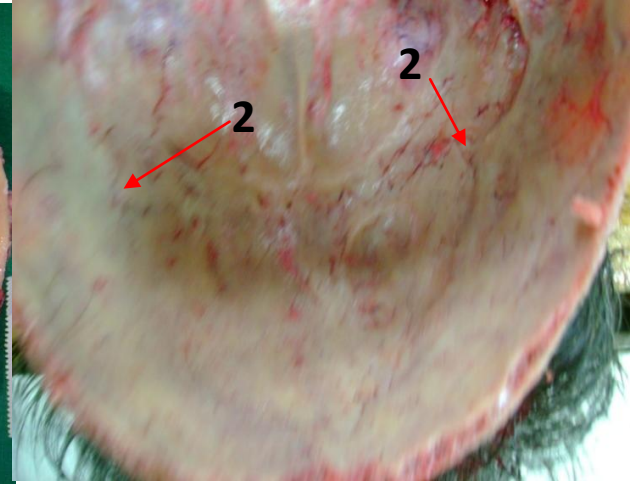
CASE-95



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

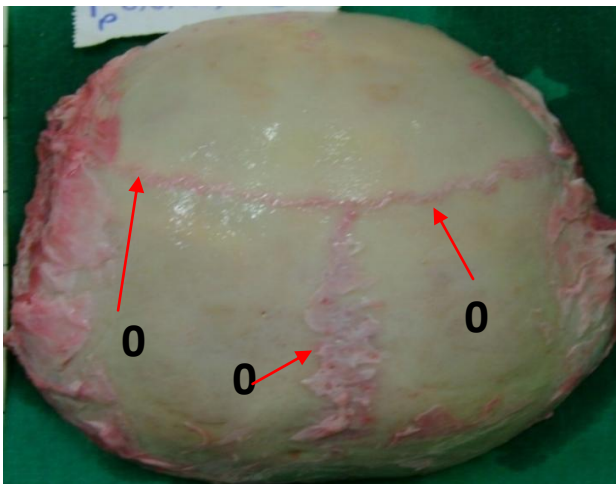


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

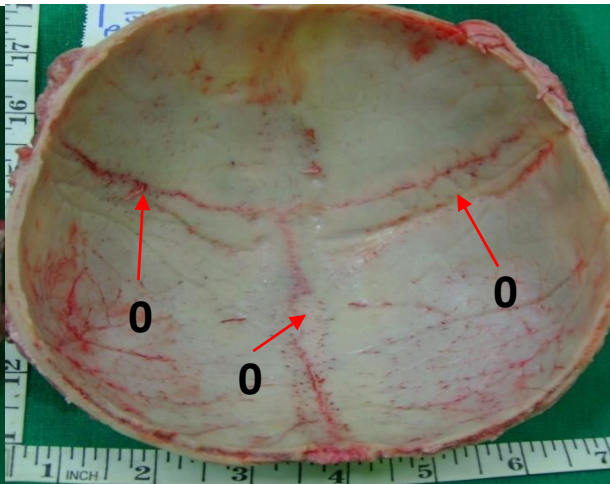


LAMDROID SUTURES (ENDOCRANIAL)

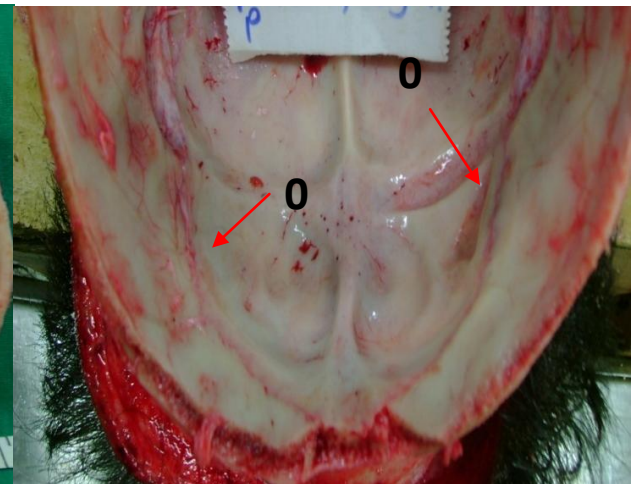
CASE-96



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



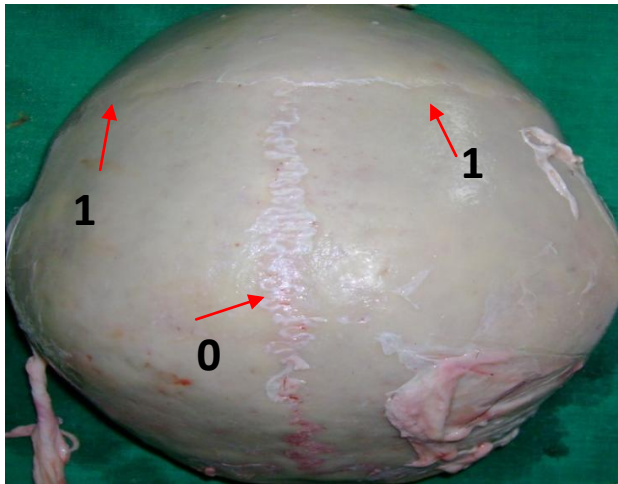
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



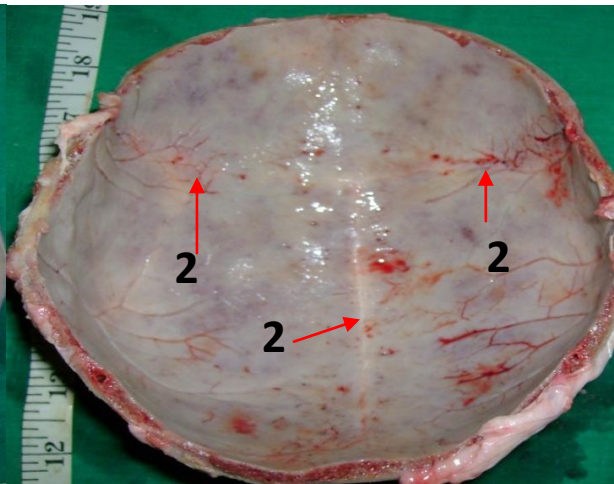
LAMDROID SUTURES (ENDOCRANIAL)

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

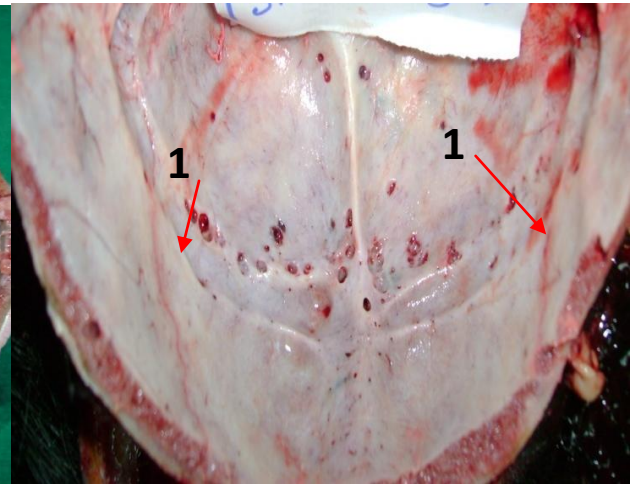
CASE-97



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

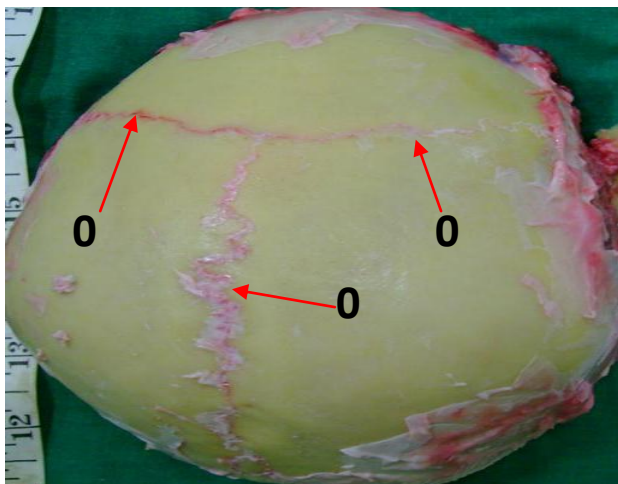


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

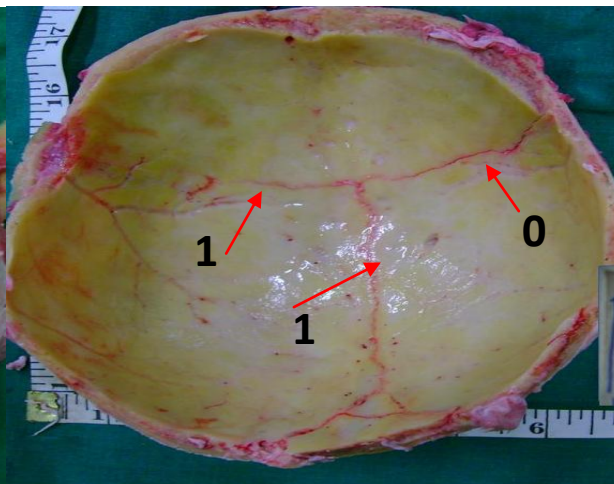


LAMDROID SUTURES (ENDOCRANIAL)

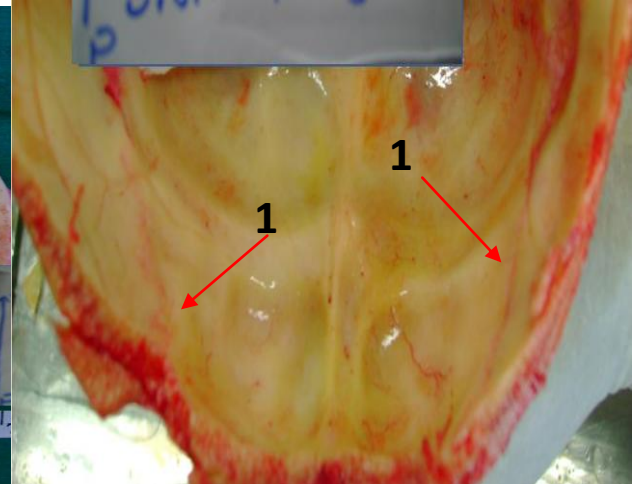
CASE-98



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



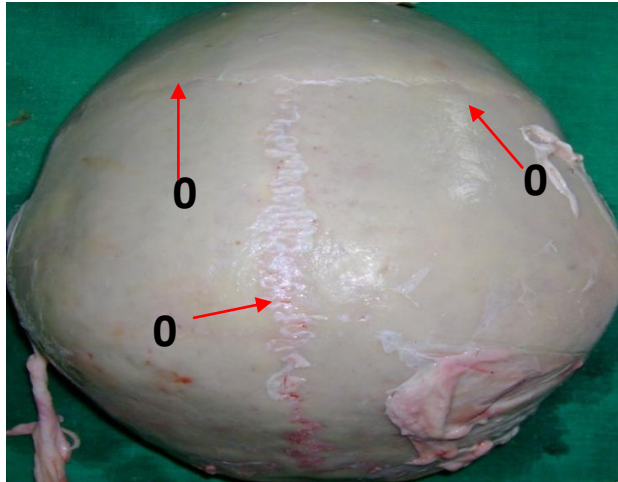
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



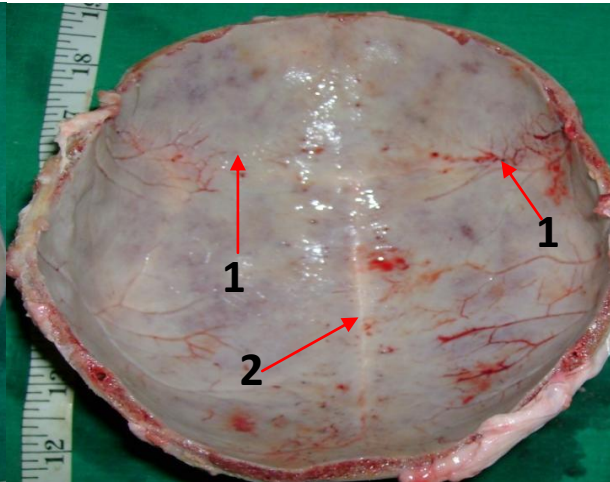
LAMDROID SUTURES (ENDOCRANIAL)

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

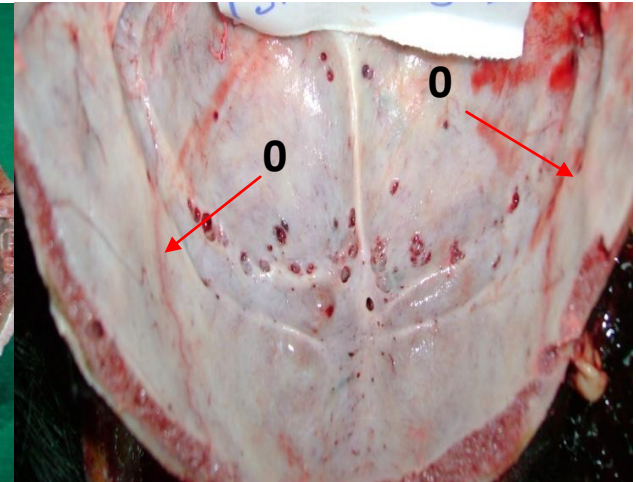
CASE-99



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

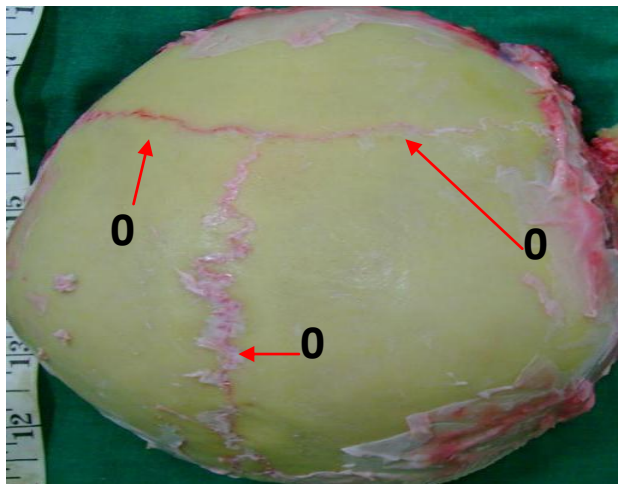


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

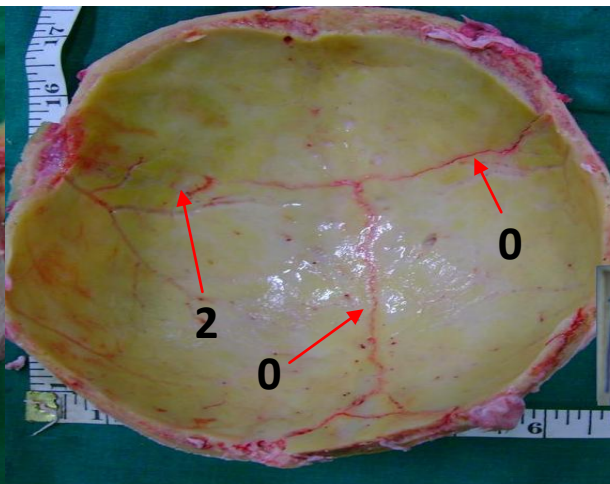


LAMDROID SUTURES (ENDOCRANIAL)

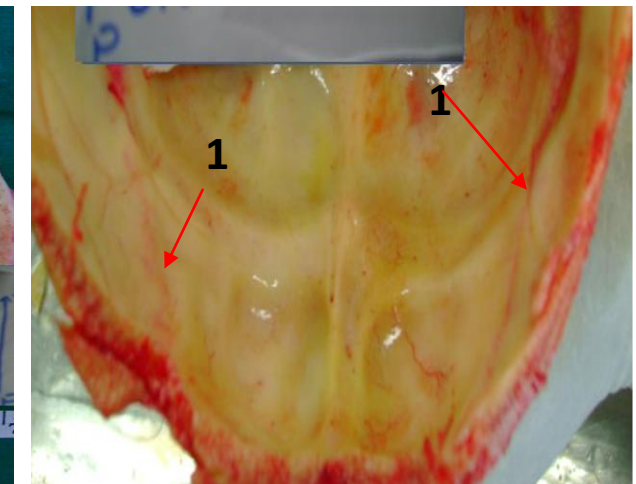
CASE-100



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



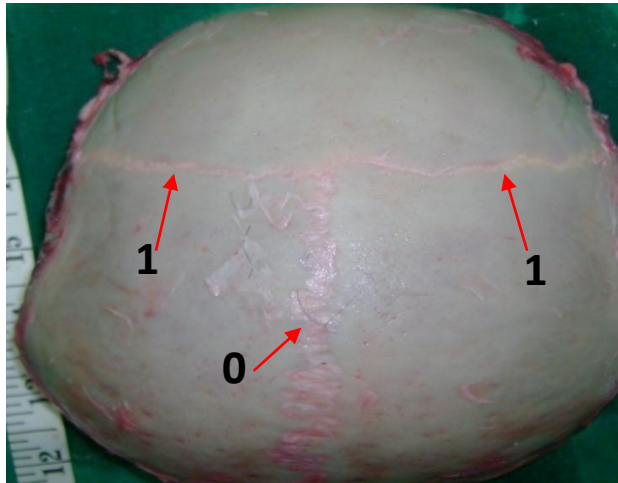
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



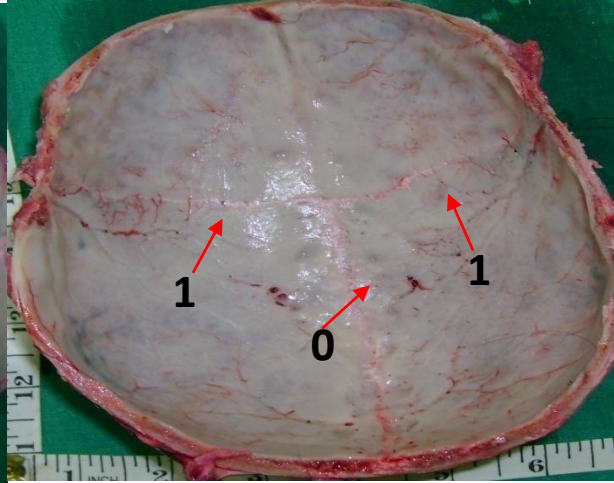
LAMDROID SUTURES (ENDOCRANIAL)

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

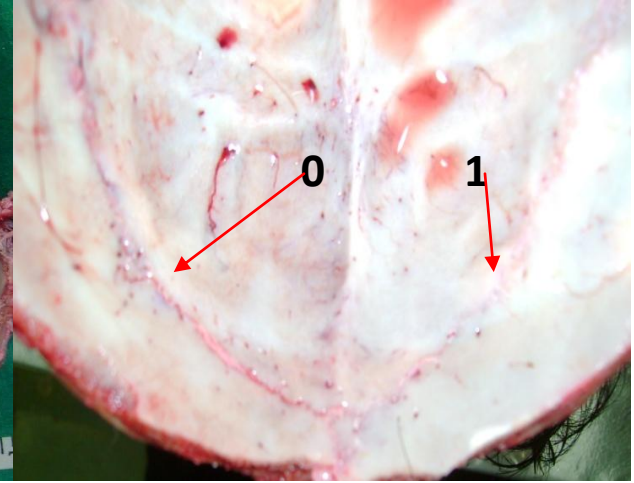
CASE-101



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

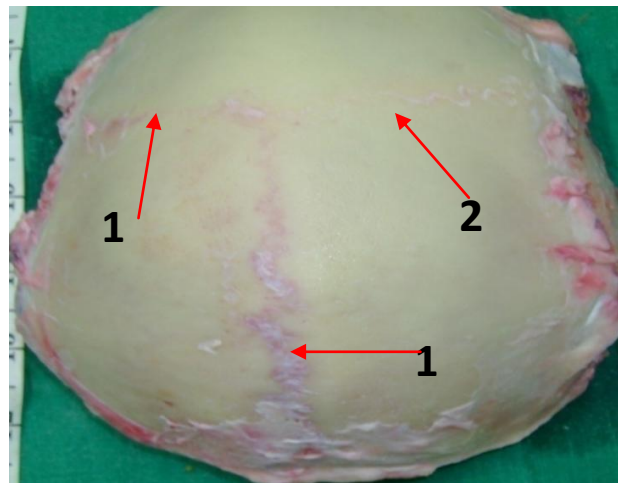


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

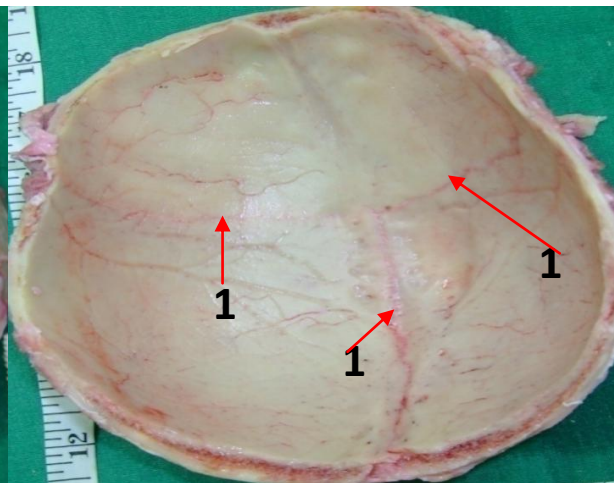


LAMDOID SUTURES (ENDOCRANIAL)

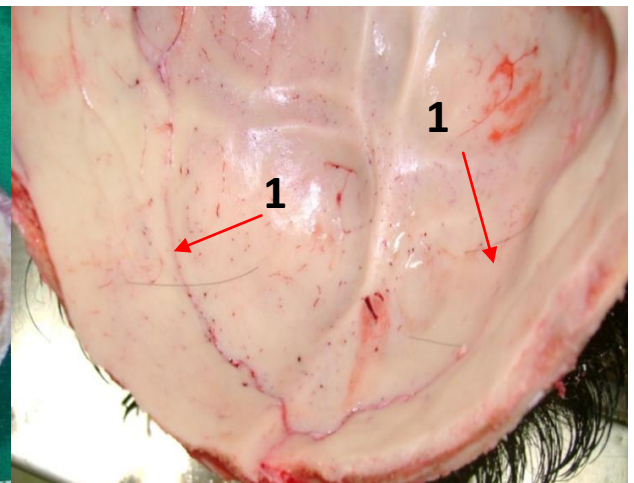
CASE-102



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



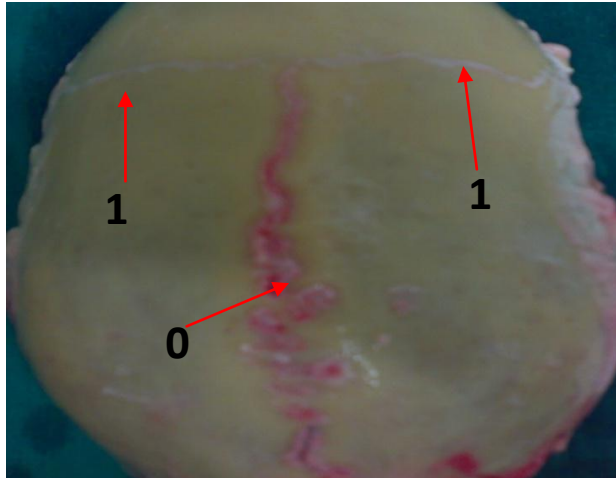
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



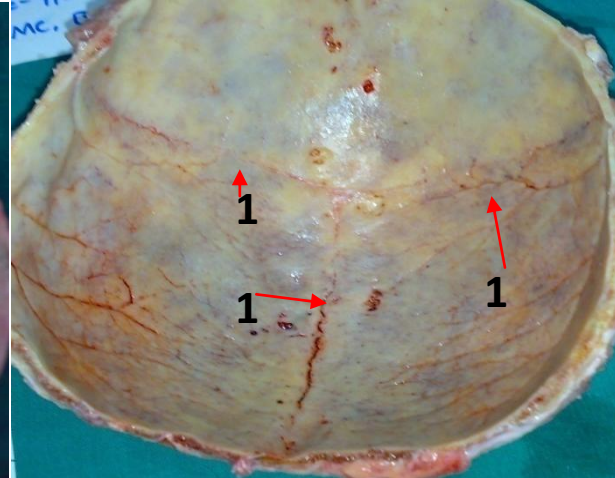
LAMDOID SUTURES (ENDOCRANIAL)

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

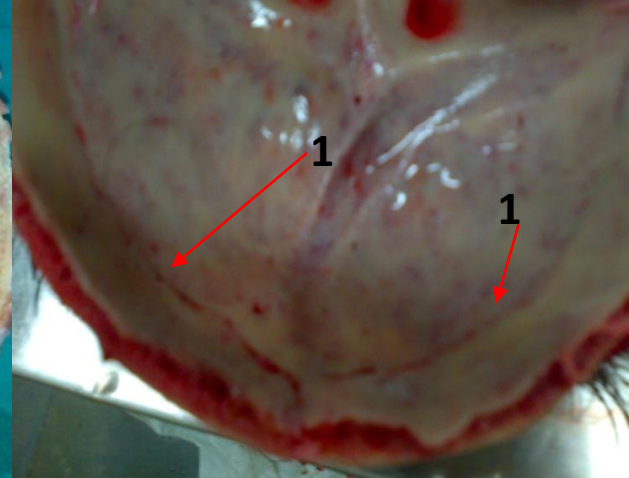
CASE-103



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

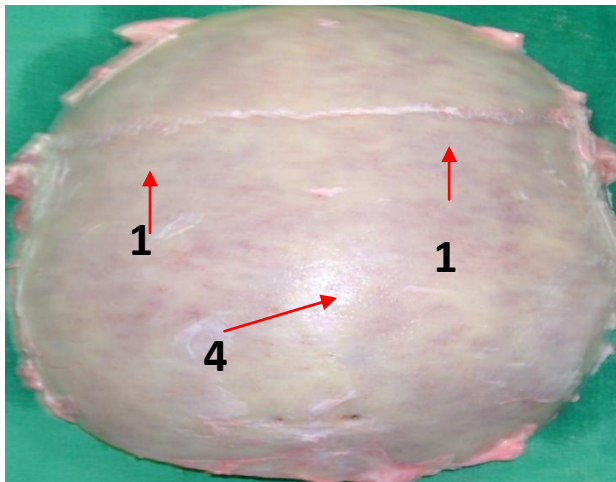


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

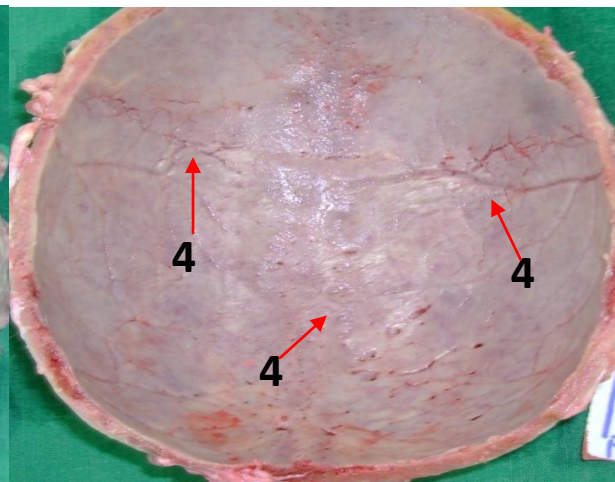


LAMDOID SUTURES (ENDOCRANIAL)

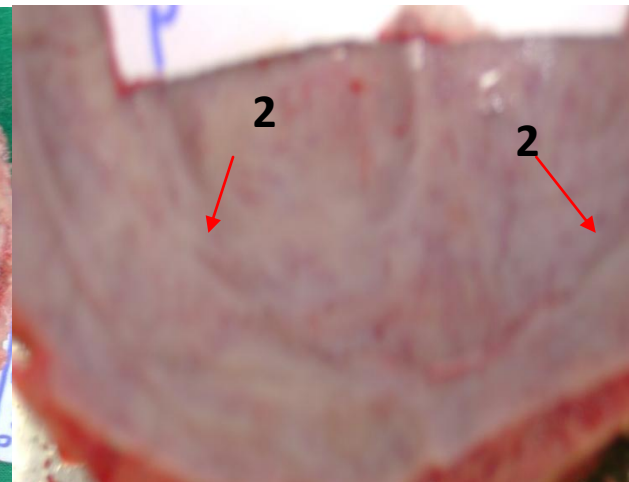
CASE-104



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



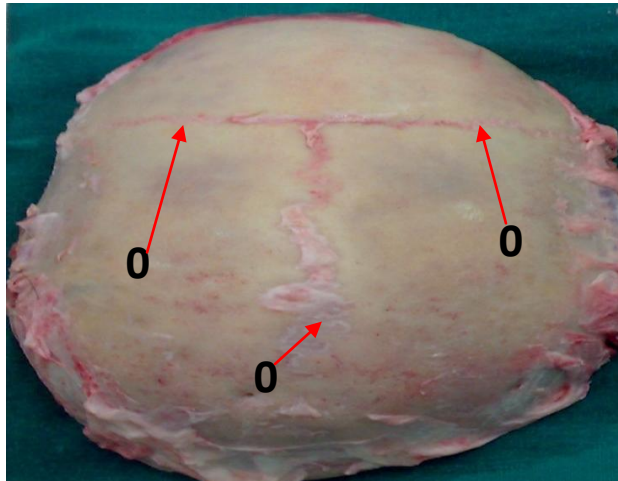
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



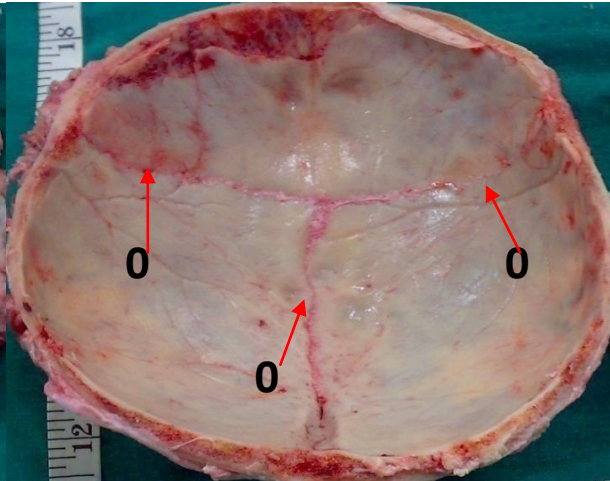
LAMDOID SUTURES (ENDOCRANIAL)

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

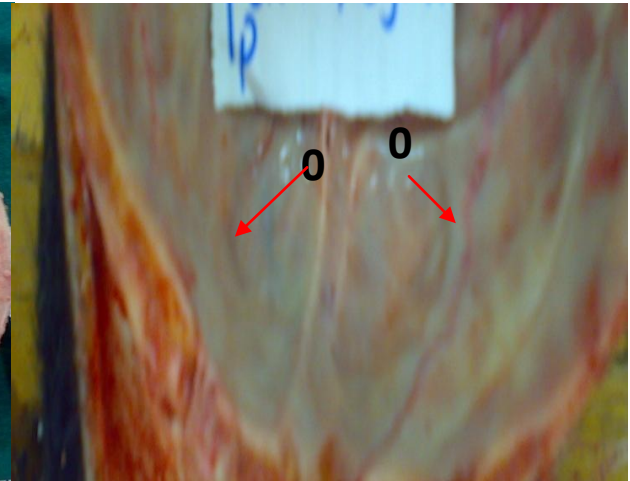
CASE-105



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

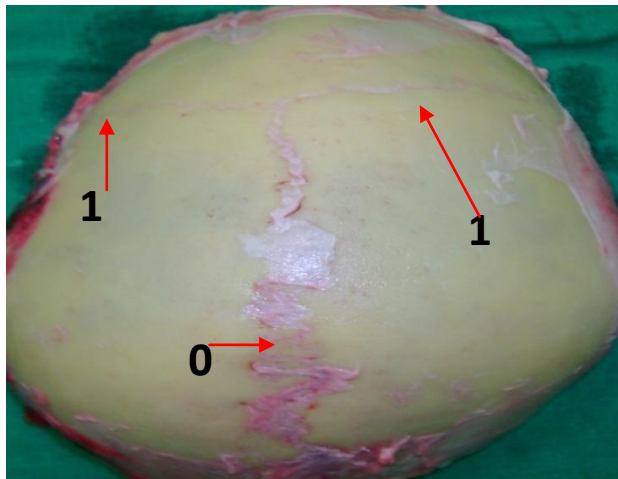


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

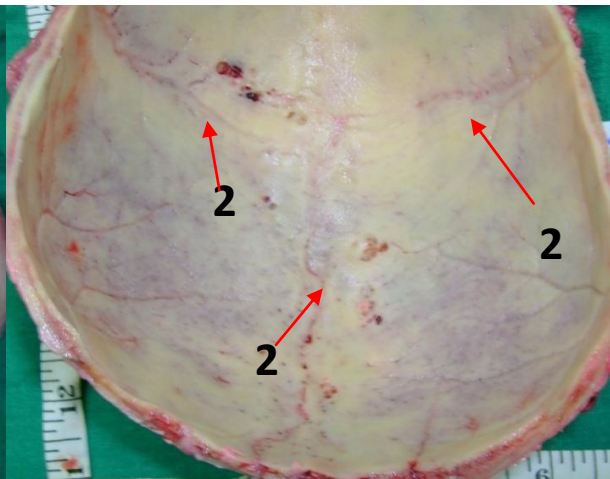


LAMDROID SUTURES (ENDOCRANIAL)

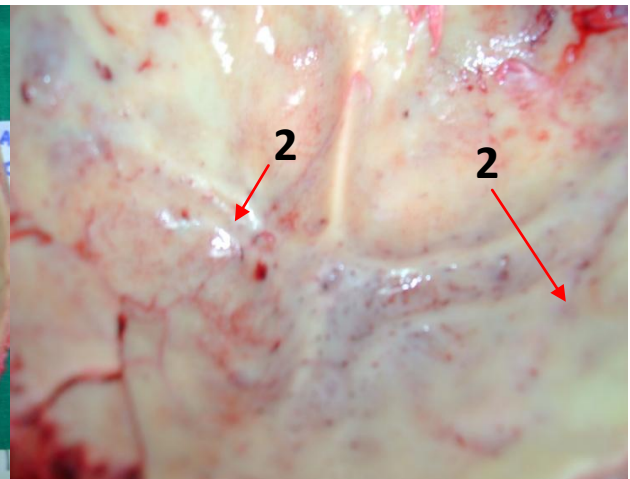
CASE-106



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



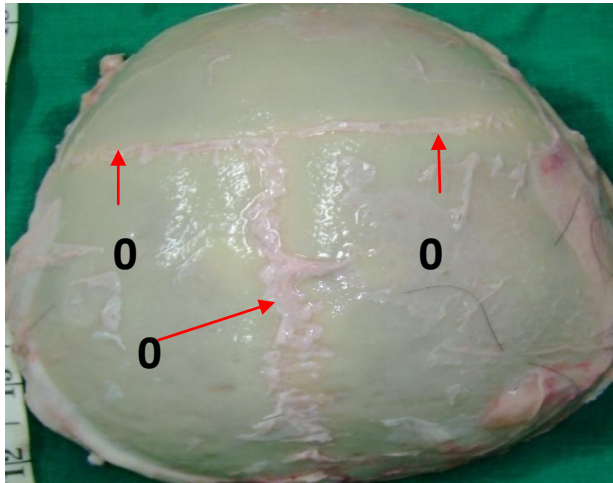
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



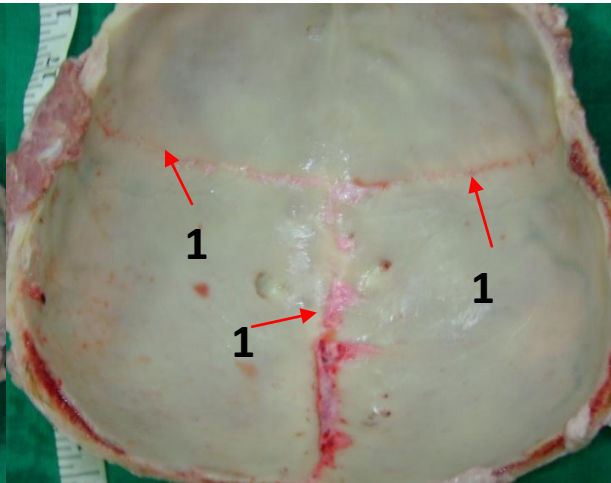
LAMDROID SUTURES (ENDOCRANIAL)

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

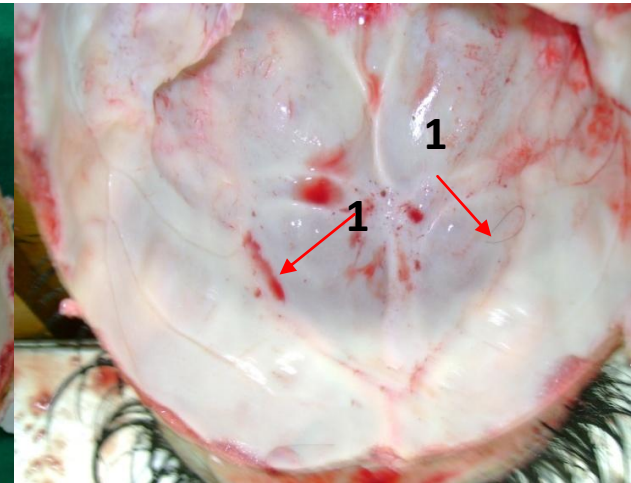
CASE-107



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

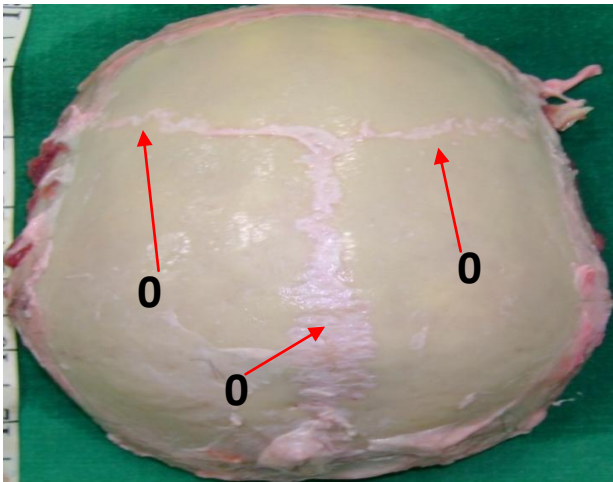


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

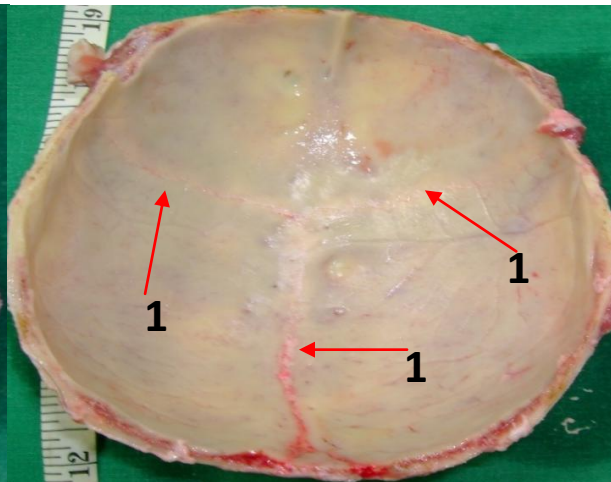


LAMDOID SUTURES (ENDOCRANIAL)

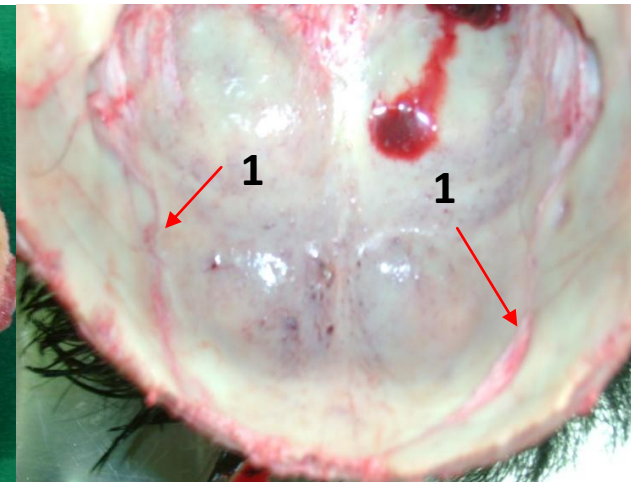
CASE-108



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



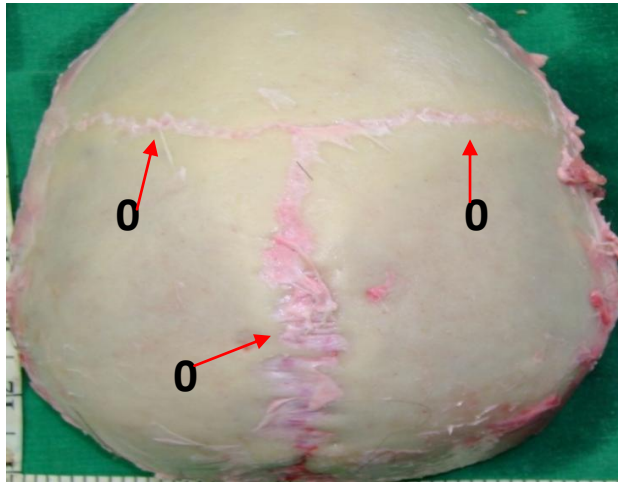
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



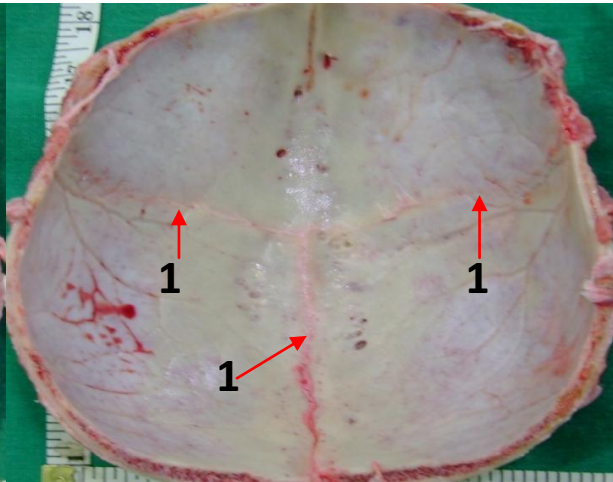
LAMDOID SUTURES (ENDOCRANIAL)

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

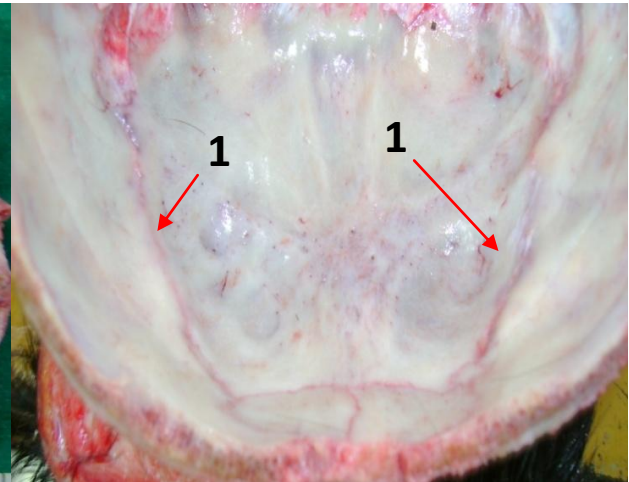
CASE-109



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

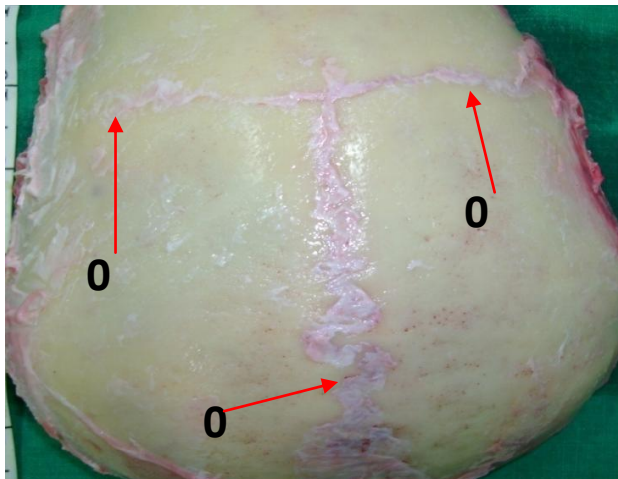


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

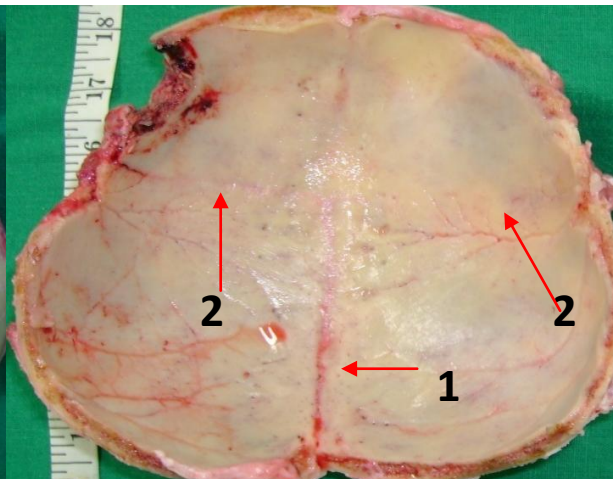


LAMDOID SUTURES (ENDOCRANIAL)

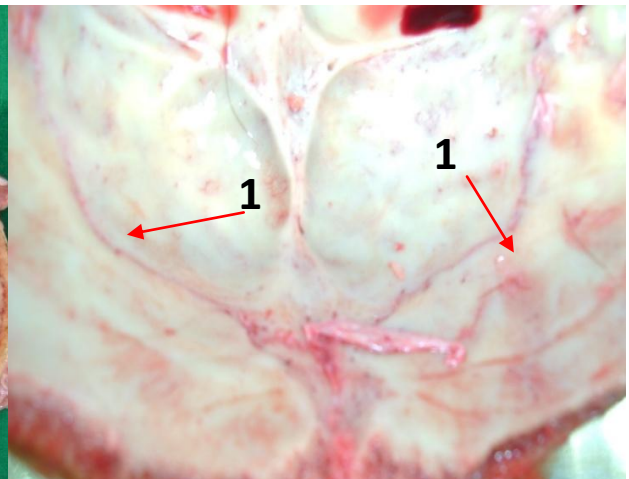
CASE-110



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



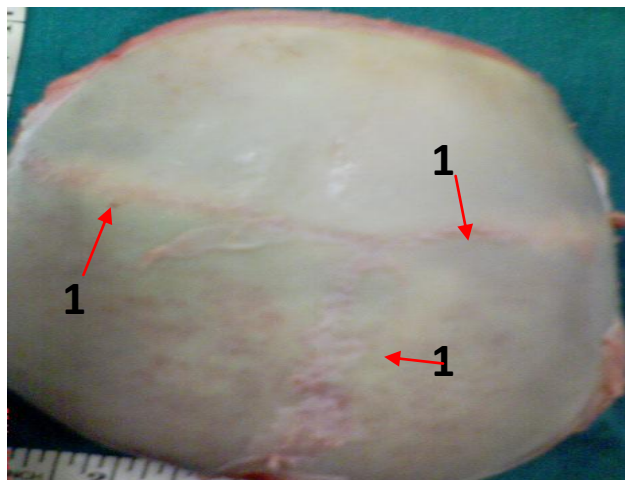
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



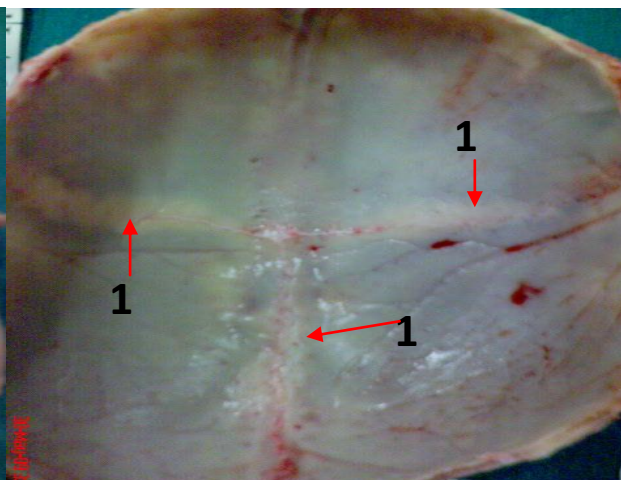
LAMDOID SUTURES (ENDOCRANIAL)

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

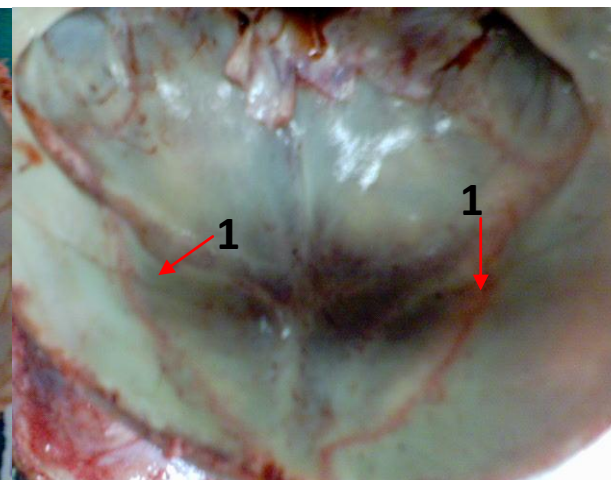
CASE-111



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

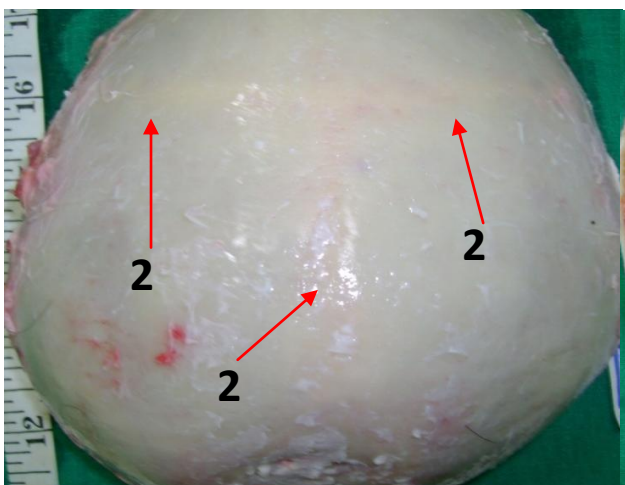


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

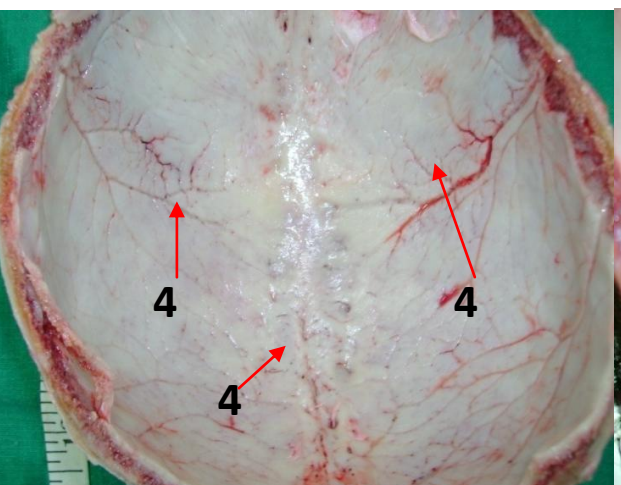


LAMDOID SUTURES (ENDOCRANIAL)

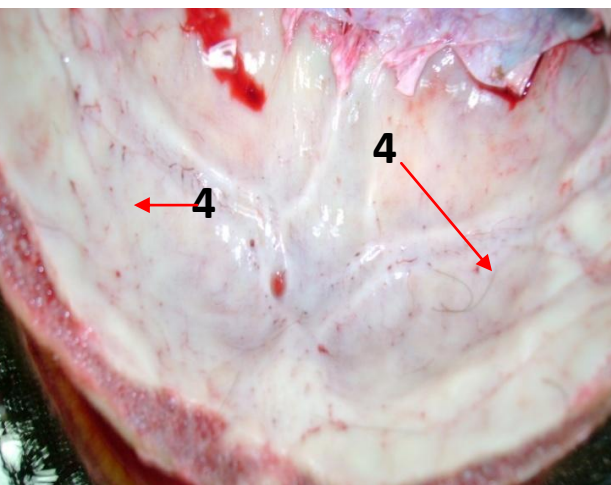
CASE-112



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



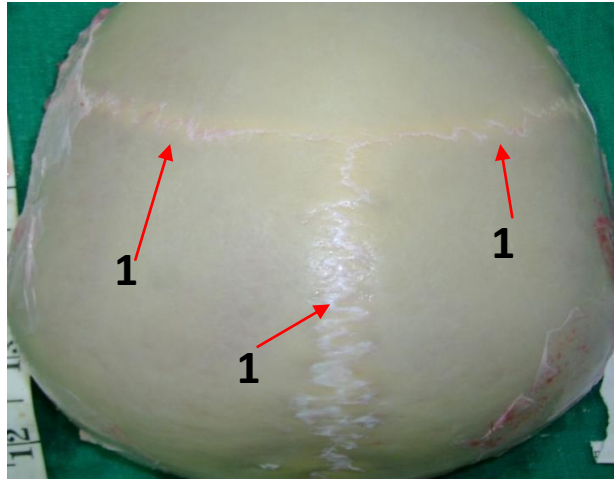
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



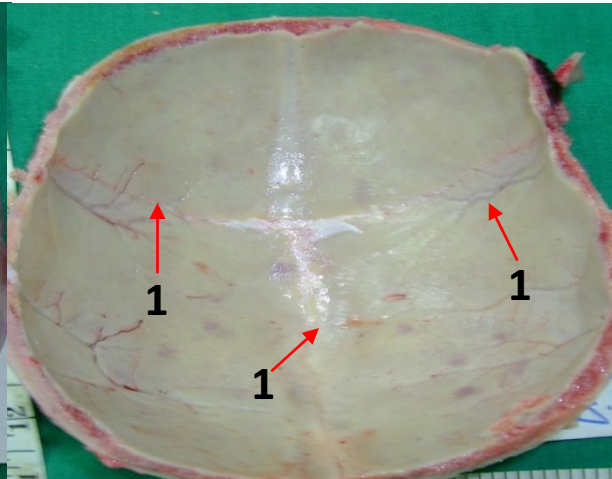
LAMDOID SUTURES (ENDOCRANIAL)

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

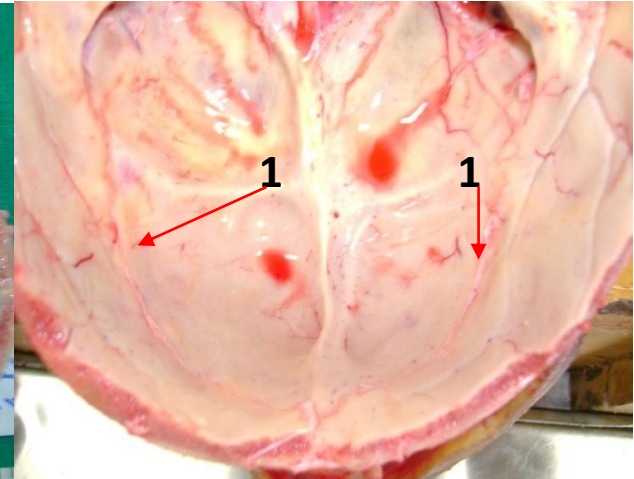
CASE-113



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

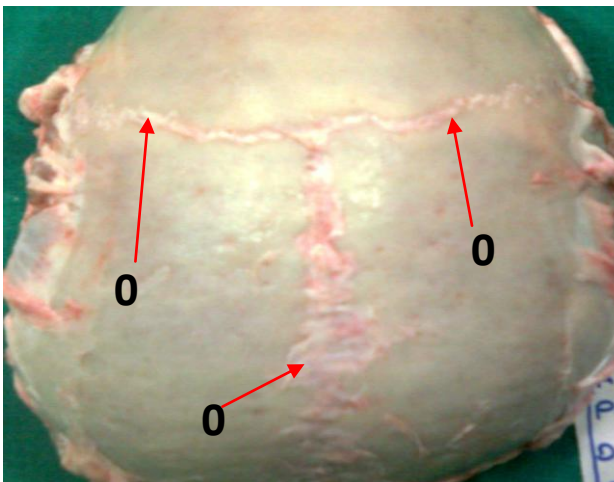


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

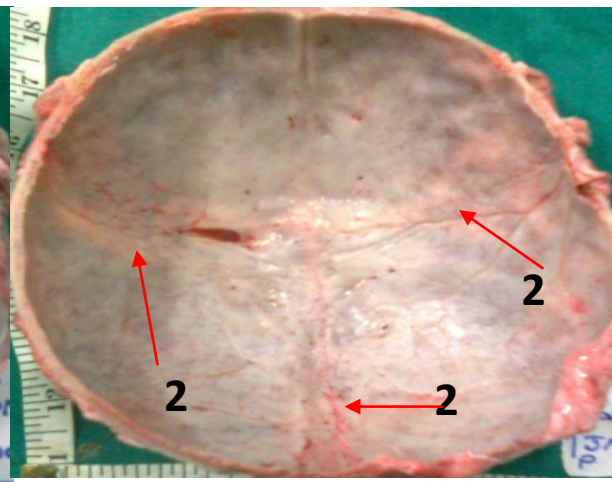


LAMDROID SUTURES (ENDOCRANIAL)

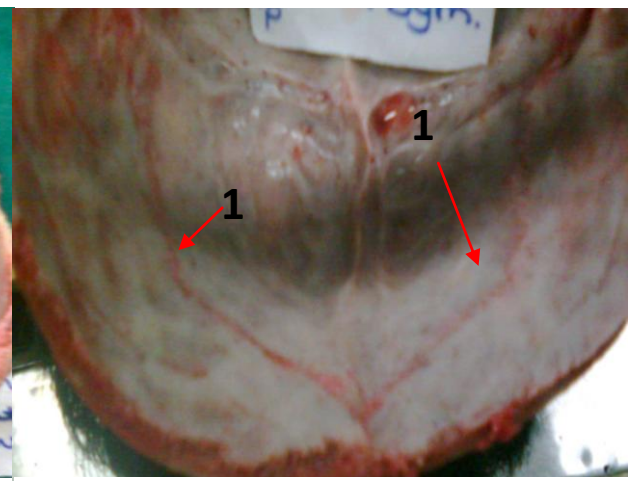
CASE-114



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



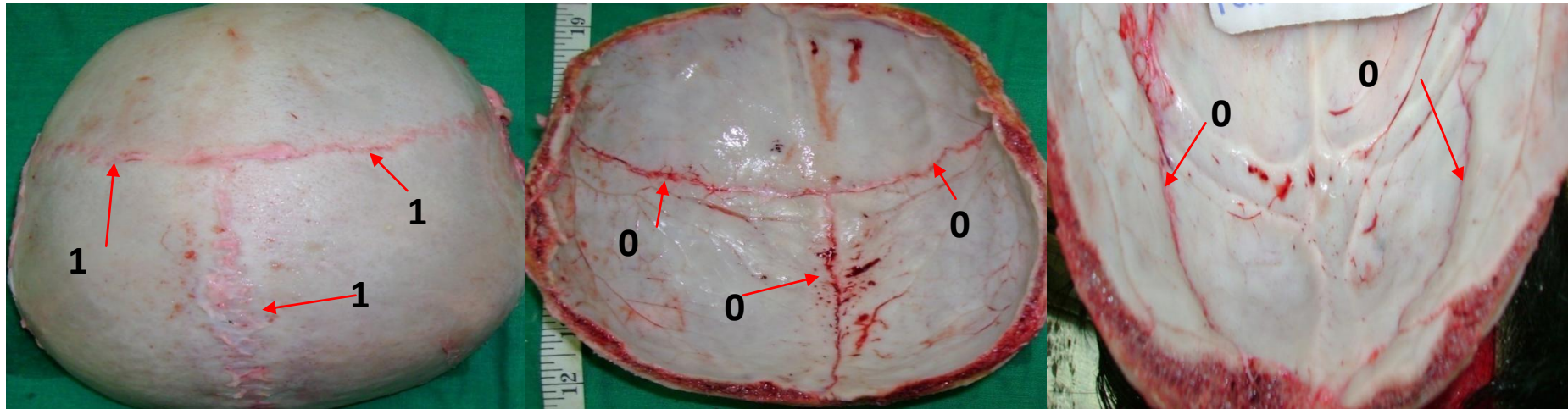
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDROID SUTURES (ENDOCRANIAL)

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

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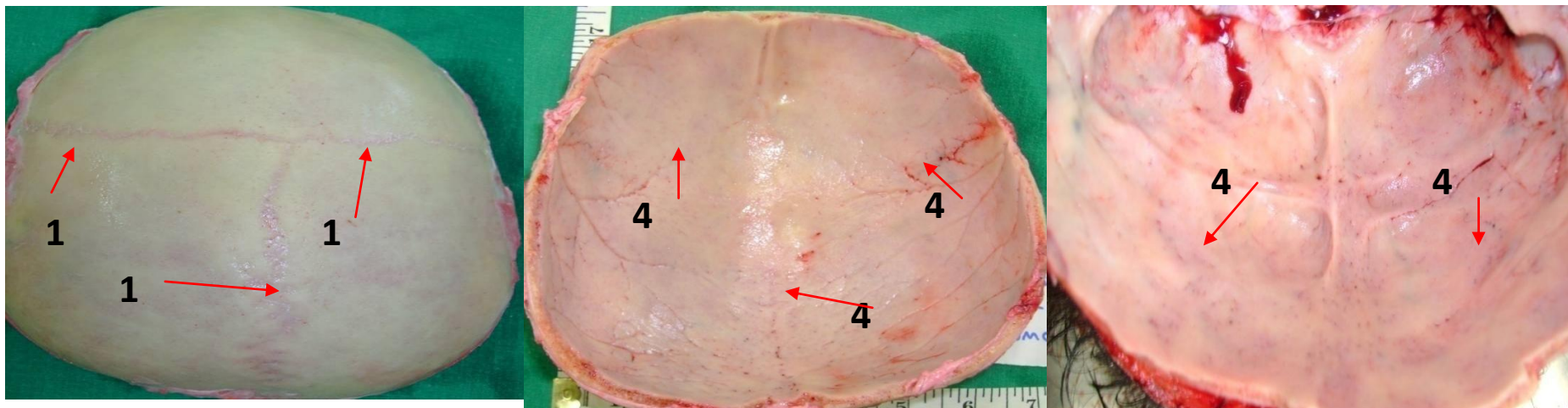


CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

LAMDOID SUTURES (ENDOCRANIAL)

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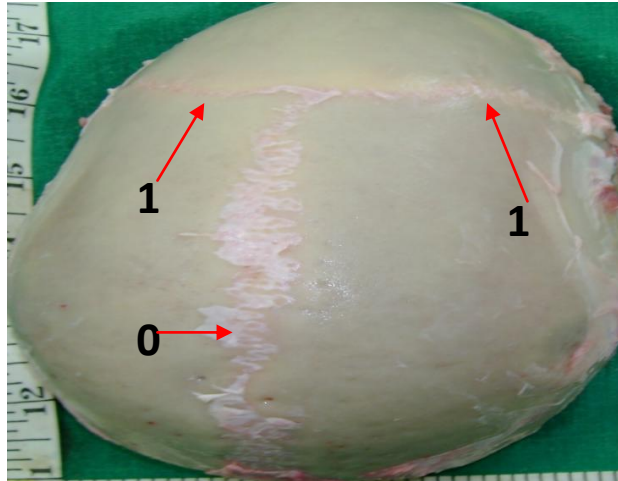
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

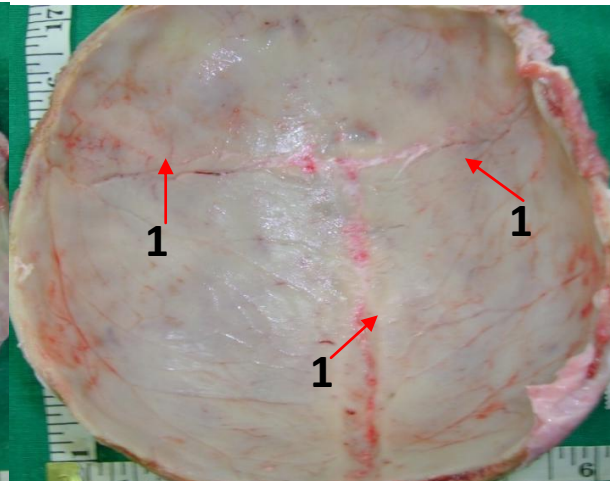
LAMDOID SUTURES (ENDOCRANIAL)

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

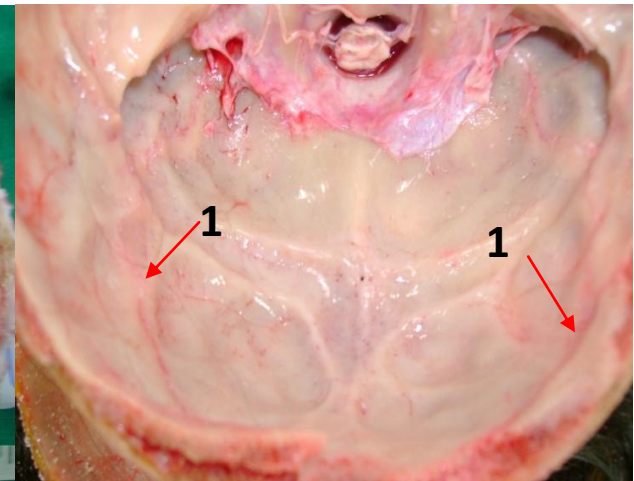
CASE-117



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

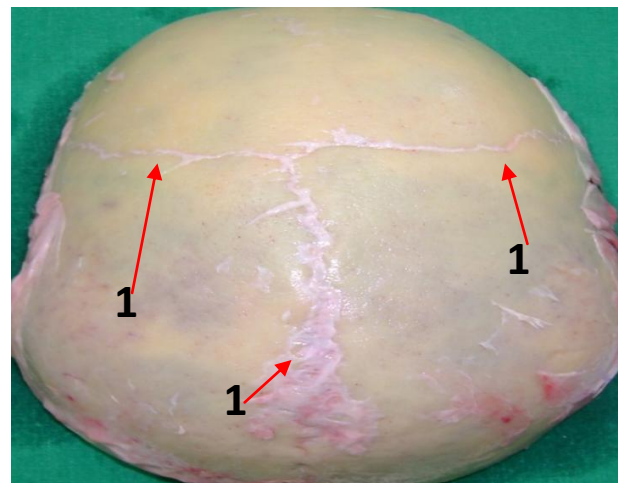


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

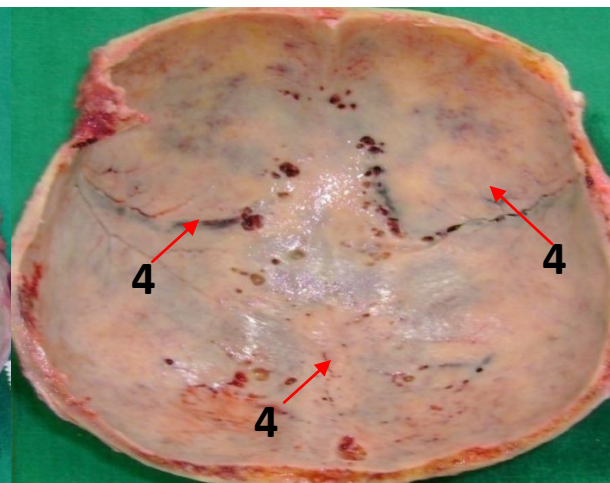


LAMDROID SUTURES (ENDOCRANIAL)

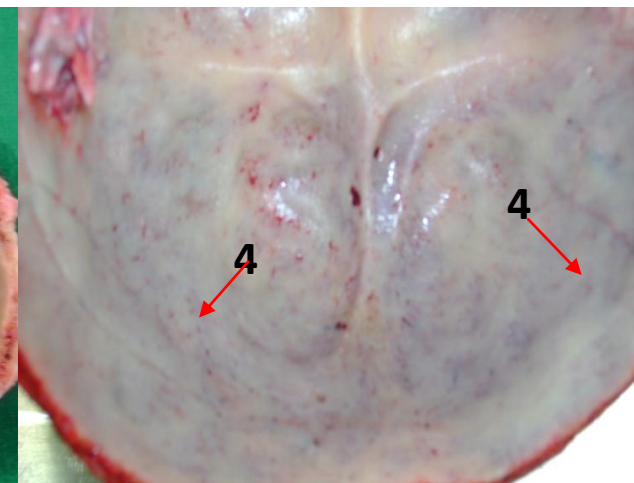
CASE-118



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



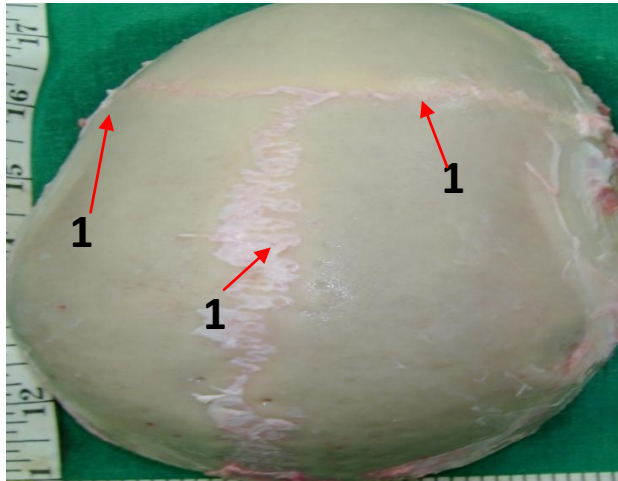
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



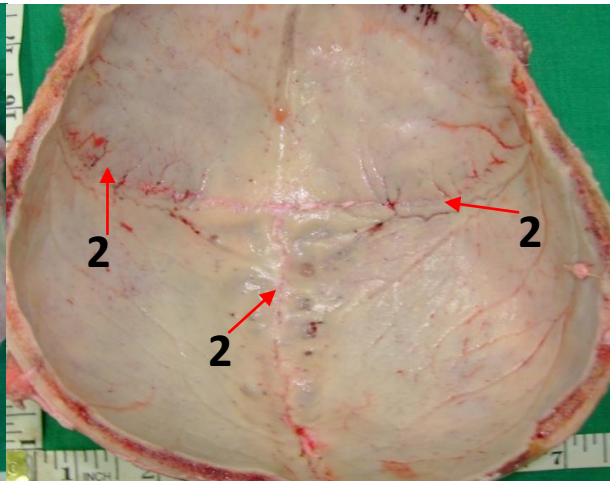
LAMDROID SUTURES (ENDOCRANIAL)

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

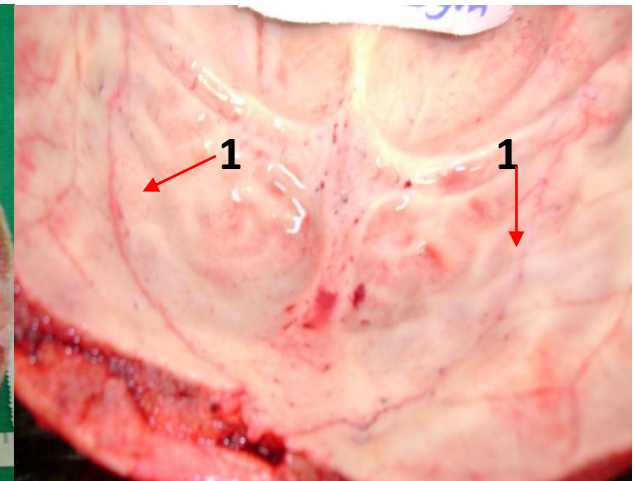
CASE-119



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

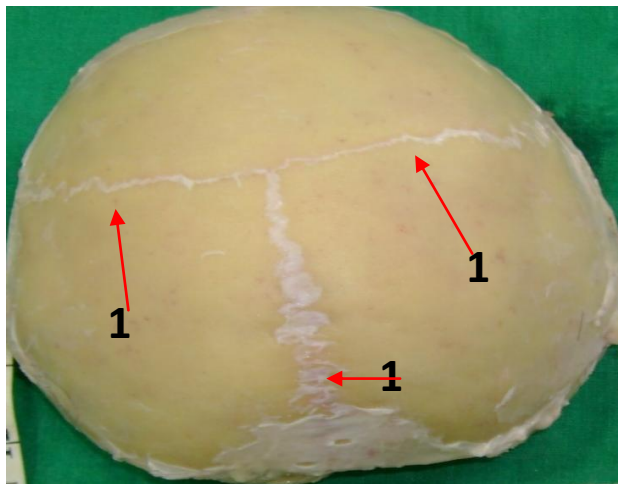


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

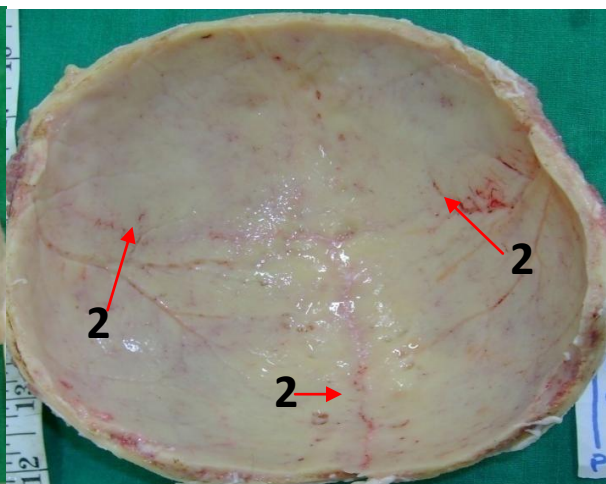


LAMDROID SUTURES (ENDOCRANIAL)

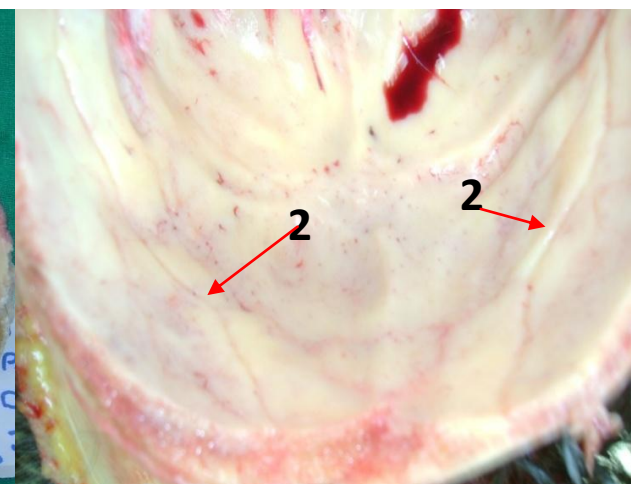
CASE-120



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



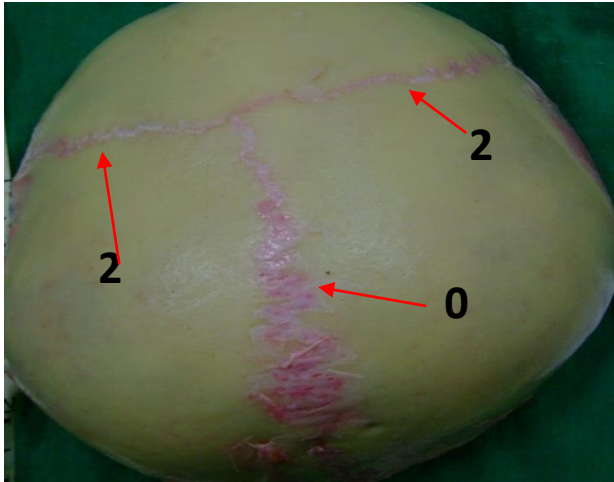
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



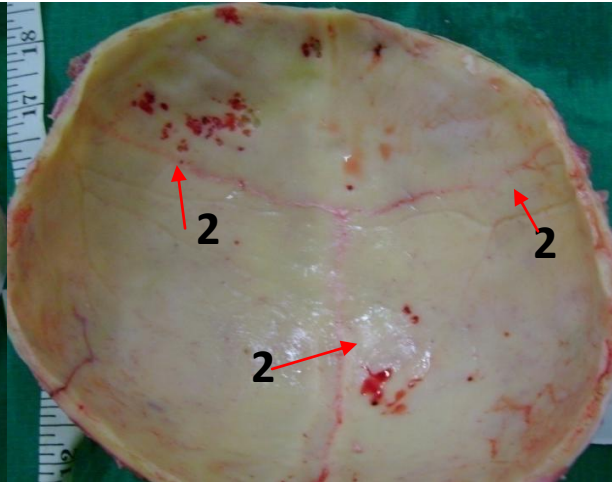
LAMDROID SUTURES (ENDOCRANIAL)

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

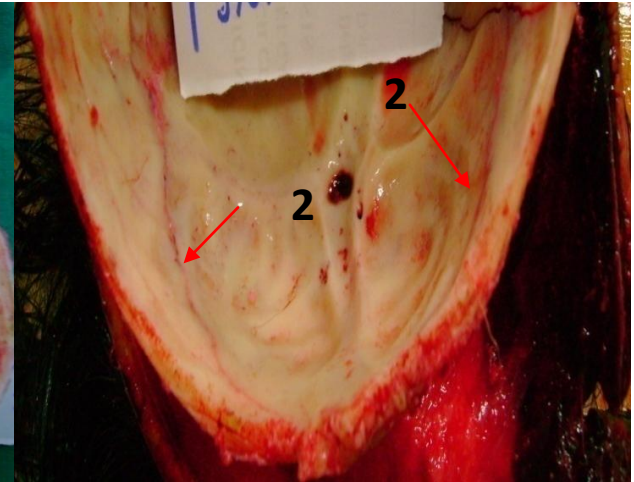
CASE-121



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

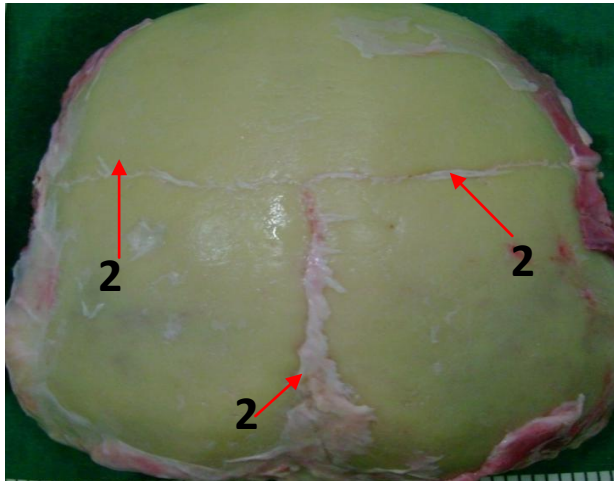


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

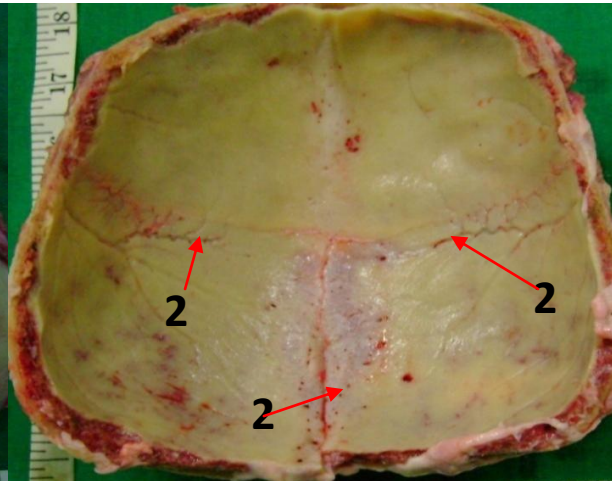


LAMDROID SUTURES (ENDOCRANIAL)

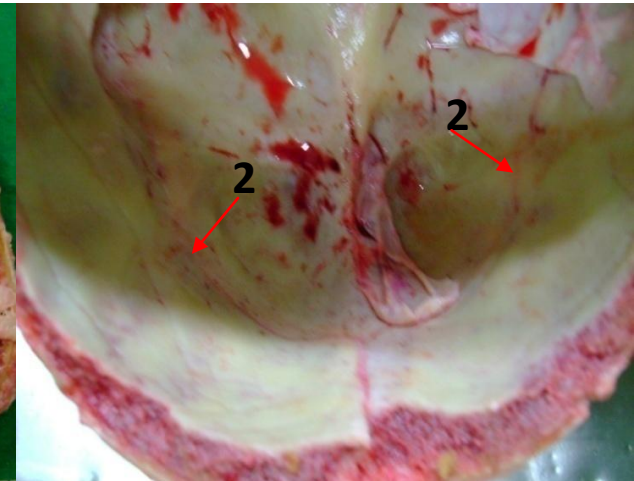
CASE-122



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



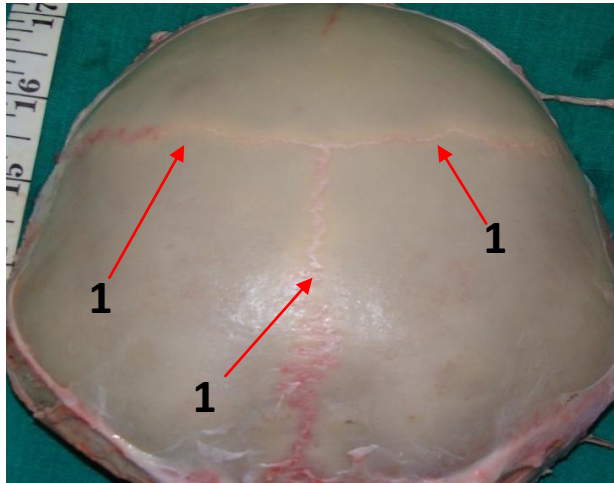
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



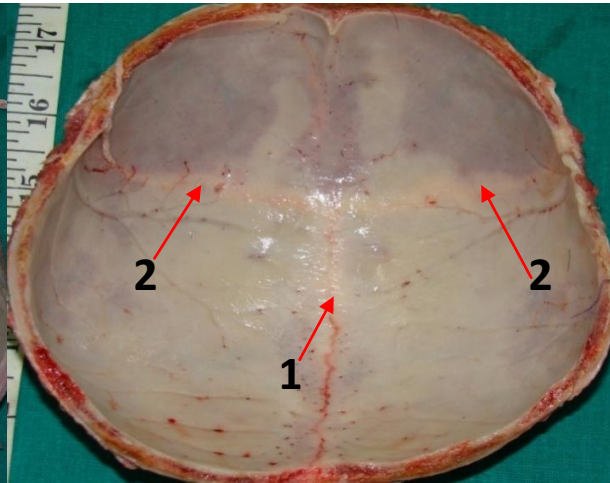
LAMDROID SUTURES (ENDOCRANIAL)

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

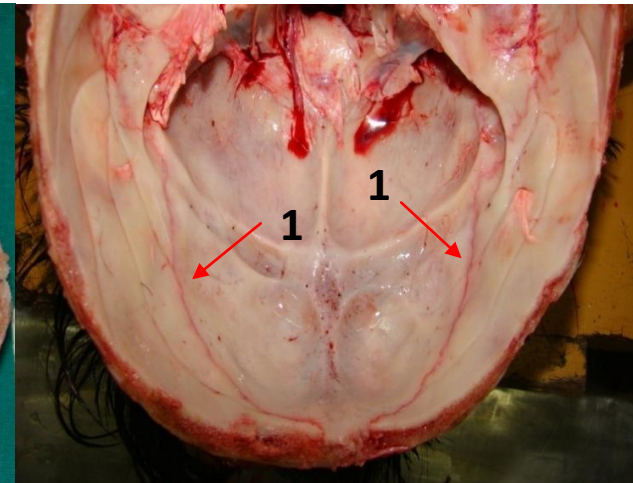
CASE-123



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

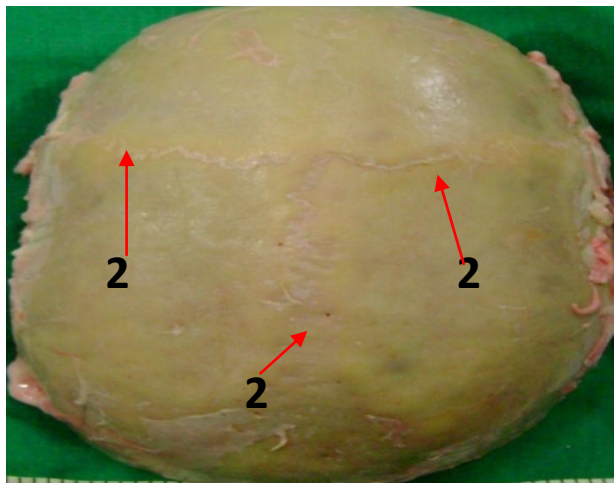


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

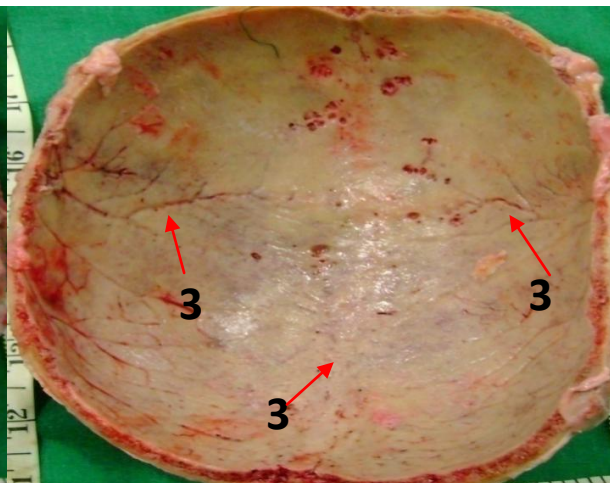


LAMDROID SUTURES (ENDOCRANIAL)

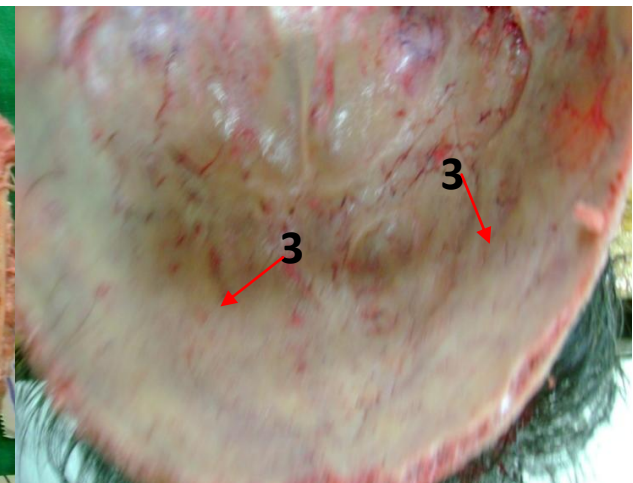
CASE-124



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



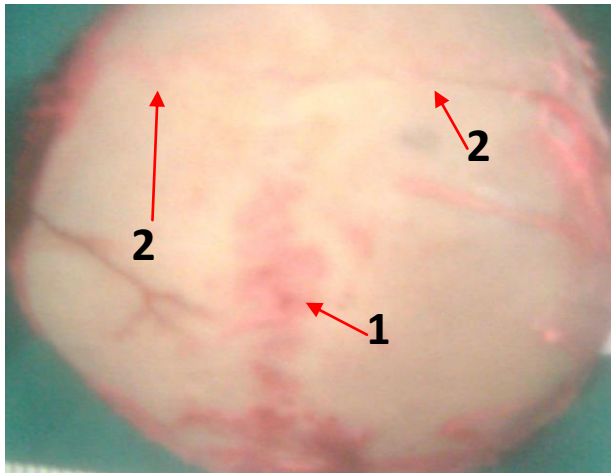
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



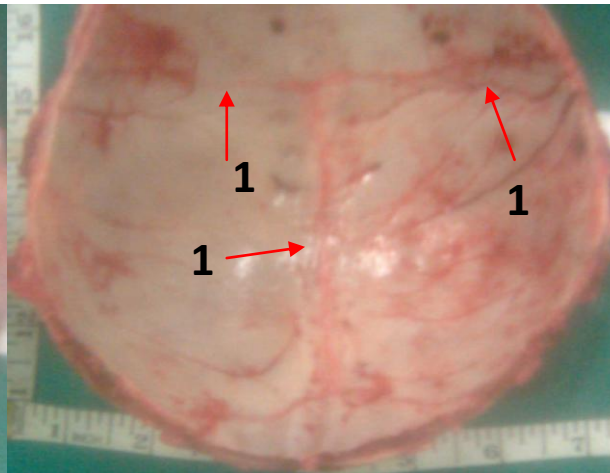
LAMDROID SUTURES (ENDOCRANIAL)

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

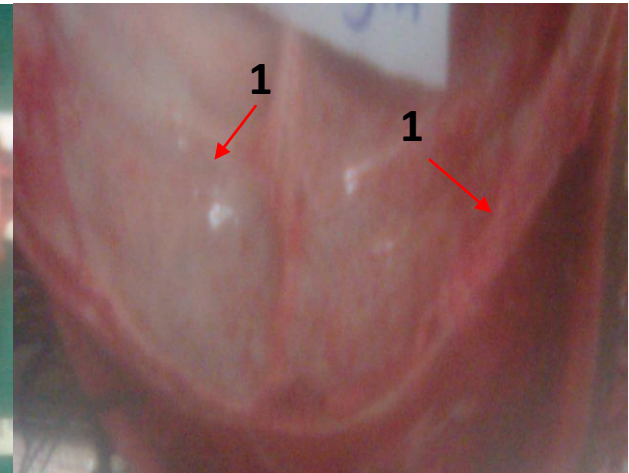
CASE-125



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

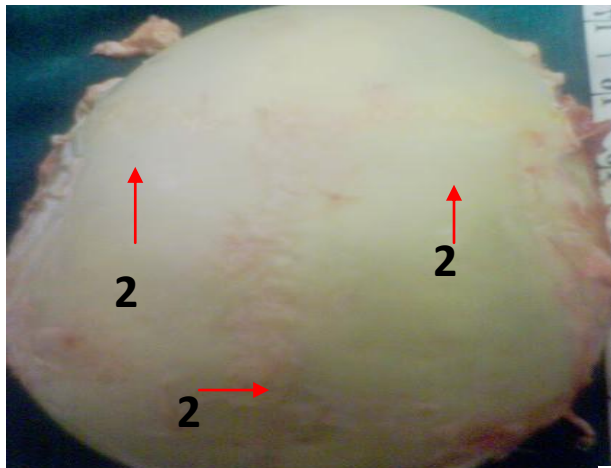


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

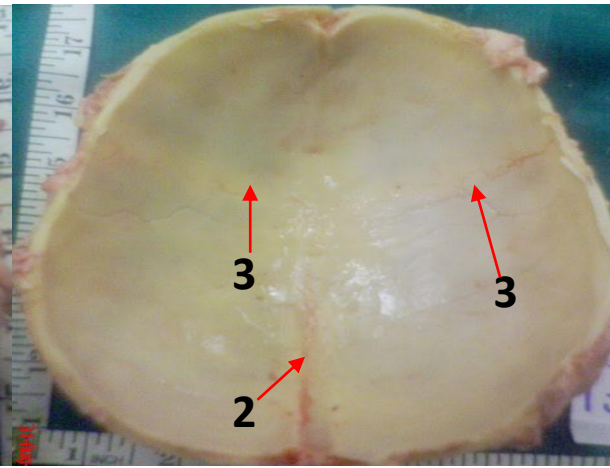


LAMDOID SUTURES (ENDOCRANIAL)

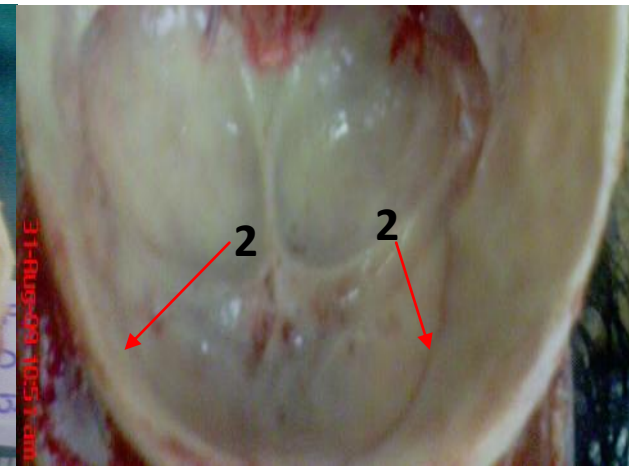
CASE-126



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



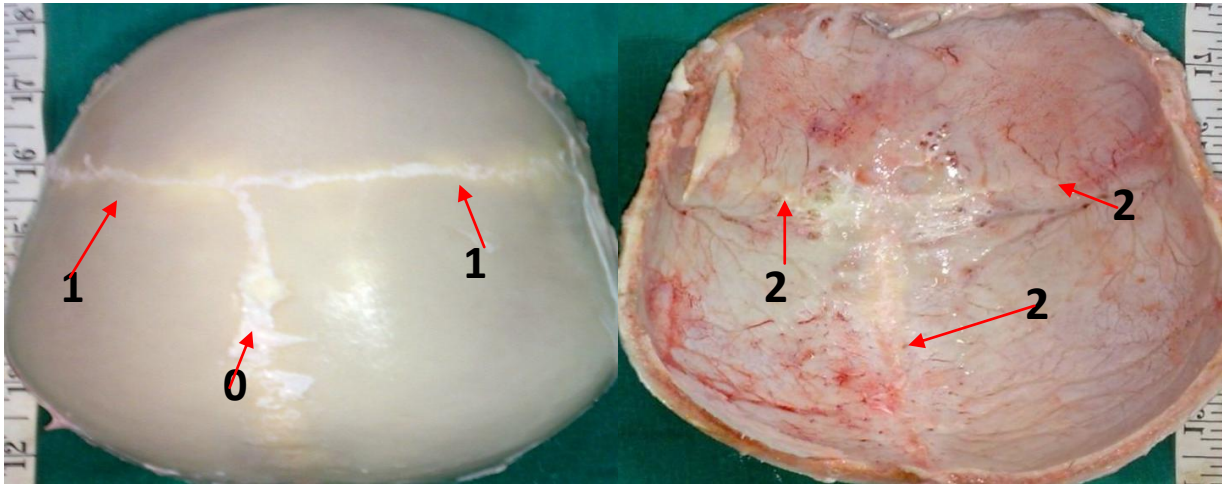
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



LAMDOID SUTURES (ENDOCRANIAL)

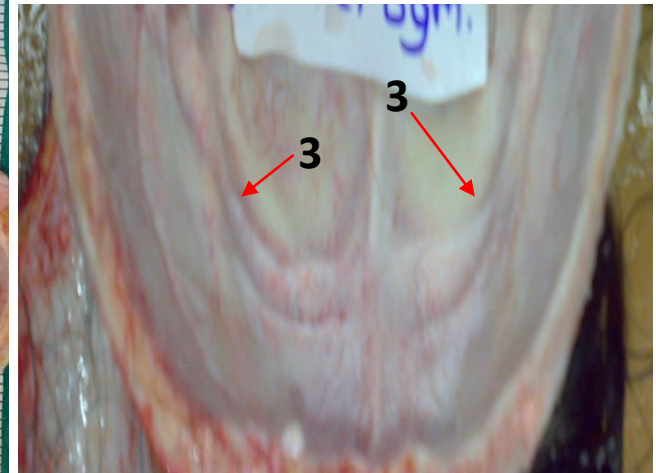
0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.

CASE-127



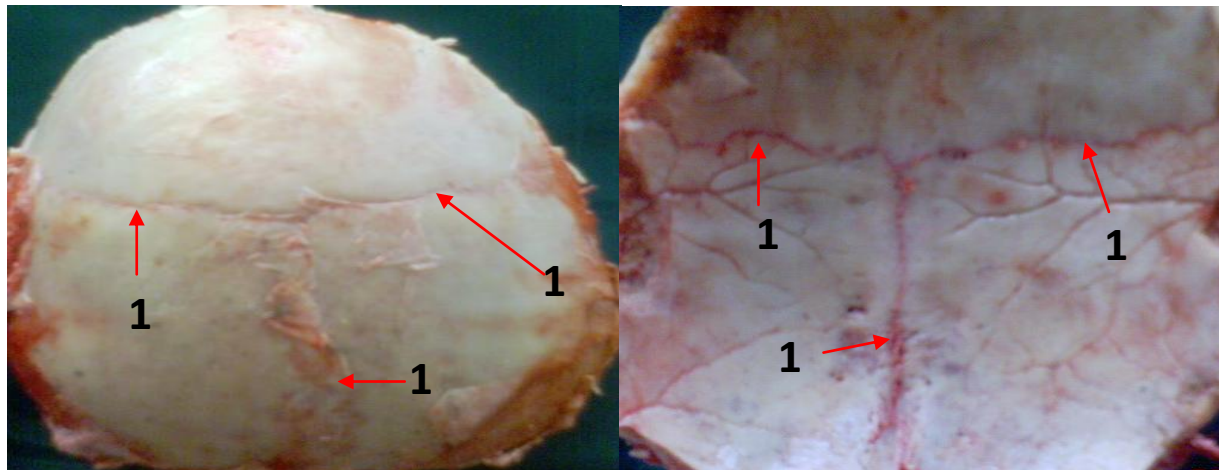
CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



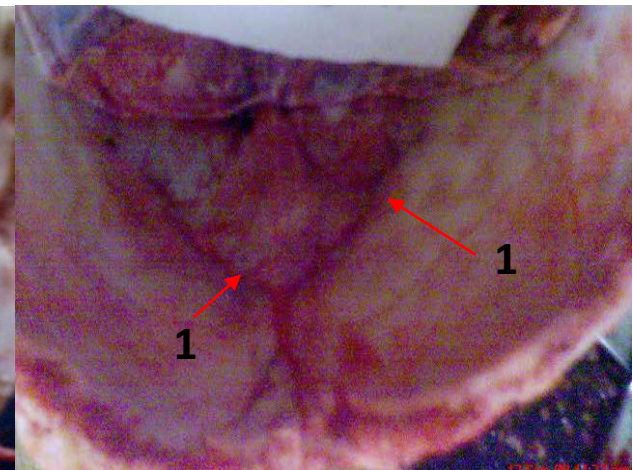
LAMDROID SUTURES (ENDOCRANIAL)

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CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

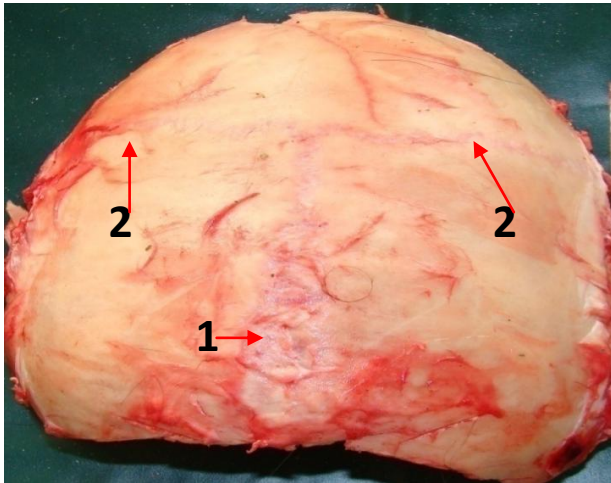
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



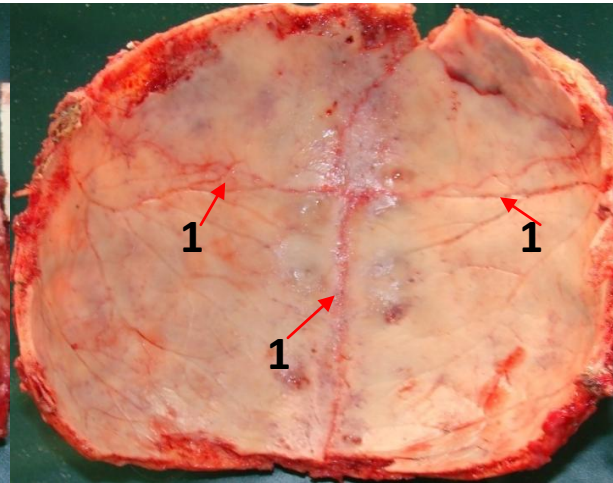
LAMDROID SUTURES (ENDOCRANIAL)

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

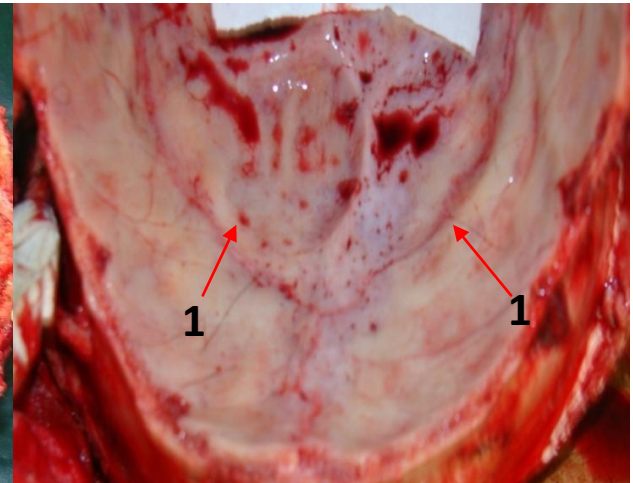
CASE-129



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

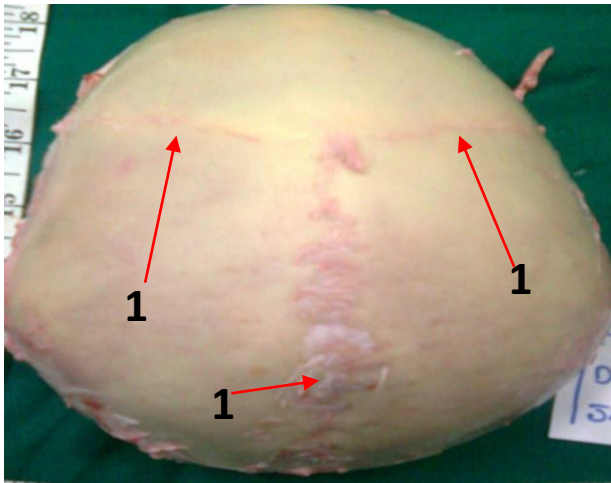


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

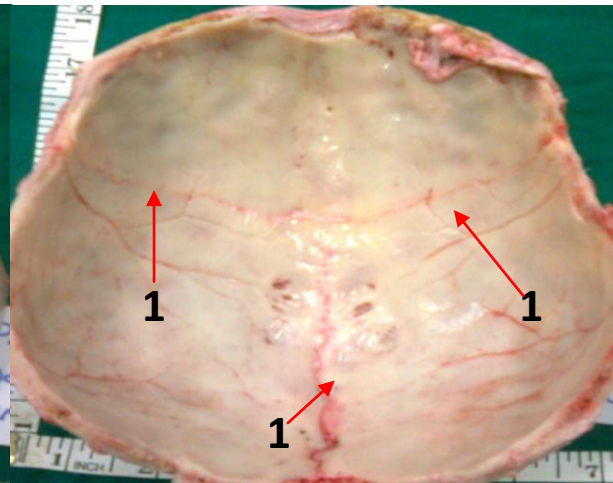


LAMDROID SUTURES (ENDOCRANIAL)

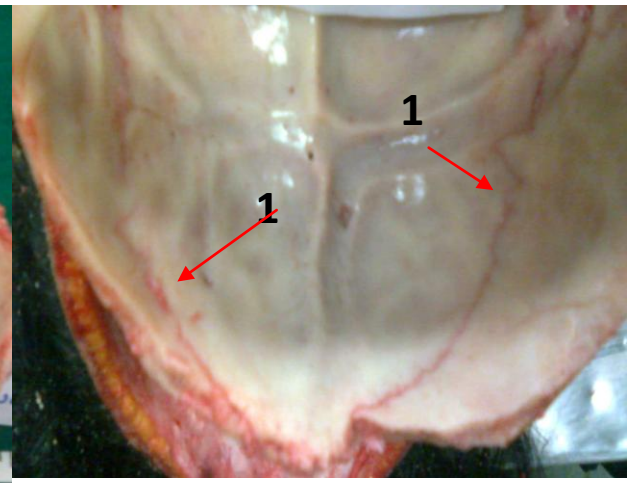
CASE-130



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



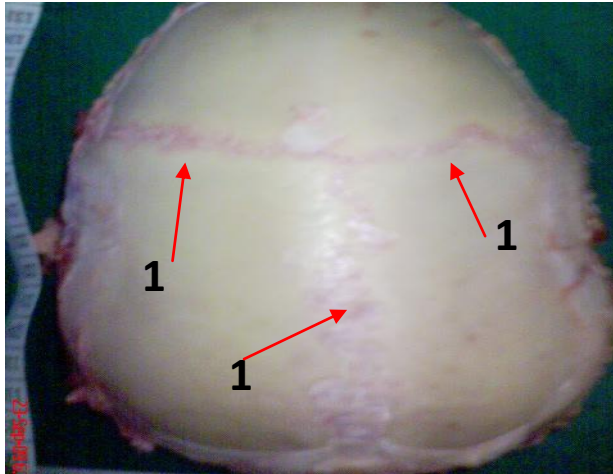
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



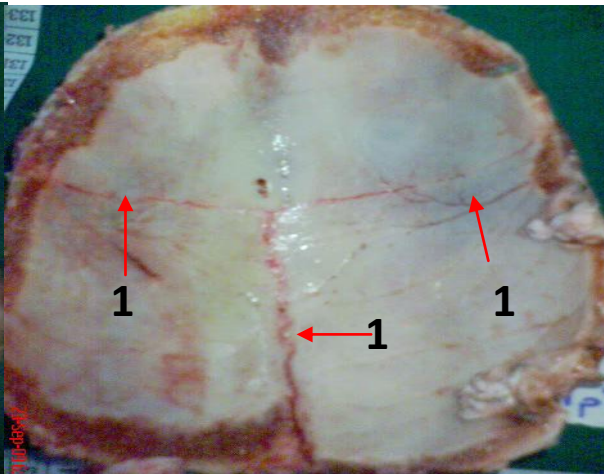
LAMDROID SUTURES (ENDOCRANIAL)

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

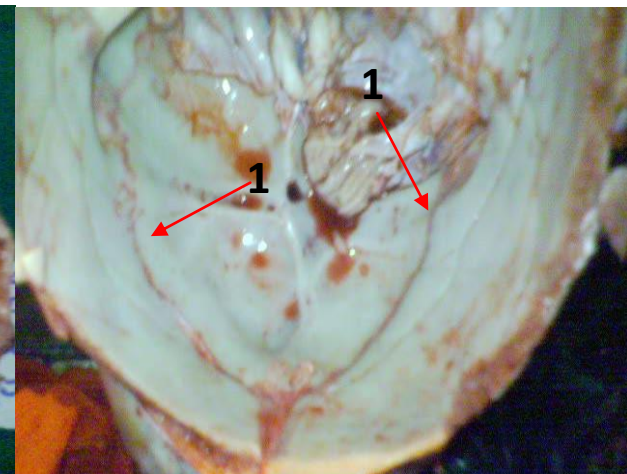
CASE-131



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

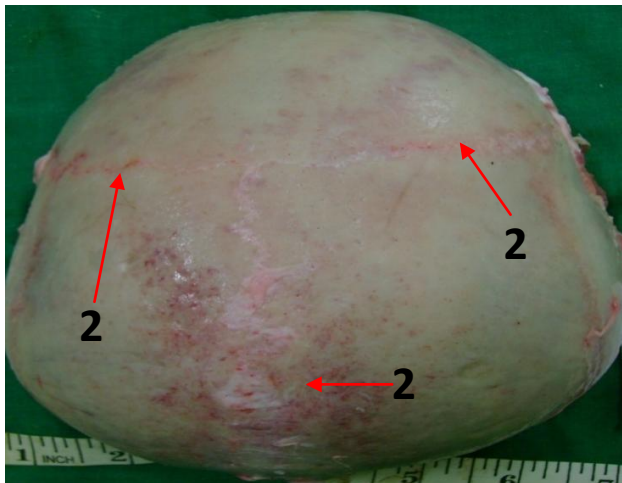


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

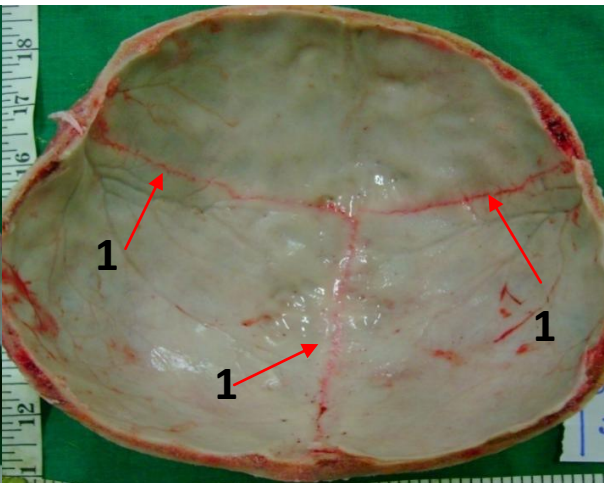


LAMDOID SUTURES (ENDOCRANIAL)

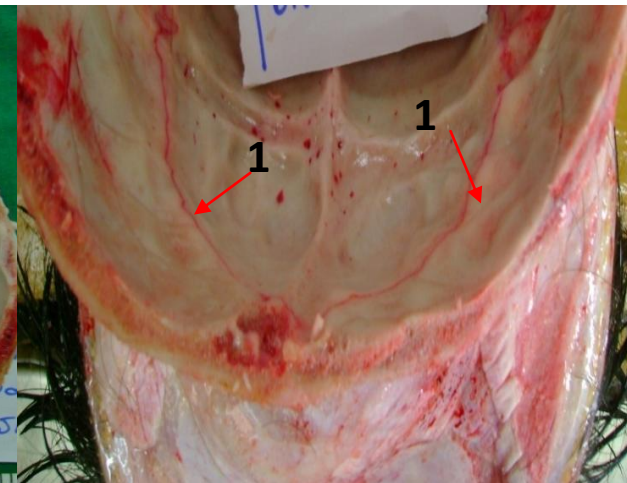
CASE-132



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



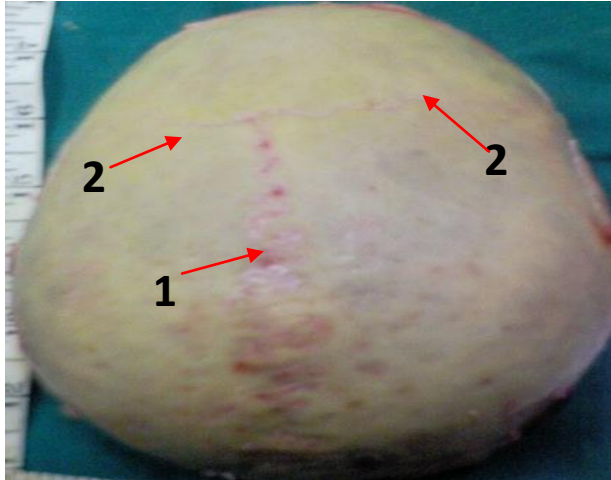
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



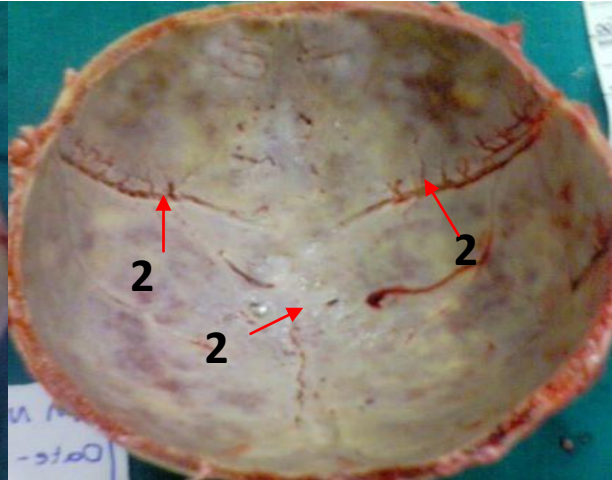
LAMDOID SUTURES (ENDOCRANIAL)

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

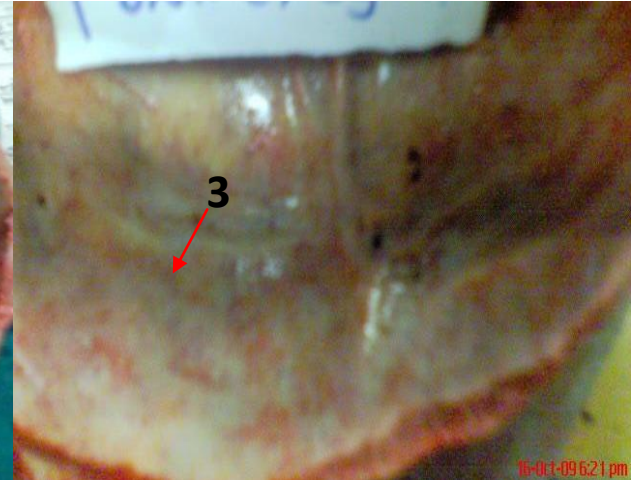
CASE-133



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

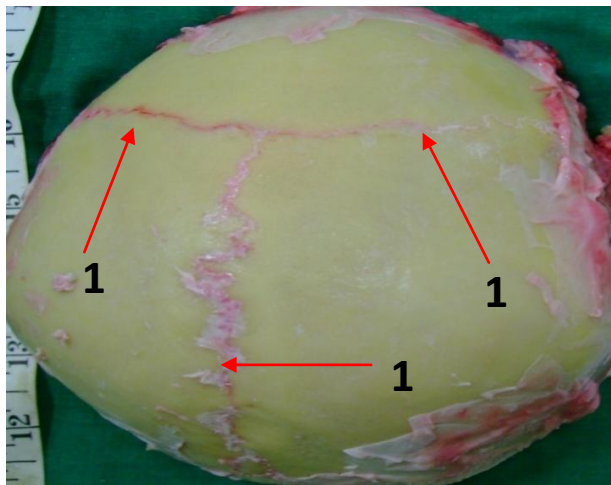


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

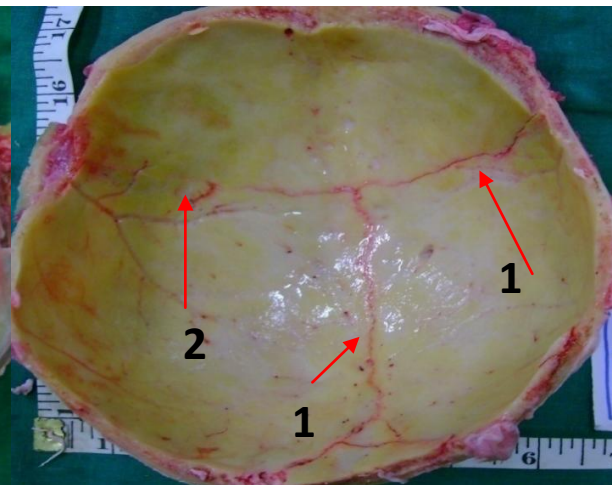


LAMDOID SUTURES (ENDOCRANIAL)

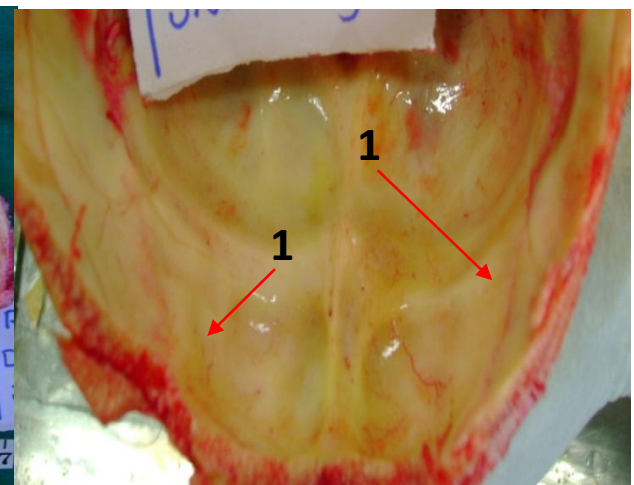
CASE-134



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



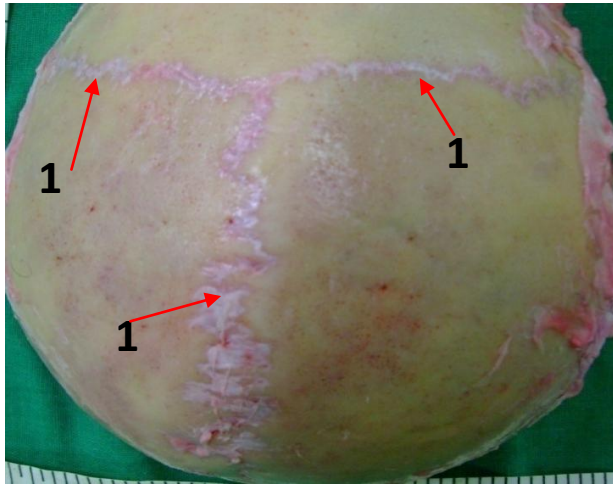
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



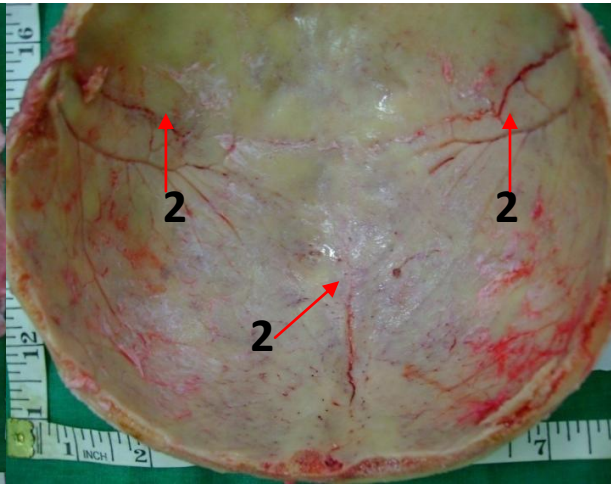
LAMDOID SUTURES (ENDOCRANIAL)

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

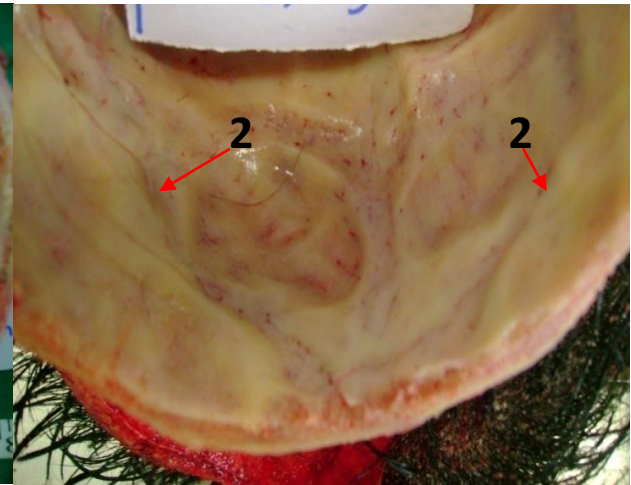
CASE-135



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

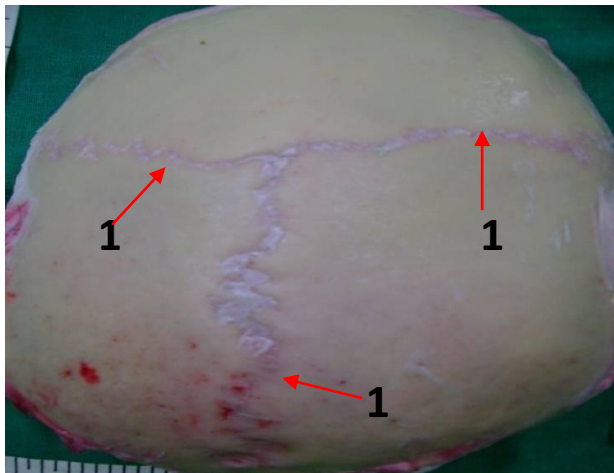


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

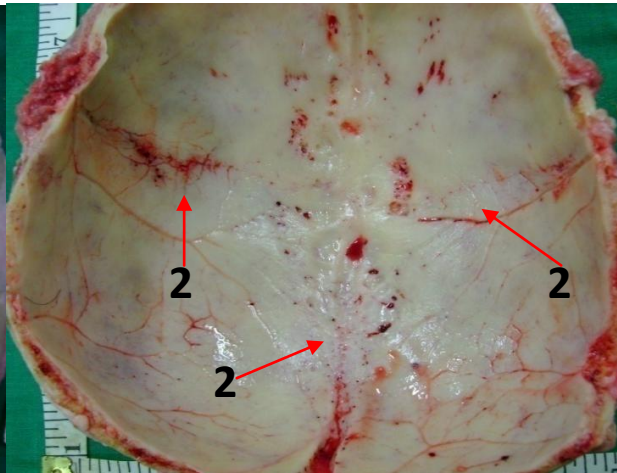


LAMDOID SUTURES (ENDOCRANIAL)

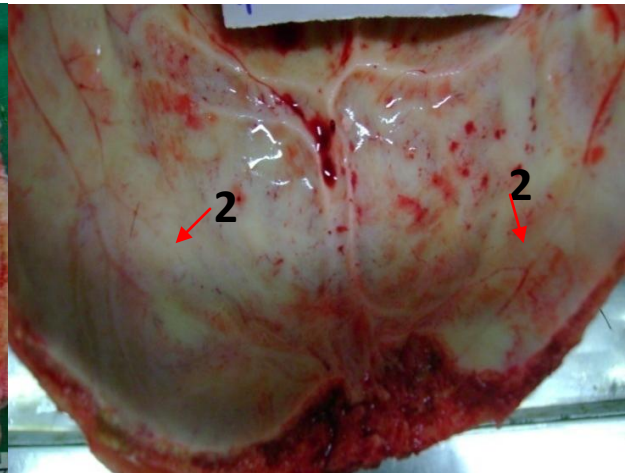
CASE-136



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



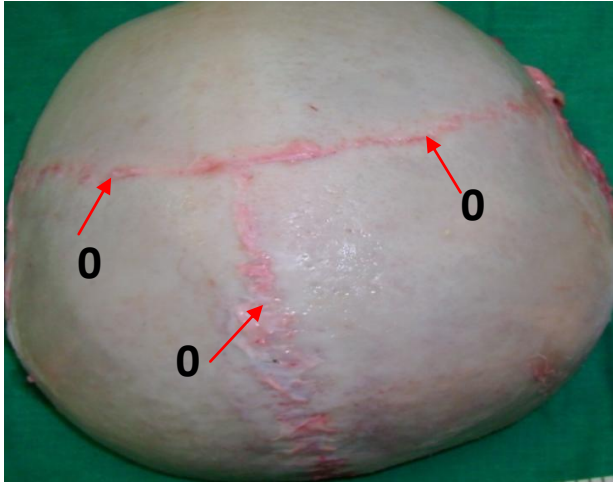
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



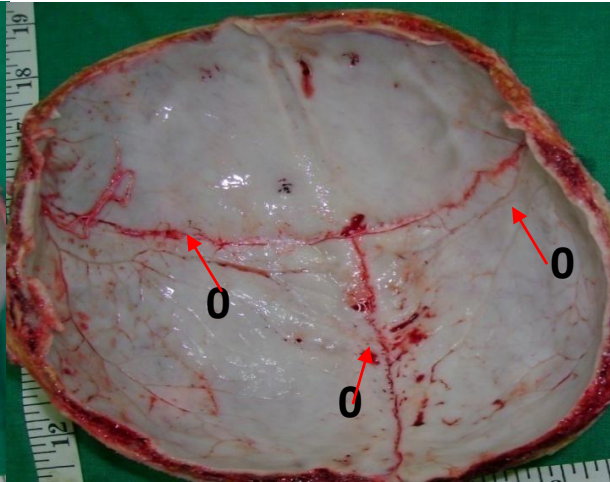
LAMDOID SUTURES (ENDOCRANIAL)

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

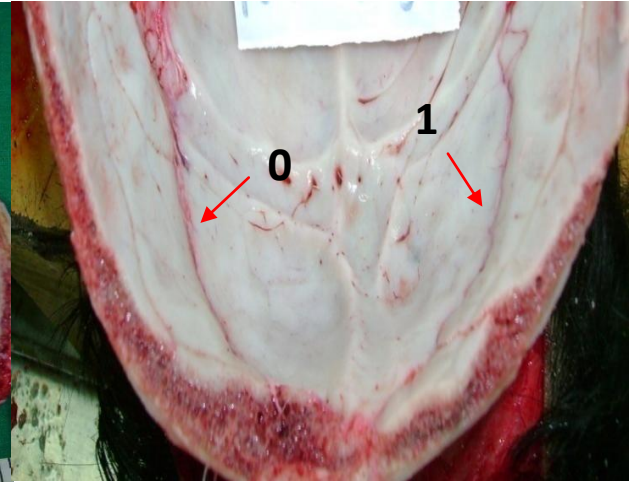
CASE-137



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

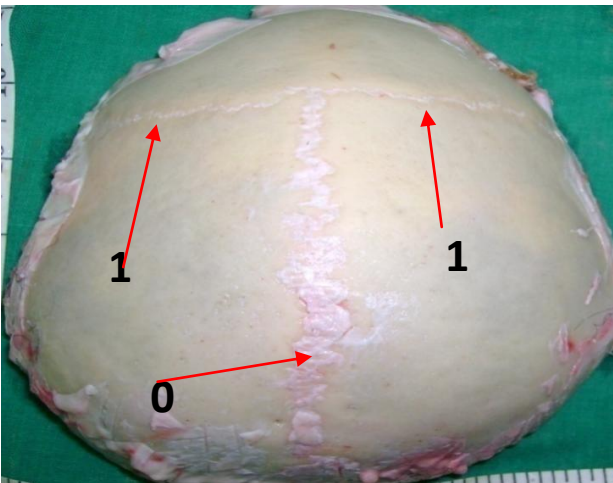


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

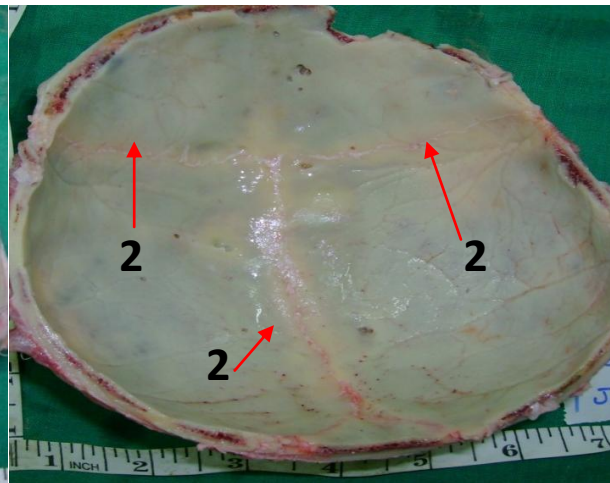


LAMDOID SUTURES (ENDOCRANIAL)

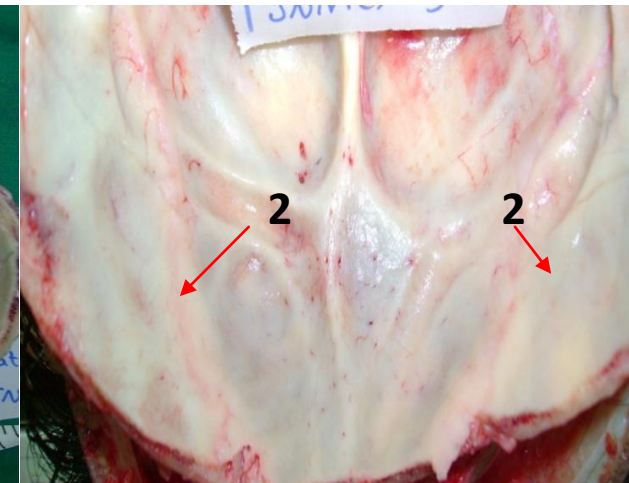
CASE-138



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



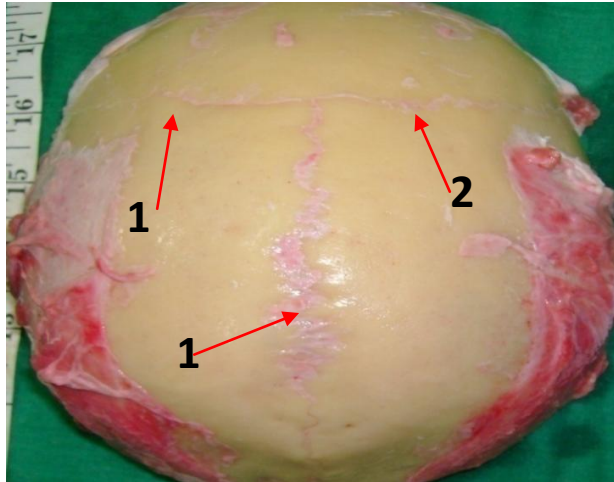
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



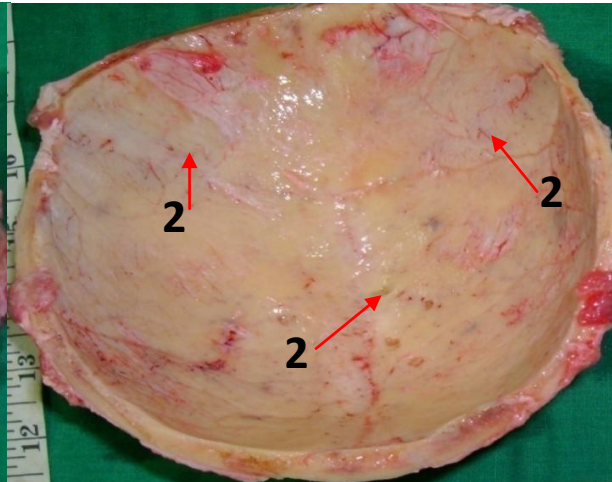
LAMDOID SUTURES (ENDOCRANIAL)

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

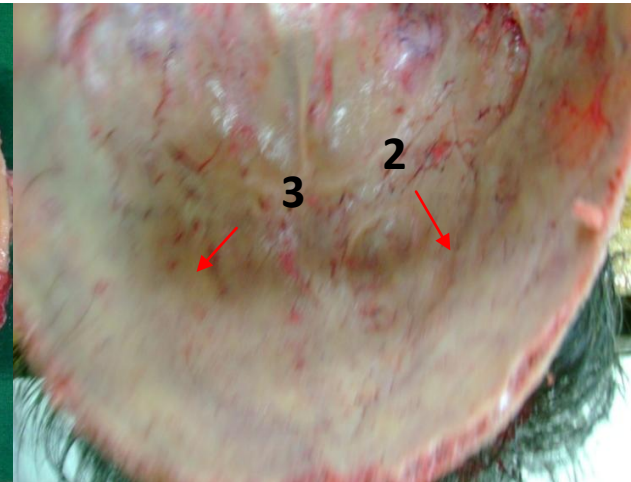
CASE-139



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

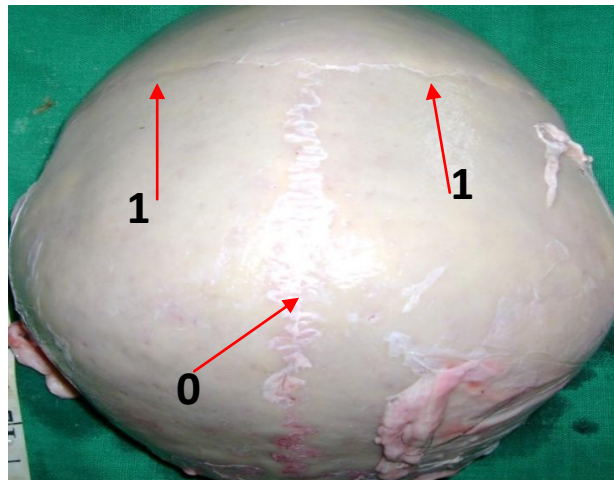


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

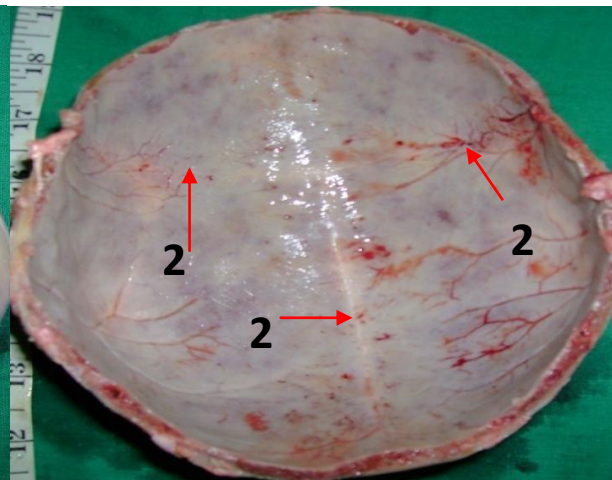


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

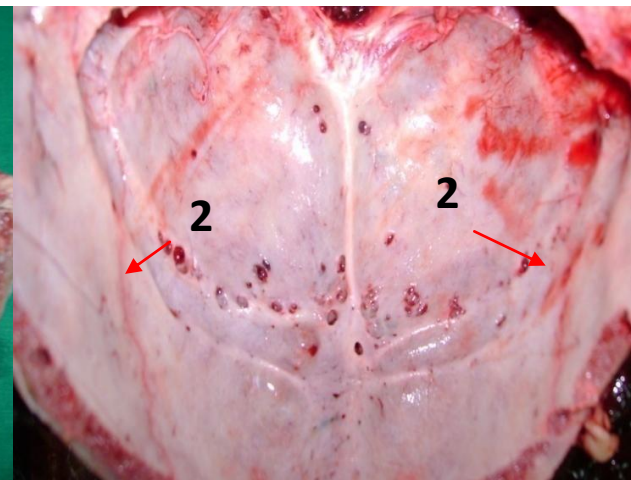
CASE-140



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

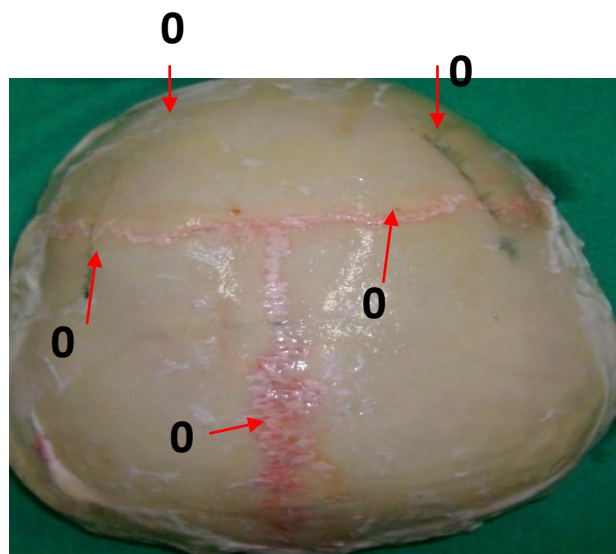


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

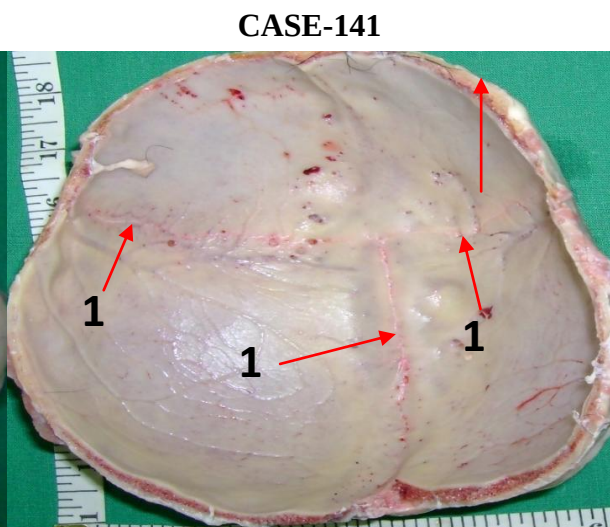


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

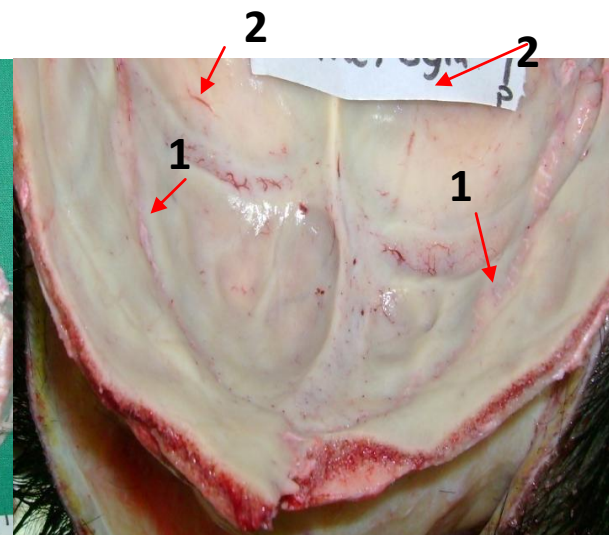
0- open, 1- less than one half closed, 2- half closed, 3- more than one half closed, 4- totally closed.



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

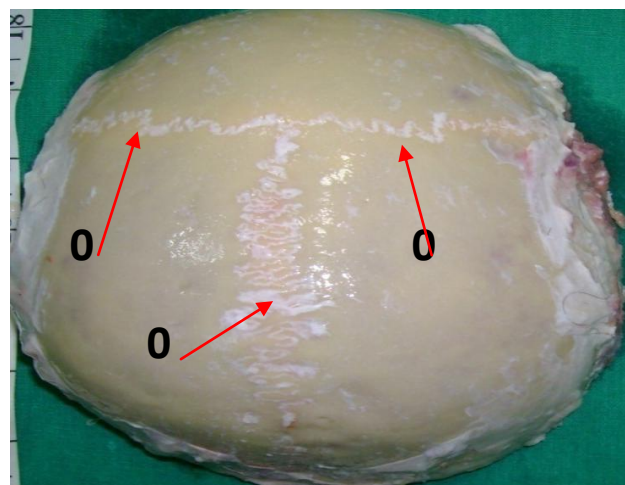


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

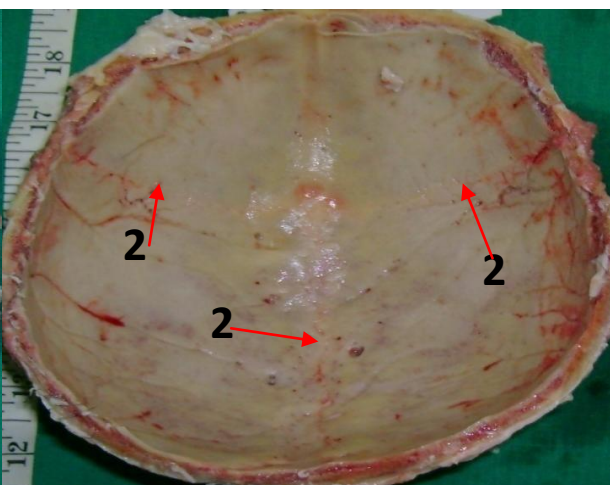


LAMDROID SUTURES (ENDOCRANIAL)

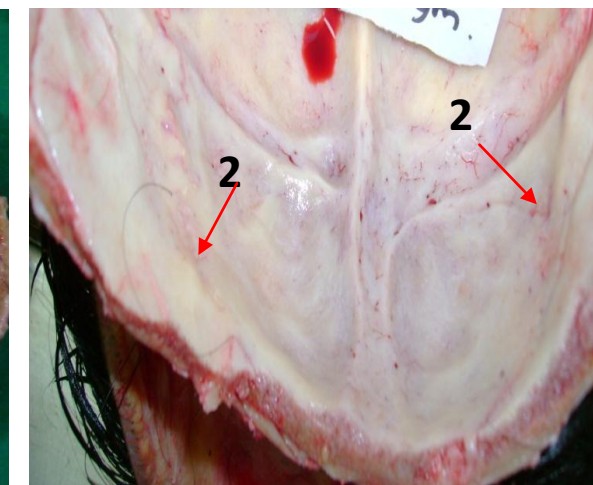
CASE-141



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

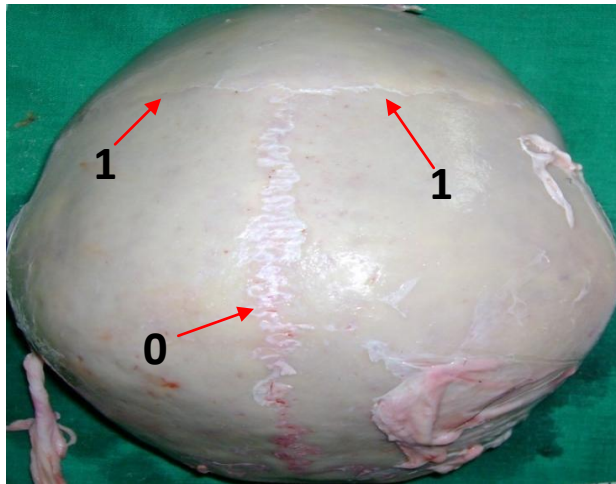


LAMDROID SUTURES (ENDOCRANIAL)

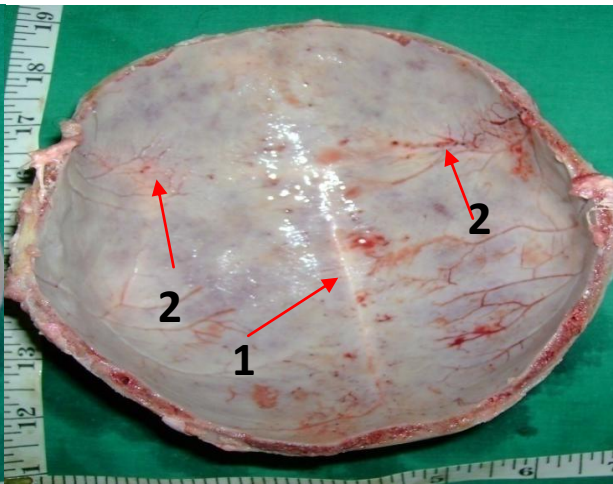
CASE-142

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

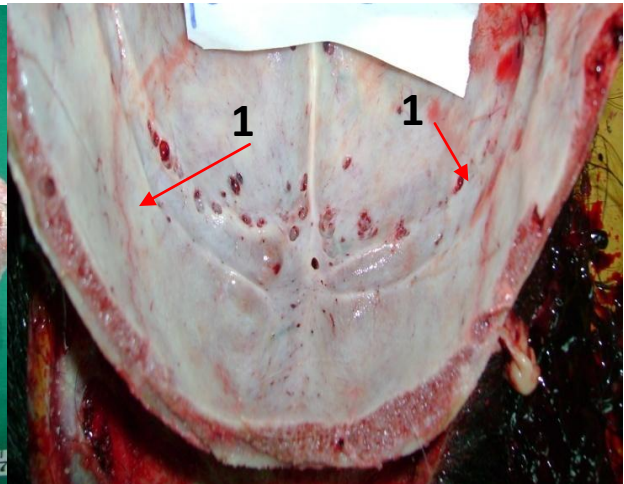
CASE-143



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

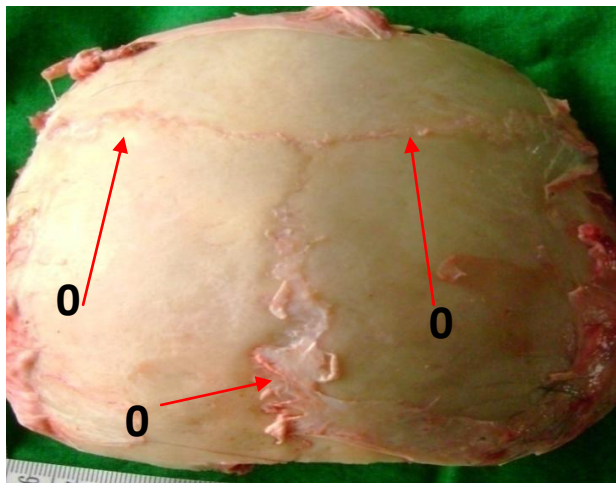


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

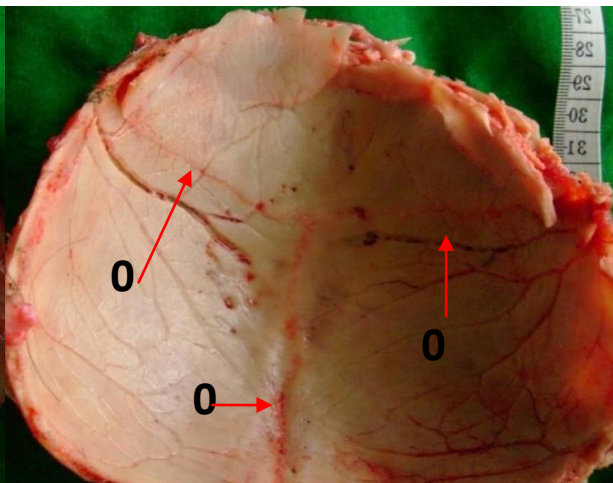


LAMDOID SUTURES (ENDOCRANIAL)

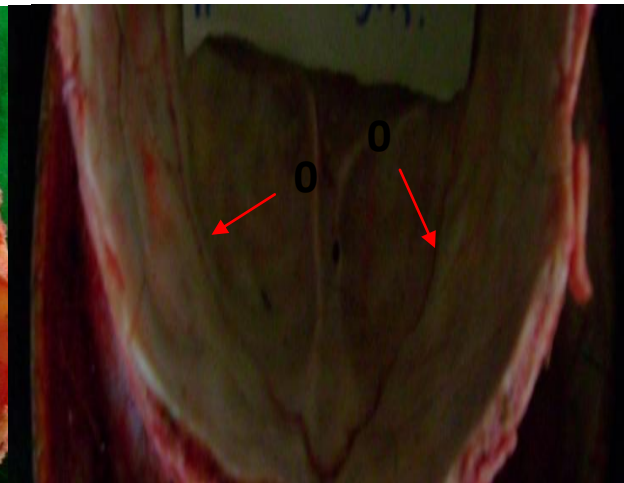
CASE-144



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



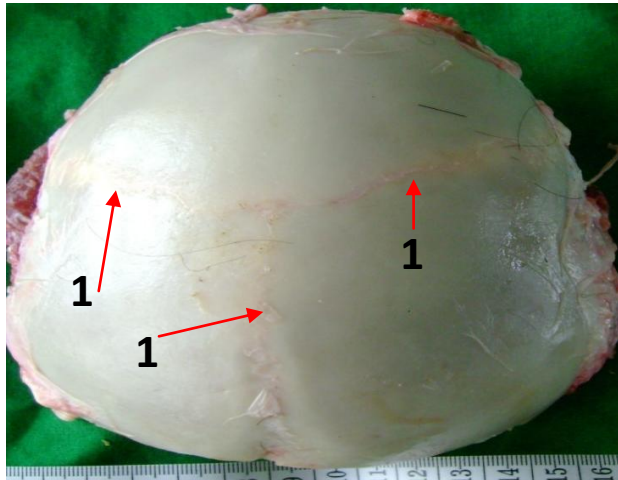
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



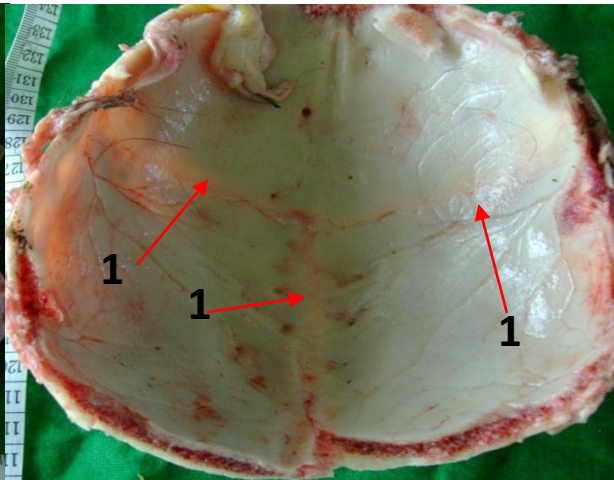
LAMDOID SUTURES (ENDOCRANIAL)

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

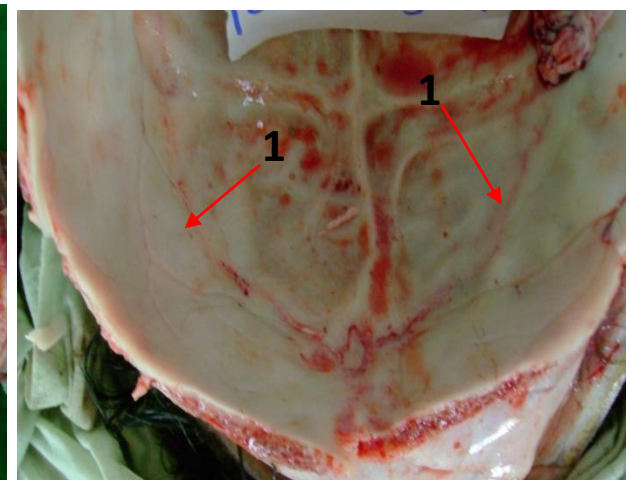
CASE-145



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

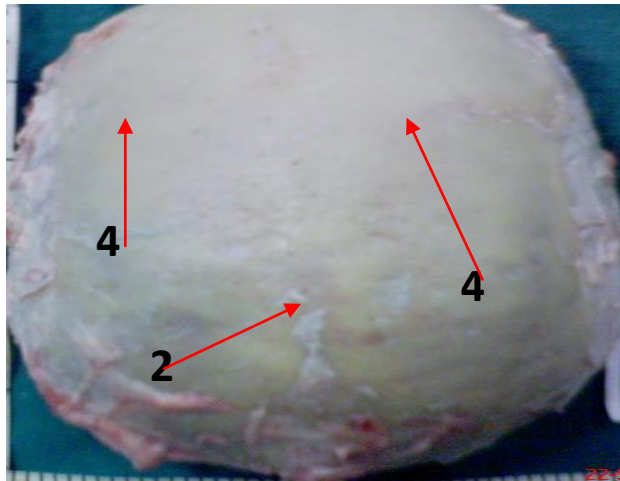


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

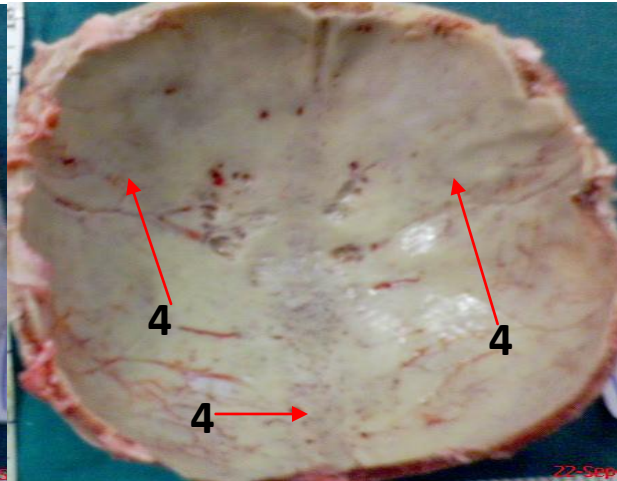


LAMDROID SUTURES (ENDOCRANIAL)

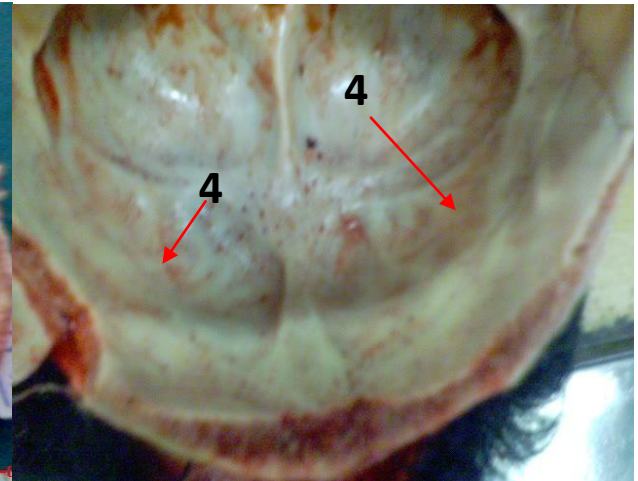
CASE-146



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



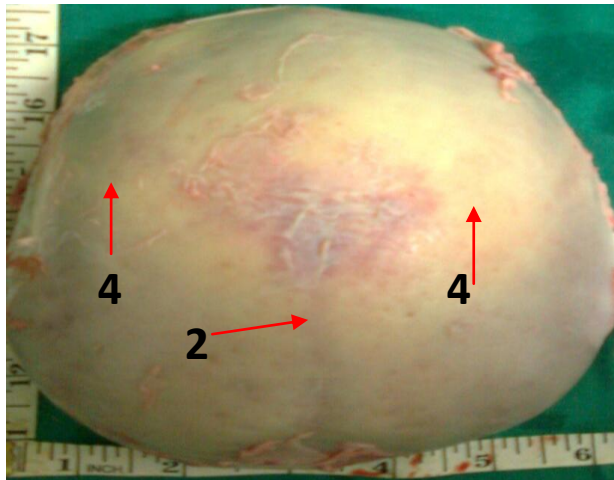
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



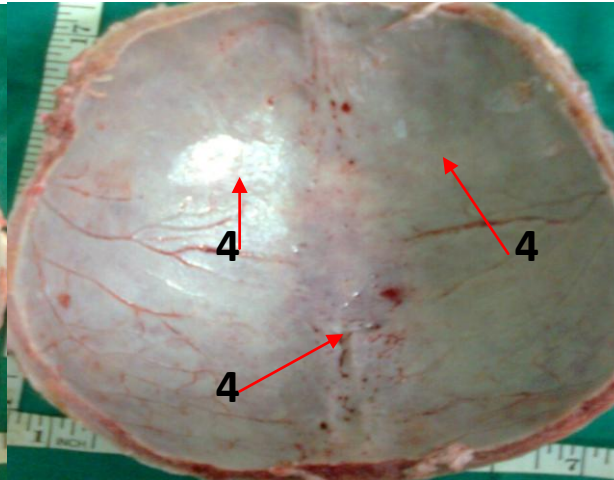
LAMDROID SUTURES (ENDOCRANIAL)

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

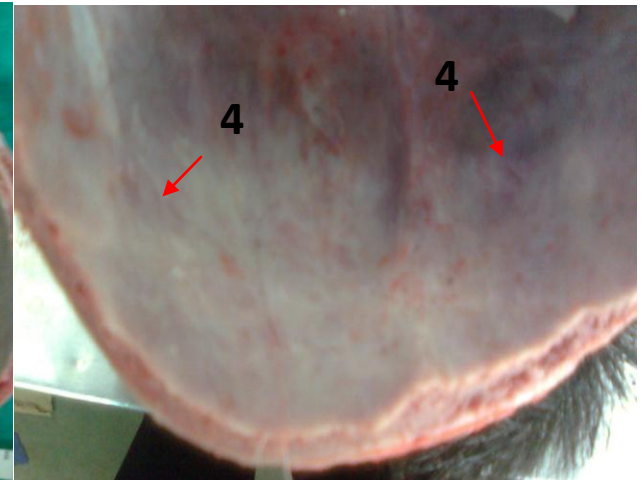
CASE-147



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

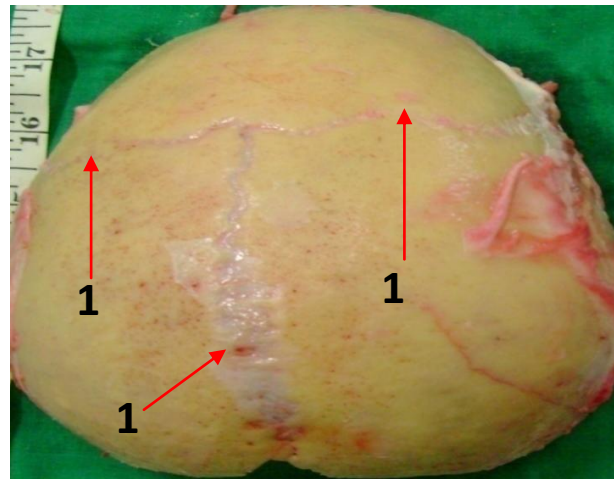


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

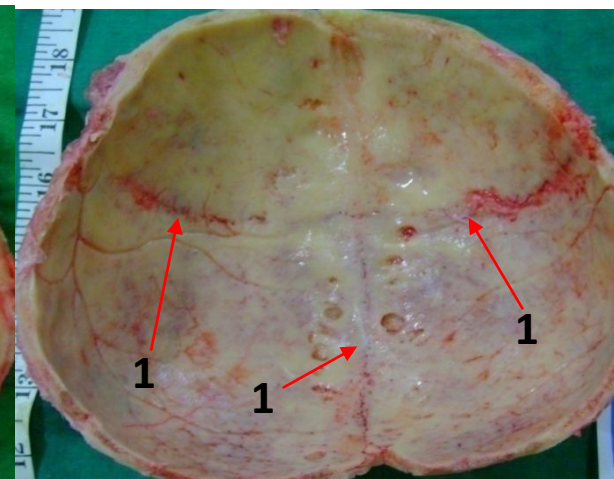


LAMDROID SUTURES (ENDOCRANIAL)

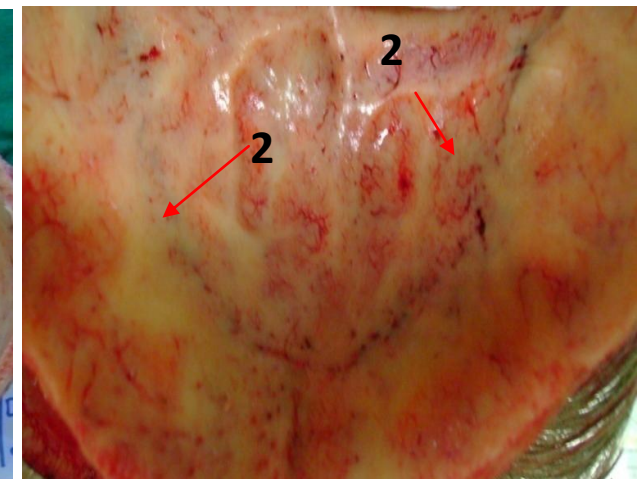
CASE-148



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)



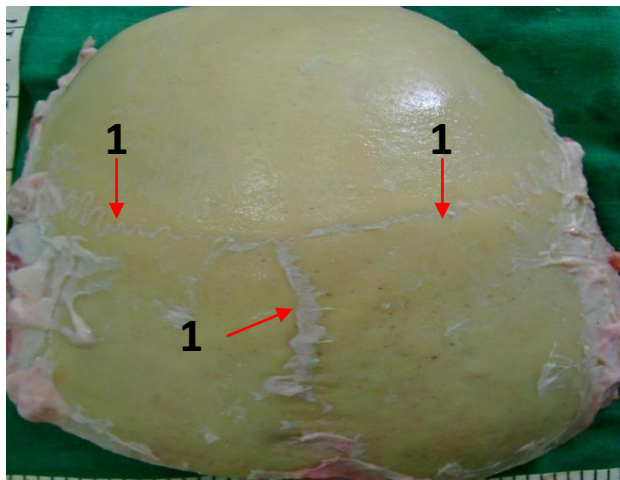
CORONAL & SAGITAL SUTURES (ENDOCRANIAL)



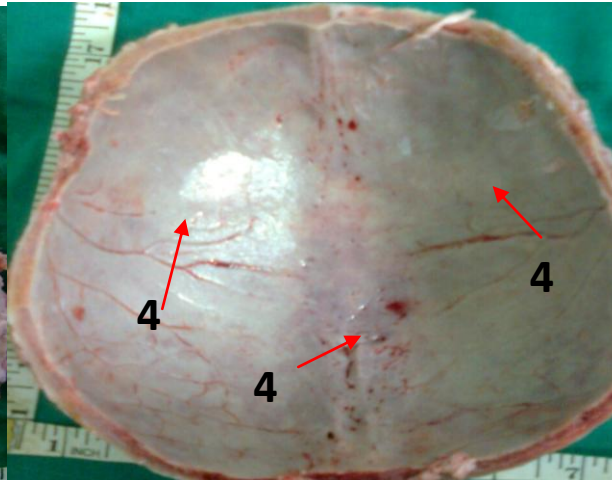
LAMDROID SUTURES (ENDOCRANIAL)

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

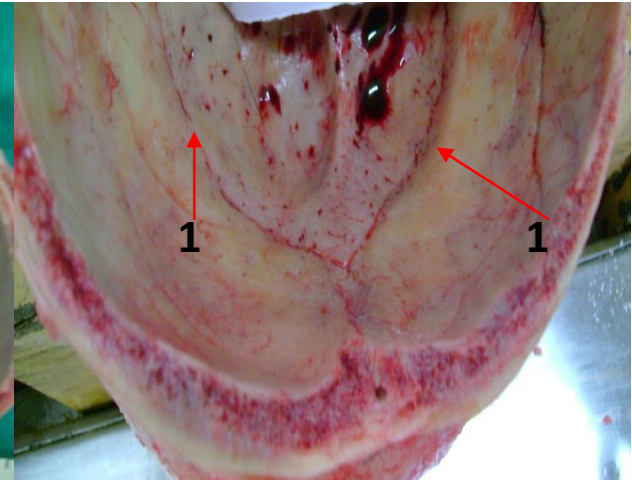
CASE-149



CORONAL & SAGITAL SUTURES (ECTOCRANIAL)

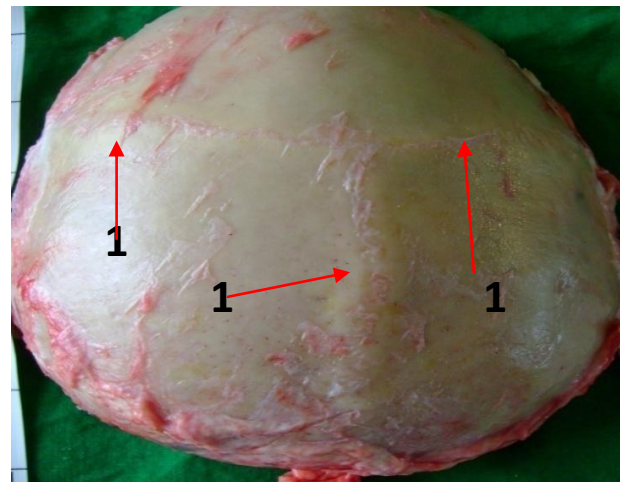


CORONAL & SAGITAL SUTURES (ENDOCRANIAL)

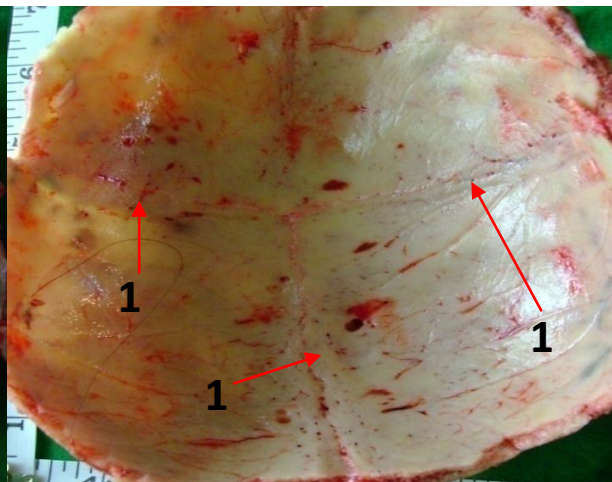


LAMDROID SUTURES (ENDOCRANIAL)

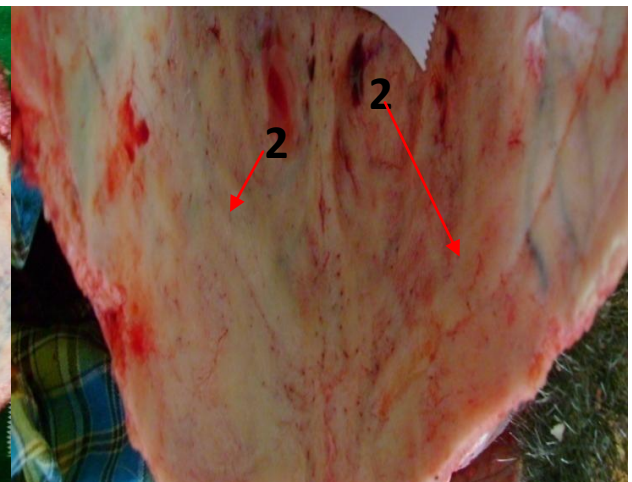
CASE-150



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.

INFORMATION SHEET

I, Dr. Raj Kumar M G, Post Graduate Student department of Forensic Medicine & Toxicology SDUMC, Kolar is pursuing dissertation on skull vault suture closure form 3rd to 6th decades in kolar region of Karnataka,India.

I have clearly explained only the photograph of the skull will be taken during autopsy and in no way identity of deceased shall be revealed by any means. I have informed at any point of time defiles of deceased can be withdrawn from dissertation work as per wish of the next of the kin.

I have also explained to the next of the kin of the deceased that the results of the scientific work will be used for the betterment of mankind.

Signature of Researcher

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.14PG012, Department of Forensic medicine and
Toxicology, SDUMC, Kolar.

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

ಮಾಹಿತಿ ಪತ್ರ

ನಾನು ಡಾ|| ರಾಜ್‌ಕುಮಾರ್ ಎಂ.ಜಿ., ಸ್ನಾತಕೋತ್ತರ ವಿದ್ಯಾರ್ಥಿ, ನ್ಯಾಯ ವೈದ್ಯಶಾಸ್ತ್ರ, ಎಸ್.ಡಿ.ಯು.ಎಂ.ಸಿ ಕೋಲಾರ, ನನ್ನ ಸಂಶೋಧನೆಯ ಸಲುವಾಗಿ ಮೃತರ ತಲೆಬುರುಡೆಯ ಕಪಾಲದ ಛಾಯಾ ಚಿತ್ರವನ್ನು ತೆಗೆದುಕೊಳ್ಳುವುದರ ಬಗ್ಗೆ ಮೃತರ ಸಂಬಂಧಿಗಳಿಗೆ ಸಂಪೂರ್ಣವಾಗಿ ತಿಳಿಸಿರುತ್ತೇನೆ.

ಯಾವುದೇ ಕಾರಣಕ್ಕೂ ಮೃತರ ಗುರುತನ್ನು, ಯಾವುದೇ ವಿಧಾನದಲ್ಲೂ ಯಾರಿಗೂ ತಿಳಿಯದಂತೆ ಗೌಪ್ಯನೀಯವಾಗಿರಿಸಲಾಗುವುದು. ಮೃತರ ಸಂಬಂಧಿಗಳ ಸಂಶೋಧನಾ ಅವಧಿಯ ಯಾವುದೇ ಸಮಯದಲ್ಲಾದರೂ ಅವರು ನೀಡಿದ ಮಾಹಿತಿಯನ್ನು ಹಿಂತೆಗೆದುಕೊಳ್ಳುವ ಬಗ್ಗೆ ತಿಳಿಯಪಡಿಸಲಾಗಿರುತ್ತದೆ. ಸಂಶೋಧನ ವಿಧಾನದ ಬಗ್ಗೆ ಮತ್ತು ಅದರ ಉಪಯೋಗದ ಬಗ್ಗೆ ಸಂಪೂರ್ಣವಾಗಿ ತಿಳಿಸಿರುತ್ತೇನೆ.

ಸಂಶೋಧಕರ ಸಹಿ

ಮಾಹಿತಿ ಸಮ್ಮತಿ ನಮೂನೆ

ದಿನಾಂಕ:

ಸಮಯ :

ನಾನು ಶ್ರೀ/ಶ್ರೀಮತಿ ಮೃತರ ತಂದೆ/ತಾಯಿ/ಗಂಡ/ಹೆಂಡತಿ/ಮಗ/
ಮಗಳು..... ವಯಸ್ಸು ಡಾ.ಎಂ.ಜಿ.ರಾಜ್ ಕುಮಾರ್,
ಸ್ನಾತಕೋತ್ತರ ವಿದ್ಯಾರ್ಥಿ, ನ್ಯಾಯ ವೈದ್ಯಶಾಸ್ತ್ರ ವಿಭಾಗ, ಎಸ್‌ಡಿಯುಎಂಸಿ, ಕೋಲಾರ ರವರು
ಕೈಗೊಳ್ಳುವ ಅಂಗಚ್ಛೇದನ ಸಂಶೋಧನೆಯ ಸಲುವಾಗಿ ಮೃತ ಶ್ರೀ/ಶ್ರೀಮತಿ.....
ಇವರ ತಲೆ ಬುರುಡೆಯ ಕಪಾಲದ ಛಾಯಾಚಿತ್ರವನ್ನು ತೆಗೆಯಲು, ಈ ಮೂಲಕ ಸ್ವತಂತ್ರವಾಗಿ,
ಸ್ವಯಿಚ್ಛೆಯಿಂದ ಸಂಪೂರ್ಣವಾಗಿ, ಸಮ್ಮತಿಸುತ್ತೇನೆ.

ಹಾಗೂ,

ಯಾವುದೇ ಕಾರಣಕ್ಕೂ ಮೃತರ ಗುರುತನ್ನು, ಯಾವುದೇ ವಿಧಾನದಲ್ಲೂ ಯಾರಿಗೂ ತಿಳಿಯದಂತೆ,
ಗೌಪ್ಯನೀಯವಾಗಿರಿಸಲಾಗುವುದು, ಯಾವುದೇ ಸಮಯದಲ್ಲಾದರೂ ಹಿಂತೆಗೆದುಕೊಳ್ಳಬಹುದು ಎಂದು
ತಿಳಿಸಿರುತ್ತಾರೆ ಮತ್ತು ಮೇಲೆ ಉಲ್ಲೇಖಿಸಿದ ಸಂಶೋಧನಾ ವಿಧಾನವನ್ನು ನನಗೆ ಸಂಪೂರ್ಣವಾಗಿ
ವಿವರಿಸಿದ್ದಾರೆ ಎಂದು ದೃಢೀಕರಿಸುತ್ತೇನೆ.

ಹಾಗೂ,

ಸಹಿ ಮಾಡುವ ಮುನ್ನ ಈ ನಮೂನೆಯ (ಪತ್ರದ) ಎಲ್ಲಾ ಅಂಶಗಳನ್ನು ಸಂಪೂರ್ಣವಾಗಿ, ಓದಿ,
ಅರ್ಥೈಸಿಕೊಂಡಿದ್ದೇನೆ.

ಸಮ್ಮತಿಸುತ್ತಿರುವ ವ್ಯಕ್ತಿಯ ಸಹಿ

ಸಾಕ್ಷಿಗಳು

(ಹೆಸರು ಮತ್ತು ವಿಳಾಸ)

1.

2.

**SRI DEVARAJ URS MEDICAL COLLEGE,
DEPARTMENT OF FORENSIC MEDICINE AND TOXICOLOGY,
TAMAKA, KOLAR.**

**A CROSS SECTIONAL POSTMORTEM STUDY ON PATTERN OF CLOSURE OF
SKULL VAULT SUTURES WITH RESPECT TO AGE FROM 3RD TO 6TH
DECADES OF LIFE AT R.L.JALAPPA HOSPITAL AND RESEARCH CENTRE,
KOLAR.**

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 Voter ID / Aadhar ID
/any ID issued by Govt: |
| 11. Date of birth: | 12. Sex: |

II. Address:

- | | |
|---------------|-----------------|
| 14. Religion: | 15. Occupation: |
|---------------|-----------------|

III. OTHER FEATURES

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

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.	Saggital suture	A/3 P/3 M/3										
2.	Coronal suture [R]	U/2 L/2										
3.	Coronal suture [L]	U/2 L/2										
4.	Lambdoid suture [RW]	U/2 L/2										
5.	Lambdoid suture [LW]	U/2 L/2										

Place :

Date :

Signature :

SI	No	PMno/date	AGE	SEX	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	
					A13	P13	M13	A13	P13	M13	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12	U12	L12
1		263114	60	F	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
2		267114	30	F	4	4	4	1	1	1	4	4	1	1	4	4	1	1	4	4	1	1	4	4	1	1
3		268114	32	M	1	1	1	0	0	0	2	2	0	0	2	2	0	0	1	1	0	0	1	1	0	0
4		272114	50	M	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
5		275114	32	F	1	1	1	0	0	0	1	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1
6		278114	55	F	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
7		10115	60	F	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1
8		21115	35	M	4	4	4	4	4	4	3	1	3	1	3	1	3	1	4	4	4	4	4	4	4	4
9		25115	60	M	2	2	2	0	0	0	3	3	2	2	3	3	3	3	4	4	4	4	4	4	4	4
10		34115	35	M	4	4	4	1	1	1	4	4	1	1	4	4	1	1	4	4	1	1	4	4	1	1
11		40115	43	M	1	1	1	0	0	0	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1
12		44115	50	M	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
13		51115	48	M	2	2	2	0	0	0	2	2	0	0	2	2	0	0	2	2	0	0	2	2	0	0
14		56115	55	M	4	4	4	4	2	3	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2
15		61115	45	M	2	2	2	0	0	0	3	3	0	0	4	4	0	0	2	2	2	2	2	2	2	2
16		72115	35	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17		73115	45	M	1	1	1	0	0	0	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1
18		75115	50	M	4	4	4	0	0	0	4	4	1	1	4	4	1	1	4	4	0	0	4	4	0	0
19		78115	32	M	1	1	1	0	0	0	1	3	2	2	1	3	2	2	4	4	4	4	4	4	4	4
20		80115	48	F	1	1	1	0	0	0	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1
21		86115	40	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22		87115	55	F	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
23		104115	56	F	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
24		118115	56	M	3	1	1	0	0	0	1	1	1	1	1	1	1	1	2	2	1	1	2	2	1	1
25		121115	42	F	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
26		132115	45	M	1	1	1	0	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1
27		135115	48	M	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
28		143115	55	M	4	4	4	1	1	1	4	4	2	2	4	4	2	2	4	4	1	1	4	4	1	1
29		155115	38	M	1	1	1	0	0	0	1	0	0	0	1	0	0	1	1	0	0	1	1	0	0	0
30		156115	60	M	4	4	4	2	3	3	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2
31		162115	55	M	4	4	4	1	1	1	4	4	2	2	4	4	2	2	4	4	1	1	4	4	1	1
32		168115	52	M	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1
33		171115	45	F	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1
34		175115	50	M	4	4	4	4	4	4	3	1	3	1	3	1	3	1	4	4	4	4	4	4	4	4
35		177115	48	M	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
36		179115	50	M	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1
37		184115	29	M	2	2	2	0	0	0	3	2	0	0	3	3	0	0	2	4	0	0	2	1	0	0
38		186115	56	F	4	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1
39		187115	60	F	3	3	3	1	2	0	3	4	2	3	3	4	2	3	4	4	2	2	4	4	2	2
40		188115	22	M	0	0	0	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
41		190115	27	F	1	1	1	0	0	0	1	3	2	2	1	3	2	2	4	4	4	4	4	4	4	4
42		194115	28	F	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1
43		197115	54	M	4	4	4	2	3	3	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2
44		202115	27	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
45		203115	30	F	1	1	1	0	0	0	1	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1
46		204115	40	M	1	1	1	0	0	0	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1
47		205115	26	M	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	1	1	2	2	1	1	1
48		206115	23	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
49		207115	60	M	4	4	4	2	2	2	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2
50		209115	35	M	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1	1	1	1	1	1
51		210115	40	F	1	1	1	0	0	0	1	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1
52		212115	35	M	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	1	1	2	2	1	1	1
53		214115	28	M	1	1	1	0	0	0	1	1	1	1	1	1	1	1	2	2	1	1	2	2	1	1
54		215115	60	M	4	4	4	2	3	3	4	4	2	2	4	4	2	2	4	4	2	2	4	4	2	2
55		216115	27	F	1	1	1	0	0	0	1	1	1	1	1	1	1	1	2	2	1	1	2	2	1	1
56		222115	30	F	3	3	3	0	2	0	4	4	0	0	3	3	0	0	4	4	4	4	4	4	4	4
57		224115	56	M	4	4	4	1	3	1	3	3	1	1	4	4	1	1	4	4	1	1	4	4	1	1
58		225115	35	M	1	1	1	0	0	0	2	2	0	0	2	2	0	0	1	0	0	1	1	0	0	0
59		233115	38	F	1	1	1	0	2	2	1	3	4	1	4	1	3	4	1	1	1	1	1	1	1	1
60		234115	25	F	1	1	1	2	0	0	2	2	3	2	1	3	2	1	3	1	3	1	1	2	1	1
61		239115	35	M	4	4	4	4	4	4	3	1	3	1	3	1	3	1	4	4	4	4	4	4	4	4
62		241115	28	F	2	2	2	0	0	0	2	2	0	0	2	2	0	0	1	1	1	1	1	1	1	1
63		242115	24	M	2	2	2	0	0	0	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1
64		247115	42	M	1	1	0	2	2	2	1	3	4	4	1	3	4	4	1	1	1	1	1	1	1	1
65		248115	21	F	1	1	1	0	0	0	1	1	1	1	1	1	1	1	2	2	1	1	2	2	1	1
66		249115	25	M	2	2	2	0	0	0	3	3	0	0	3	3	0	0	1	1	0	0	1	1	0	0
67		251115	21	M	2	1	1	1	1	1	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1
68		260115	27	M	1	1	1	0	0	0	1	3	2	2	1	3	2	2	4	4	4	4	4	4	4	4