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Closure of cranial sutures and expansion of epiphysis of bones as indicators of ageing in forensic sciences: A Review

Sujata Mohanty[1], Aurobinda Das[1]*

[1]Biology division, State forensic science laboratory, Bhubaneswar, Odisha, India

[1*]Serology division, Regional forensic science laboratory, Berhampur, Odisha, India

***Corresponding author**:aurobindadas1@gmail.com*

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Abstract

Ageing is very difficult to define due to it is difficult to distinguish between real effects of time and degenerative diseases. For this analysis cross sectional study is to be done and results compared with the individuals with different age and interpretations must be taken for the genetic and environmental origin. There are numerous changes of adults for the morphological, physiological and psychological changes and the distinction between pathological and normal situation is always arbitrary. Skull deformation requires first determining the thickness of the skull and how it changes with age. The present study involves all the detail information of the cranial sutures and relation between sutures and aging. the cranial sutures maintain a state of patency by synchronised remodelling efforts of bone deposition and resorption from infancy through early adulthood. The ability to estimate age from the skeleton requires a thorough understanding of the nature, sequence, and timing of skeletal changes across time, as well as the link between these processes and chronological metrics. Age indicators should be traits or processes that change unidirectional with age, correlate with chronological age and vary consistently among individuals. It's vital to remember that chronological and biological ages aren't perfectly matched because the skeletal ageing process differs from person to person. The trajectory effect describes how the gap between biological and chronological age develops as people get older. The review also describes about the epiphysis and its relation between the ageing which is the bony caps on

the extremities of long bones and other bony structures. For this review many research articles and review articles have been studied. Many researchers has been studied about the relation between the epiphysis and aging. epiphyseal appearance, and union is most useful for immature individuals and has even been used to predict future growth in living individuals.

Key words: ageing, cranial sutures, expansion of epiphysis, interdigitation, metaphysis

1. Introduction

Bone has mechanical and homeostatic purposes, including protecting internal organs, permitting mobility and load-bearing, housing marrow, and serving as a calcium homeostasis reservoir. These capabilities deteriorate with age, bone becomes weaker and less capable of performing mechanical duties, and calcium stores are frequently depleted. To learn why this doesn't happen to everyone and how the factors that cause it affect people. Bone is made up of inorganic mineral crystals, an extracellular organic matrix, cells, lipids, and water, and is a composite structure. The mineral crystals are similar to hydroxylapatite, a geologic mineral. We'll call bone mineral hydroxyapatite because it's made up of OH-deficient nanoparticles. The majority of mineral crystals contain impurities, primarily carbonate, magnesium, citrate, and other trace elements, the concentration of which varies depending on the animal's diet **[1-3].**Mechanical and other signals are also received by the cells that make, nourish, and modify the mineralized extracellular matrix, which dictate the qualities (morphology and function) of the bone. Bone composition changes depending on health and disease, tissue location, and animal and tissue age. Bone has a hierarchical structure that is independent of age: from the level of entire tissue, where diverse types of bones exist, to the level of individual bones which includes long and short, flat and tubular—to the tissue level, where bone is arranged into cortical and trabecular**[1].**

The components of bone are kept in balance to prevent fractures while keeping the skeleton's weight low. Toughness, or ductility, is necessary to absorb the energy from impact loads, while stiffness (resistance to deformation) and strength (maximum stress to failure) are required to bear enormous loads. It's vital to remember that changes in collagen structure can lead to increased brittleness due to a shift in its cross-linking profile, which affects the morphology of the mineral component as well as stiffening the organic matrix. It's also crucial to remember that, while bone mineral density (BMD) declines in some fragility conditions like osteoporosis, BMD increases in others **[4].**

In the ends of all long bones and in the central region of other bones, there are compact areas (cortices) and spongy areas (trabecular). Bones change shape to help mechanical purposes, such as being strong enough to endure significant stresses while still being streamlined to reduce energy demands. Men and women over 85 years of age, for example, have been observed to have the most "unfavourable" hip geometry, thinner cortices, and lower resistance to bending/buckling **[6].**Genetics, bone loading, and cell activity are all factors that contribute to these morphological alterations.

The majority of bone cells are mesenchymal in origin: chondrocytes, which are responsible for the deposition of the growth plate and subsequent remodelling, and osteoblasts, which are responsible for bone formation and remodelling. It facilitate the mineralization process; and osteocytes, which respond to load and regulate bone resorption and formation. The longevity of all normal cells, including osteoblasts, osteoclasts, and osteocytes, is determined by the number of replication cycles and external variables **[7].**The lengths of the telomeres at the ends of genes are likely the determinant of that number in the cell nucleus.

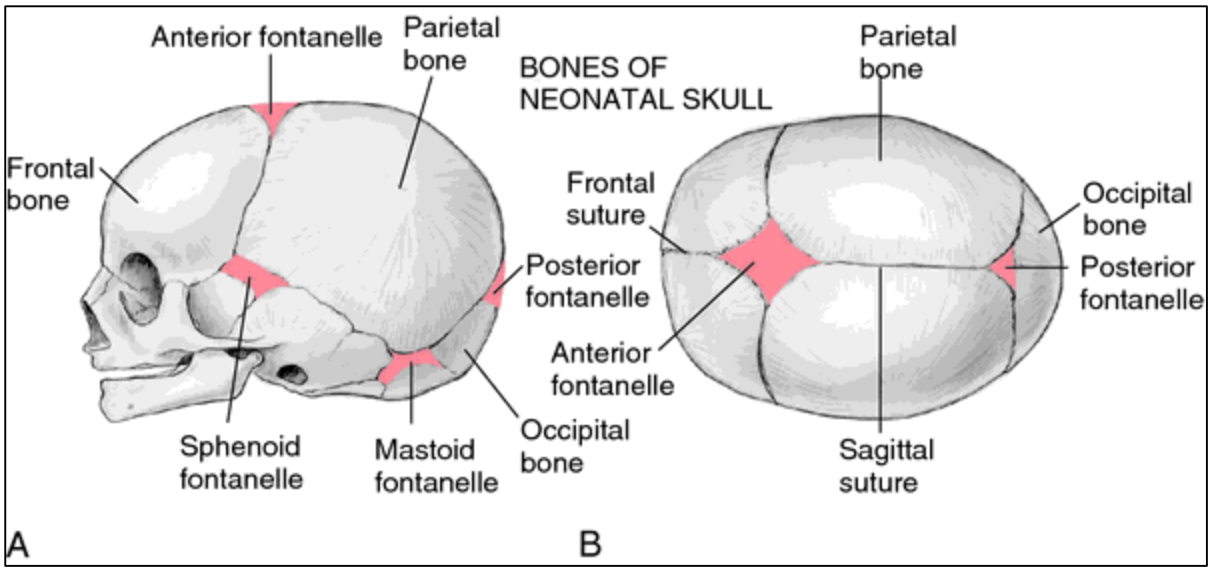
Aging is very difficult to define due to it is difficult to distinguish between real effects of time and degenerative diseases. For this analysis cross sectional study is to be done and results compared with the individuals with different age and interpretations must be taken for the genetic and environmental origin. There are numerous changes of adults for the morphological, physiological and psychological changes and the distinction between pathological and normal situation is always arbitrary **[8].**

Understanding the significance of skull thickness in skull deformation requires first determining the thickness of the skull and how it changes with age. The primary function of the skull is to protect the brain. It is made up of 22 bones, eight of which make up the neurocranium and are joined by sutures (synarthrodial joints). The majority of these cranial bones are classified as flat bones, and their layered bone structure, which includes a cancellous bone layer called diplo wedged between two layers of dense cortical bone, distinguishes them (cortex) **[9].**The brain and skull morphology are significant in assessing the ageing human; nevertheless, little is known about how the skull changes with age. The normal growth and development of the skull takes place along the osteogenic interfaces of the cranial sutures, which is a highly regulated process.The calvarial bones' boundaries, as well as the tissues above and below them, work together to form a complex. As the skull continues to grow and support the developing brain's demands for expansion, the cranial sutures

maintain a state of patency by synchronised remodelling efforts of bone deposition and resorption from infancy through early adulthood. When this delicate equilibrium is disrupted, a variety of pathologic disorders develop, which, if left untreated, can lead to visual and cognition deficits.Craniosynostosis, or the early union of one or more cranial and/or facial sutures, is a prime example. Surgical repair of craniosynostosis by cranial vault reconstruction is now the primary treatment option for craniosynostosis. However, during the last decade, elegant investigations have revealed multiple genes that are required for the preservation of suture patency and the activation of suture fusion **[10].**

2. Cranial sutures

Cranial sutures are fibrous bands of tissue that connect the bones of the skull. An infant's skull is made up of 6 separate cranial (skull) bones which includes, frontal, occipital, two parietal and two temporal bones. Strong, fibrous, elastic tissues that hold these bones together are called Sutures (Figure 1). Fontanelles are the gaps between the bones that stay open in newborns and young children. They're also known as soft areas. These areas are a natural aspect of growth. For roughly 12 to 18 months, the skull bones are separated. They then grow together as part of regular growth. They stay in touch well into adulthood. The position of the Twofontanelles are On the top of the middle head, just forward of center i.e. anterior fontanelle and In the back of the middle of the head which is called posterior fontanelle



(Figure 1).

Figure 1: Structure of skull showing sutures and fontanelle of neonatal skull

Anterior fontanelle is the diamond shaped junction of coronal, frontal and sagittal sutures which becomes ossified within 18 to 24 months. Posterior fontanel is the triangular fontanel at the junction of the sagittal and lambdoid sutures; ossified generally by age one **[11].**

The skull (cranium) is made up of a complex arrangement of bones which are split into neurocranium and viscerocranium throughout development and are derived from mesenchyme, which encircles the developing brain (Figure 2). The viscerocranium is derived from the neural crest, and is composed of 14 bones, the paired nasal bones, maxillae, palatine bones, lacrimal bones, zygoma and inferior nasal conchae, along with the singular vomer and mandible.

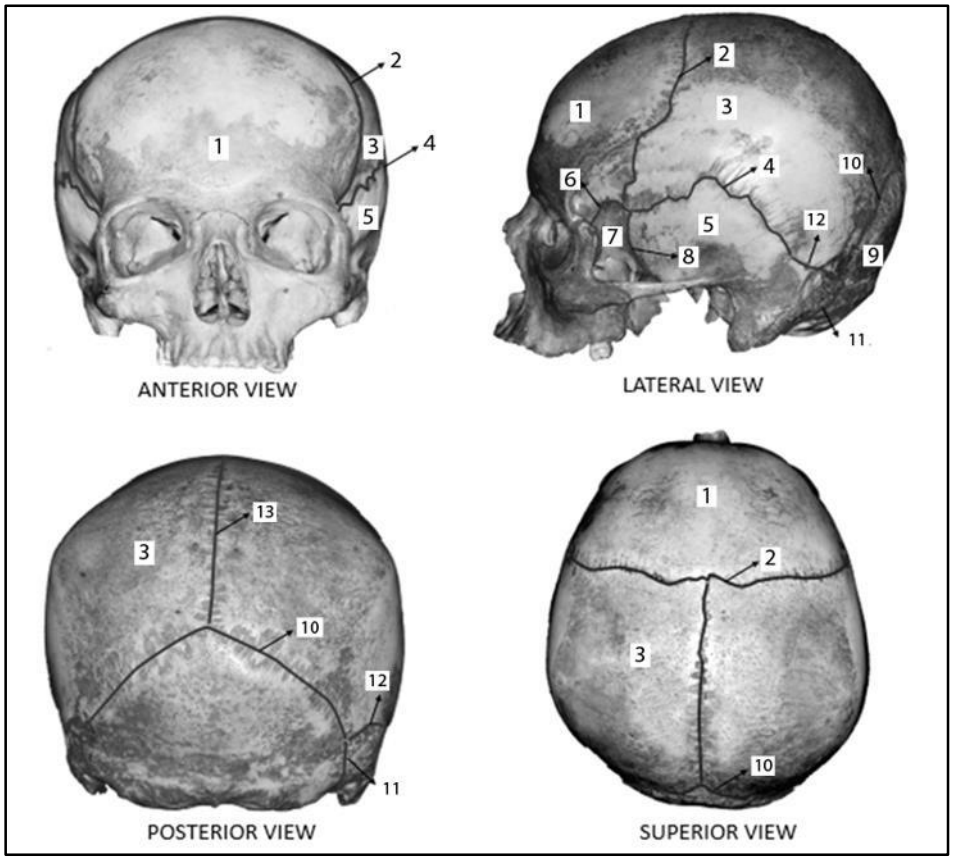


Figure 2: different views of adult skull

The frontal, sphenoid, ethmoid, occipital, and paired temporal and parietal bones make up the neurocranium (cranial vault and base), which serves as a protective casing around the brain in humans. Parts of the frontal and occipital bones, as well as the paired parietal bones, make up the superior region of the neurocranium, or cranial vault.

Cranial sutures are highly specialised tissues that are required for skull growth, far exceeding the notion that they are just the articulation of two bones. Human metopic suture has previously been found to contain cartilaginous tissue, as well as a mix of chondroid tissue and bone matrix, bridging the gap between the two frontal bones. Sutures are areas where osteogenic progenitors produced from embryonic mesenchyme are restricted between flat calvarial bones and can proliferate or differentiate in response to signalling pathways. There are various functions for the sutures like it enables the tight passage of newborn through birth canal, it serves as a shock absorber, it allows for the occurrence of brain growth**[12-15].**

2.1 Principles of age estimation from sutures

The ability to estimate age from the skeleton requires a thorough understanding of the nature, sequence, and timing of skeletal changes across time, as well as the link between these processes and chronological metrics. Skeletal age assessment thus entails comparing biological age (or physiological age) to chronological age (the number of years a person has lived). Age indicators should be traits or processes that change unidirectional with age, correlate with chronological age, and vary consistently among individuals **[16, 17].**It's vital to remember that chronological and biological ages aren't perfectly matched because the skeletal ageing process differs from person to person **[18].** This mismatch emerges because biological age is determined by genetics, nutrition, environmental circumstances, and degree of activity, among other things, whereas chronological age is determined by time. The trajectory effect describes how the gap between biological and chronological age develops as people get older **[19].**

Skeletal age estimation is a transformational process in which an anthropologist must convert a descriptive skeletal age signal into a chronological age. Unfortunately, due to the stages necessary in assessing skeletal morphology and converting these data into a chronological age, this approach adds error. In many circumstances, this can lead to a wide age range that is accurate but not very exact **[18].** In some circumstances, knowing other biological factors first can help with age prediction. Female development, for example, occurs earlier than male development, and growth trajectories differ amongst populations. When calculating age, any evidence of sex or ancestry should be taken into account, and when possible, age estimation guidelines based on the population of the skeletal material studied should be employed. When population-specific criteria are unavailable, more inclusive standards with larger age ranges should be used instead.

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Because age estimation methods for the growth and development and degenerative phases of the lifespan are fundamentally different, skeletal age can be classified into one of two categories.Adult – those ages occurring during the mature, degenerative stage of skeletal change, including embryonic, foetal, infant, child, and adolescent periods; and juvenile (also called subadult) – those ages occurring during the growth and development process, including embryonic, foetal, infant, child, and adolescent periods (table 1).

Table 1: Skeletal changes, its growth and development stage

Stage	**Time period**
Embryo	First 8 weeks of intra-uterine life
Fetus	From 8 intra-uterine weeks to birth
Infant	Birth to 1 year
Child	1 to 15 years
Adolescent	15 to 17 years
Adult	17 years and older

When all permanent teeth have emerged and all epiphyses have fused, the skeleton's growth and development is deemed complete **[20-22].** Because the capacity to estimate other biological factors such as sex, ancestry, and size may rely on whether an individual is a juvenile or an adult, the skeletal age category (juvenile or adult) should be determined early in the examination process. For example, stature rises during childhood and adolescence (until around the age of 18), but falls as an adult due to degenerative changes in the spinal column. As a result, assessments of stature must take into account the decedent's age **[23].** Because skeletal indications used to assess the sex of an unidentified individual are usually absent or underdeveloped until after puberty, estimating sex from juvenile skeletal evidence is not recommended.Certain skeletal traits, such as muscle attachment sites, may become more robust with age in adult females, which should be considered when evaluating the skeletal remains of older adults. In subadults, ancestry-related cranial features are frequently absent or less apparent than in adults **[24].**

There are various methods for the age estimation which includes dental method, at different developmental stages, juvenile aging method can be assessed. In this method determination of the development of the teeth as well as crown to be done. Although each tooth develops in the same order (from the crown cusp(s) to the root apex), the timing differs depending on the tooth position. After determining the degree of development,

skeletal age is derived by comparing calculated mean ages for each tooth at that developmental stage. During most of the growth and development period, girls are more advanced in their dental development than boys. The rate of tooth calcification varies by population. These difficulties can hinder research because sex and ancestry aren't always known for juvenile skeletal remains. Certain procedures are exclusively applicable to the mandibular dentition and thus cannot be used on maxillary teeth **[25, 26].**

Another method for the age estimation is osteological methods. Particularly during foetal development, there is a significant linear association between diaphyseal length and age. This procedure is effective until the epiphyses and diaphyses unite, which usually occurs around the age of ten **[27].** Because dental development may be low in foetal skeletal material, the approach is not only more precise, but it is also particularly useful for ageing foetal skeletal material. The lengths of the major limb bone diaphyses may be used to aid in this determination.

3. Indicators of advanced age

There are various ways that often depict advanced age with minimal association to a precise age, such as adult age estimations utilising specific changes in features or traits. These procedures are often utilised when other parts of the body, such as the pubic symphysis and sternal rib ends, are inaccessible or unsuitable for inspection, and they only provide a rough estimate of adult skeletal age, such as younger or older. The sutures of the cranium and palate tend to close and obliterate as people get older. Although certain techniques have acquired acceptance among forensic anthropologists, others have not. Following studies have attempted to improve the approach for forensic use **[28].** The closure patterns of various cranial sutures have been proven to have a poor correlation with chronological age. Individual brain and connective tissue (dura) development and somatic dysfunction appear to be more closely associated to cranial suture closure than chronological age **[29].**Complete suture closure and obliteration, on the other hand, are usually signs of elderly age. The ectocranial and/or endocranial surfaces are usually the focus of cranial suture closure research. With the use of these methods, the sutures are usually scored as: (Figure 3)

1. There is no sign of bone bridging over the suture because it is open.
2. Any sign of bone bridging up to 50% closure indicates minimal closure.
3. Significant closure is indicated by evidence of more than 50% bony bridging.
4. The suture edges have been completely obliterated **[30].**

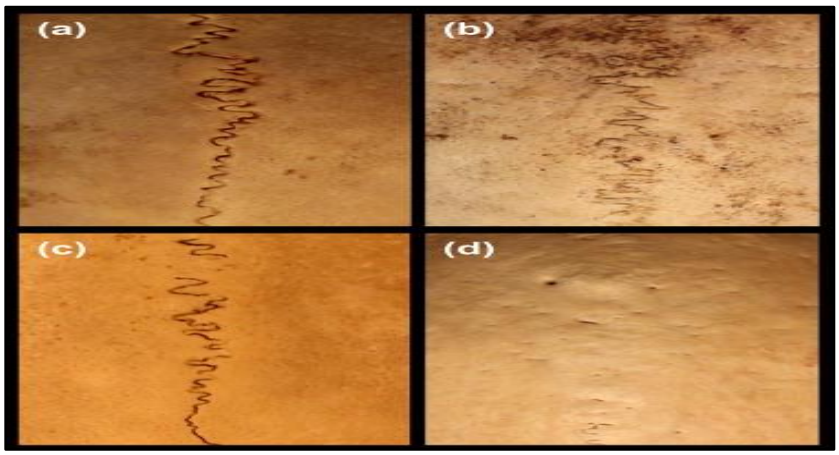

Figure 3: Progression of cranial suture closure

(a) Open suture, (b) minimal closure, (c) significant closure, and (d) obliteration of suture

Various suture areas of the cranial vault or palate are scored (typically within a 1 cm area) depending on the method utilised, and the sum of the scores (i.e., the composite score) correlates to a relatively broad age range **[31].**The vault sutures (mid-coronal, bregma, anterior sagittal, obelion, lambda, and mid-lambdoid) and lateral-anterior sutures (sphenofrontal, pterion, mid-coronal, inferior sphenotemporal, and superior sphenotemporal) each have their own composite score. The sagittal suture, as well as the left coronal and lambdoidal sutures, are scored for the endocranial surface. The lateral-anterior sutures performed better than vault sutures and notably sutures on the endocranial surface, according to an analysis of several vault locations. The palatal sutures were also looked at as a potential age indication. The incisive suture, the anterior and posterior median palatine sutures, and the transverse suture are all evaluated using this procedure **[32, 33].**Unlike cranial suture closure scoring systems, the presence of any closure (bony bridging) along the suture line is scored as obliteration for the maxillary suture. Osteoporosis, or an increase in bone porosity, is frequently connected with advanced age (or decrease in bone density). There will never be a single skeletal sign of age at death that accurately reflects the myriad elements that accrue with chronological age, each of which might offer valuable information to the age estimate. Any indicator that both significantly represents biological age and has informational content that is independent of other indicators, whether under forensic or archaeological conditions, will be valuable in determining a final age estimate.

4. Mechanism of closure of sutures

The paired coronal sutures (between the frontal and parietal bones), the paired lambdoid sutures (between the parietal and interparietal bones), the single sagittal suture (between the parietal bones), and the single human metopic or murine posterior frontal suture (between the paired frontal bones) are the six primary sutures of the cranial vault. There are two types of interdigitations seen within the sutures of the cranial vault. The bone margins have a notched or sawlike look, and the coronal and sagittal sutures are serrated. There's also a denticulate pattern, in which the articulating bones' little toothlike projections enlarge as they approach their free ends. The lambdoid sutures are an example

of this **[34].**Each cranial suture begins as a small strip of undifferentiated tissue that connects two skull bones. The linear suture line does not begin to develop a wave pattern until after delivery. A complex interdigitated structure with a noninteger fractal dimension is sometimes generated in the late stages of growth.

Sutural development is thought to be influenced by a variety of growth and transcription factors. Despite the identification of the molecules involved and their interactions, the process of suture interdigitation remains a mystery. It has been argued that interdigitation is functionally related to mechanical tension **[35, 36].**

The mechanism by which the fractal structure of sutural tissue is created has been offered as a model. To represent the generation of the interdigitated structure, the model employs the Eden model, which involves random growth of the interface. The model, on the other hand, implies that the ragged edges of bones form before the two edges approach close together, which is not the case in reality. Furthermore, because this model ignores known molecular interactions in the forming suture, it's difficult to reconcile the model's proposed fractal dynamics with real evidence from molecular developmental biology investigations.

Miura et al produced the model which is a simple model that can build and experimentally validate the interdigitated structure based on experimental data. To begin, they observed the process of suture interdigitation in human and mouse skull specimens. They then enumerated all of the molecules involved in the developing process and divided them into three groups based on their location and function. Then, based on the data, they identified two parameters to represent the situation: tissue differentiation status (u) and substrate concentration (v), and built a basic two-species reaction–diffusion model. They quantitatively examined the model's behaviour, focusing on the substrate molecules' basal influence (a0), and verified the model using several experimental methods. Model-based predictions were in high agreement with experimental results, implying that the model captures the key aspects of the skull suture interdigitation mechanism.

In this study, it was found that, sutures were straight in new born human skull while adult sutures were interdigitated. To know about all the details of pattern forming of the sutures, they choose the younger specimen and tracing was done with the pattern of sagittal sutures of human skull specimens and measured the amplitude of interdigitation

and fractal dimension. Suturalinterdigitation amplitude and fractal dimension rose with age, however the relationship was not strong. Due to substantial individual diversity, it appears that the process of pattern development using human specimens could not be seen in detail. As a result, they used noninvasivemicroCT to track the progression of sagittal suture interdigitation in mice. As a result, they used noninvasivemicroCT to track the progression of sagittal suture interdigitation in mice.

This system's one-dimensional simulation replicates the preservation of thin sutural tissue. An intuitive interpretation of the mechanism is that when the undifferentiated sutural tissue thickens, undifferentiated mesenchyme and substrate production increase, promoting osteogenesis and thus advancement of the osteogenic front. If the undifferentiated sutural tissue becomes significantly thinner, the process reverses. In this scenario, the suture thickness is maintained by this feedback system **[37].**

5. Epiphysis

Bone is created via the replacement of a cartilaginous model and the transformation of connective tissue (intramembranous ossification) (endochondral ossification). 1 In flat bone, intramembranous ossification occurs (e.g., cranium, periosteal surface of the diaphysis of long bones)The articular surfaces are formed by endochondral ossification, which is responsible for bone lengthening. All three major sections of long bones, the diaphysis, epiphysis, and metaphysis, are formed by the endochondral ossification process. In the foetus, the diaphysis develops initially.Mesenchymal cells create a cartilaginous structure with a calcifying chondrocyte centre surrounded by a thin cancellous bone collar. The major ossification centre is the name given to this location. The nutrition foramen is where vascular invasion begins. The creation of neonatal bone, which consists of a core marrow cavity surrounded by a thin periosteum, is aided by growth factors and multipotent stem cells **[38].**

At the proximal and distal ends of the bones, the epiphysis is a secondary ossification centre in the hyaline cartilage that forms the joint surfaces. The bony caps on the extremities of long bones and other bony structures are called epiphyses. The vascular reserve zone cartilage, which is responsible for epiphysis growth toward the joint, and the epiphyseal plate, which is responsible for bone length growth, are both responsible for epiphysis growth. The epiphyseal plate is usually made of hyaline cartilage and can be

seen as a radiolucent line between the epiphysis and the metaphysis on radiographs of young animals (Figure 4).

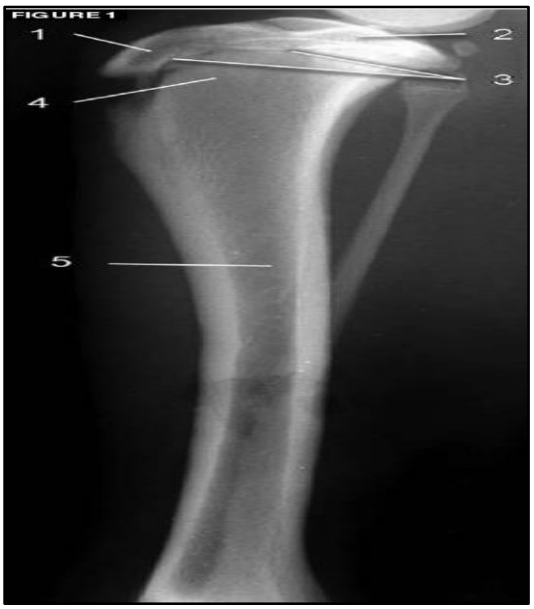

Figure 4: 1) apophysis 2) epiphysis (pressure epiphysis) 3) Epiphysial plate 4) metaphysis 5) Diaphysis

The epiphysis in mature animals is made up of cancellous bone surrounded by a thin layer of compact bone. Pressure epiphyses, which are found at the extremities of long bones, and traction epiphyses (apophyses), which are sites of genesis or insertion of major muscles, are the two types of epiphyses (e.g., the greater trochanter of the femur) **[38-40].**

5.1 Components of epiphysis and metaphysis

A fibrous component, a cartilaginous component, and a bony component make up the growth plate. The fibrous component, which surrounds the growth plate, is separated into an ossification groove known as the Ranvier groove and a perichondrial ring known as the LaCroix ring.

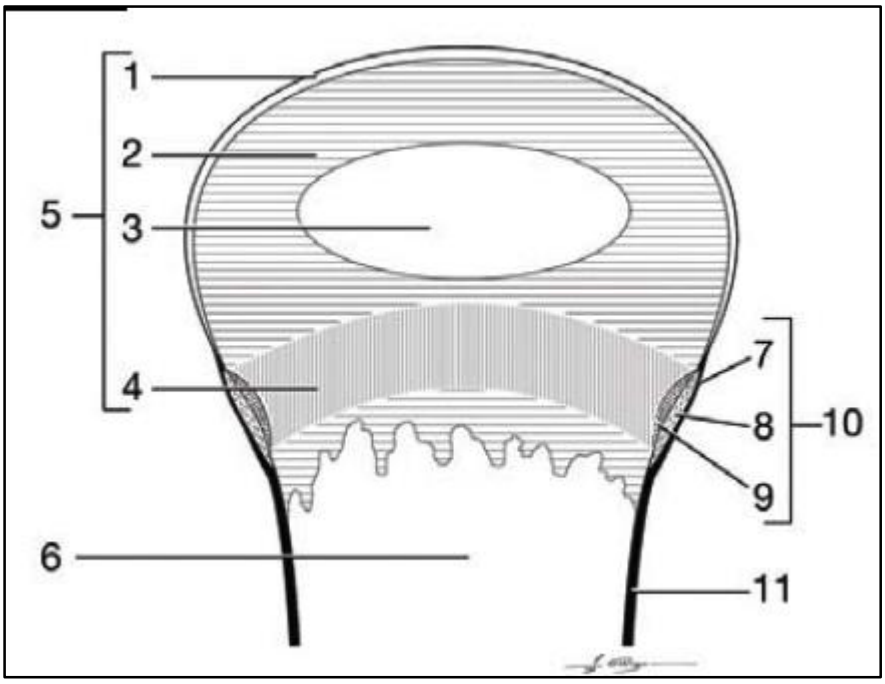

Figure 5: Components of epiphysis and metaphysis. 1)Articular cartilage, 2) Epiphysial cartilage 3) Ossification centre, 4) Epiphyseal plate, 5) Epiphysis, 6) Metaphysis, 7) Periostum, 8) LaCroix ring, 9) Ranvier groove, 10) Fibrous components of epiphyseal plate, 11) Cortical bone

The role of the Ranvier groove is to supply chondrocytes for expansion of the growth plate's diameter and length. Between the ossification groove and the metaphysis periosteum, which sheathes the growth plate, is the LaCroix ring. It gives the growth plate mechanical support. Growth cartilage is protected from shear stresses by the fibrous component. The growth plate's cartilaginous component is separated into three zones: reserve, proliferative, and hypertrophic. The maturation, degeneration, and provisional calcification zones make up the hypertrophic zone itself. The bony component of the growth plate is located right next to the cartilaginous component. This is the stage at which cartilage cells become bone.**[41, 42].**

5.2 Epiphyseal bone bridge formation

Salter-Harris fractures that are not displaced usually heal without complications. When the fracture is shifted to the physeal-epiphyseal border, cellular debris and the creation of vertical septa are visible, followed by the construction of an epiphyseal bone bridge between the epiphysis and metaphysis. Epiphyseal bone bridges, like Salter-Harris VI

fractures, can cause growth to stop and angular limb deformity to occur due to asymmetric restriction of residual growth **[42].**

5.3 Epiphysis as an age indicator

In radiographic analyses of bones with associated soft tissue, their look and size are particularly valuable in establishing age at death. The emergence and union of the epiphyses linked with lower extremity bones can also be beneficial in determining age at death, especially during adolescence **[43].**The little growing epiphyses can be difficult to recognise and recover in recovered skeletal remains, and their placement within the skeleton can be difficult to determine. The little growing epiphyses can be difficult to recognise and recover in recovered skeletal remains, and their placement within the skeleton can be difficult to determine **[44].** The ossification centres appear in the following order in main lower extremity bones: (1) femur, (2) tibia, (3) fibula, (4) metatarsals, (5) distal phalanges, (6) proximal phalanges, and (7) middle phalanges**[45, 46].** When epiphyses are nearly fully developed and in the process of merging with the corresponding diaphysis, they are most useful in skeletal age assessment processes. The proximal femur, greater trochanter of the femur, distal femur, proximal tibia, distal tibia, proximal fibula, distal fibula, metatarsals, and foot phalanges are the epiphyses of the lower limb that are most effective in age assessment. A visible line of non-union between the epiphysis and the neighbouring aspect of the bone can be seen on radiographs, indicating an ununited epiphysis. As the epiphyses fuse, these lines fade away or vanish entirely. An uneven and fracture-free articular surface is evidence of non-articulation when bones are devoid of soft tissue. It's vital to remember that between the start and finish of epiphyseal closure for each epiphysis, a significant amount of time might pass. As a result, while using literature to understand observations on closure, it's important to pay attention to the definitions of closure that is utilised**[47].** Because adolescent females mature at a faster rate than boys, sex should be taken into account when calculating the age at death from epiphyseal union. Because many sources publish data for the two sexes separately, if the sex is known, sex-specific statistics should be consulted. If the gender is unknown, the age range considered should be widened to account for the potential of either gender. Many ossification centres occur around 25% earlier in girls than in boys, according to Lewis and Garn **[48]**(e.g., approx 19 percent earlier in the knee area). Sex

differences in the time of epiphyseal union in the lower limb might range from 1 to 2 years **[49].**

Many generic literatures demonstrate correlations between age of death and the date of epiphyseal appearance and union. A radiographic atlas for age progression in the knee is provided by Pyle and Hoerr; a similar atlas is available for the foot and ankle. The Hoerr et al. radiographic atlas contains information and radiographic images of the foot and ankle in boys and females from the 38th week of pregnancy to adulthood **[50, 51].**

McKern and Stewart provide evidence of skeletal union in skeletal remains devoid of soft tissue, but only in males of military age. Rather than only the mean values, their analysis provides vital information on the variation of epiphyseal union. The head and distal end of the femur were discovered to be particularly beneficial among the epiphyses of the lower extremity **[52].** The epiphyses of the ankle and hip join before those of the knee in the lower extremities.Diaphyseal expansions into the cartilaginous extremities of the bone are known as "pseudo-epiphyses" Individuals with a leg-length difference had more age-related variation than those without **[53, 54].**

In 130 individuals from the Hamann–Todd collection, Walker and Lovejoy give radiographic data on age progression in the proximal femur and calcaneus. They give radiographic guidelines for the femur that are divided into eight phases. Each phase's radiographic images are accompanied by a detailed narrative **[55].** Adult remodelling, according to Ruff and Jones, can change asymmetry in cortical bone. Adult cortical remodelling patterns coincide with activity levels as people age. Their research on mature tibiae suggests that the loss of cortical bone during remodelling causes asymmetry alterations **[56].**However, Atkinson and Weatherell discovered that bone density varied along the femoral diaphysis, with the greatest density at the mid shaft. The density of the diaphysis changed at different points throughout its circumference. For a thorough treatise on judging ossification centres from radiographs, the reader is recommended to consult the chapter entitled Radiology of the Lower Extremity

There are a number of ways for estimating age at death using information from the lower extremity. The nature and precision of these approaches varies depending on the age of the material being investigated and the anatomical locations that can be analysed. To determine the age at death, all available data should be considered. Through childhood, long-bone diaphyseal lengths and other bone measurements are still significant in age

determination processes, however soft tissue measurements can also be informative. Additionally, as adolescence progresses, information about sex and population diversity becomes more important and must be considered when accessible **[57].**

6. Literature review

Vijay Kumar et al studied relation of fusion of skull sutures and age. Cross-sectional observational study was done in this study. Sample size was selected as 70. The researchers looked at all of the autopsy cases that were between the ages of 21 and 50 to see if there was a link between age and cranial suture closure. Sagittal coronal and lambdoid sutures were investigated for their ectocranial and endocranial closure patterns.Endocranial cranial suture fusion was more regular than ectocranial cranial suture fusion, and it was seen as early as 21-30 years old.The first suture to fuse was the coronal suture. Females were observed to have closure earlier than males. There was no clear link discovered between age and suture closures **[58].** Beauthier et al performed the control study in the elderly to estimate palantinesurutes as an age indicator. They dismantled the palatine sutures of 134 skulls (with known sex and age at death) into 15 subparts and five stages of fusion to calculate the average coefficient of obliteration which was then linked to five age classes. They used numerous regression equations to get total palatine suture scores for this investigation. They compared our findings to those obtained using the Mann technique and classically segmented and scored ectocranial suture age determination methods, on the one hand, and the Mann method on the other. Palatine sutures aren't any better than cranial vault sutures at predicting death age. Despite the fact that suture research is mainly subjective, Palatine suture observation adds to age-range estimation, especially in elderly and very elderly people, where other approaches are no longer efficient **[59].** Meindl et al determined the skeletal age at death based lateral anterior sutures. Simple ectocranial scoring of specific spots on the external table is used in this procedure. A sample of 236 crania from the Hamann-Todd Collection was used to produce composite scores for two groups of sutures, lateral-anterior and vault systems, which are utilised to provide estimations of age-at-death. Several tests suggest that the lateralanterior sutures are superior to the vault sutures, that ectocranial observation is superior to endocranial observation, and that age estimations are unaffected by race or gender. When used in conjunction with other skeleton age indicators, suture closure can yield valuable estimates of age-at-death in both archaeological and forensic

contexts **[60].** Cameriere et al studied the Carpals and epiphyses of radius and ulna as age indicators. The goal of this study, which included 150 Italian children and adolescents aged 5 to 17, was to see if the proportion of carpal area (Ca) mineralization could be utilised as a criterion for age assessment. The ratio of the total area of the carpal bones and epiphyses of the ulna and radius (Bo) to the total area of the carpal bones and epiphyses of the ulna and radius (Ca) was determined. For linear regression analysis, this ratio (Bo/Ca) was used **[61].** O'Connor et al studied Epiphyseal maturity indicators at the knee and their relationship to chronological age. The goal of this study is to determine the age at which morphological changes in the epiphyses at the knee develop in a modern Irish population using radiography. The radiographs of 221 participants aged 9–19 years (137 males; 84 females) were evaluated. Six of the seven markers showed a significant difference between boys and females at the same developmental level. For boys, the narrowest age range documented for a single grade of development was 2.2 years for Grade 2 tibial tuberosity development. The current study's findings on changing morphology of the epiphyses at the knee may be useful as a supplement to methods for assessing skeletal maturity before orthopaedic surgery or determining skeletal age in clinical circumstances where either delayed or premature skeletal maturation is suspected **[62].** Cameriere et al studied epiphyses of radius and ulna as age indicators using longitudinal data. The goal of this project is to create a novel formula for age estimation using a sample from a radiological collection of wrist bones from developing infants, children, and adolescents recorded at the Burlington Growth Centre. A total of 623 X-rays of left hand-wrist bones were evaluated by measuring the area of carpal bones and epiphyses of the ulna and radius in a group of 82 people (43 boys and 39 girls) aged 3 to 16 years. Finally, the Bayesian calibration method appears to be appropriate for determining age and its distribution in subadults based on hand-wrist maturity. It can also readily add other age predictors, resulting in a multivariate predictors-based subject distribution [63].

7. Conclusion

There will never be a single skeletal sign of age at death that accurately reflects the myriad elements that accrue with chronological age, each of which might offer valuable information to the age estimate. Any indicator that both significantly represents biological age and has informational content that is independent of other indicators, whether under

forensic or archaeological conditions, will be valuable in determining a final age estimate. The information presented above shows that cranial suture closure is such a requirement. This isn't to say that ageing through suture closure isn't risky; it certainly isn't. The age of a human can be classified as juvenile or adult depending on whether the skeleton is in the process of growth and development or is mature and in the process of degeneration. Both bones and teeth develop quickly at birth, although this process slows down significantly throughout childhood. When all permanent teeth have emerged and all epiphyses have closed, the skeletal growth and development process is complete. Biological and chronological ages aren't often in sync, especially in late adulthood. Adult age indicators highlight the degenerative changes that occur as people get older. One of the most trustworthy parts of the skeleton for adult age estimation is the pubic symphysis. Changes in the morphology of the auricular surface and sternal rib end are two more approaches. Advanced expertise and more sophisticated instrumentation are required for age estimation approaches based on bone or teeth histology investigation. When macroscopic age indications are missing, these strategies may be useful.

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