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Dental Age Estimation in Prenatal, Neonatal, and Postnatal Ages- A Review

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ABSTRACT
In forensic medicine, the age of a foetus or an infant can be determined using a plethora of methods. These techniques can be used for a variety of circumstances, including the age of living infants in clinics, the age of bodies during autopsies, or the age between the prenatal 16 weeks and the postnatal 72 weeks, human remains, with an age determination error of 0 to 1 week. if the last menstrual cycle's beginning day is known, the age of the foetus can be calculated during gestation. However, this calculation can be unpredictable due to metrorrhagia or calendar errors. Prenatal ultrasound data can also be used to estimate the foetus' age; this method, which is purely hypothetical, involves converting 2D measures of an image to 3D measurements. The role of teeth in the age estimation of fetuses or infants is unquestionable and has several advantages, as teeth start growing during the prenatal embryonic period as teeth havefewer variations than bones, and are more resilient to outside effects due to their hardness. Generally, for estimating a newborn's age and assessing their progress the parameters, head circumference, birth weight and length are frequently utilized. The purpose of this article is to examine alternative approaches to calculating chronological age in pre-nates, neonates, and postnatal ages from the level of dental development to the time of death.
KEYWORDS: *Age Estimation, Teeth, Forensic Odontology, Pre-natal, Neo-natal, Postnatal.*

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INTRODUCTION

Teeth grow in the alveolar bone sockets in the upper and lower jaws during the fetal and neonatal stages [1]. Beginning at the sixth week of pregnancy, tooth development continues until the second trimester, or around 13 weeks in utero, when mineralization in the shape of the cusp tips of the deciduous teeth becomes visible on radiographs. These tiny cusp points are kept in their crypt by soft tissues [2]. Due to the gradual apposition of enamel, dentin, and cementum matrix at specific rates, the crown and root sizes of the tooth changes linearly over a predetermined period, beginning at the start of the calcification and continuing until the hard tissues is completely formed[1]. Therefore, the age can be estimated throughout the development of the dentition with a precision of one year, and during the early stages of this time, microscopic examination of the teeth can provide the age with an accuracy of "plus or minus few days" [3]. In this group of people, age estimation is usually quite accurate.

METHODS OF AGE ESTIMATION

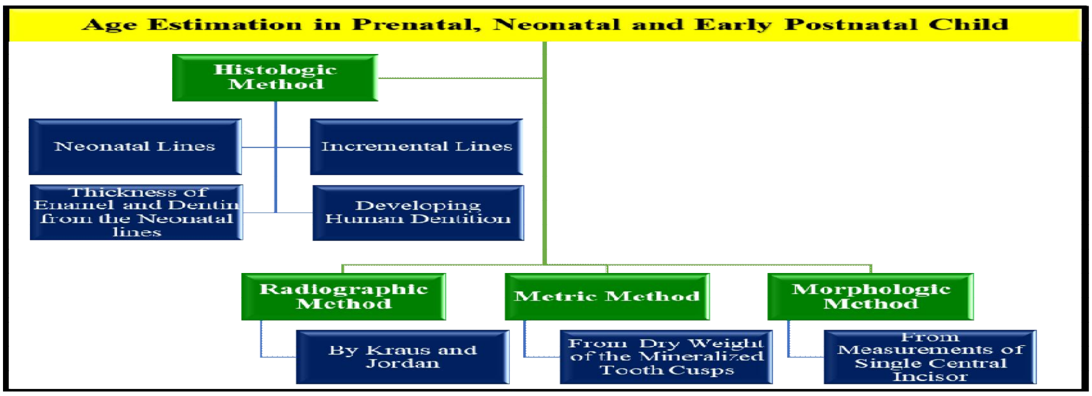

FIGURE 1: Methods of age estimation in prenatal, neonatal, and postnatal ages

There are four methods of Prenatal, neonatal, and early postnatal age estimate in children: histological method, radiographic method, from the weight of the developing dentition, and morphologic method [FIGURE 1].

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HISTOLOGICAL METHOD

The histological approach is an invasive procedure used on deceased people. Histological techniques are utilized to determine the stage of tooth development during the pre-mineralization period for the prenatal, neonatal, and postnatal periods[3]. Mineralization starts from dentin and is followed by enamel. It is presumed that calcification can be spotted histologically earlier than radiographs, as it takes more than 12 weeks to be radiologically apparent, due to the demand for an adequate amount of hard tissue deposition [4]. It is very sensitive to do a histological investigation during this period and can need radiographic support. There are various histological methods to estimate age:

1.1. AGE ESTIMATION FROM NEONATAL LINES:

Enamel, dentin, and cementum are examples of dental hard tissues that mineralize in a rhythmic incremental manner. The germs of deciduous teeth are not complete at birth, and the enamel hasn't fully hardened. The emergence of an exaggerated neonatal line, an incremental lineis caused by a change in the environment from extrauterine to intrauterine life, which causes physiological disruption in ameloblasts' cellular activity during birth.This line is a result of a change in the size, orientation, and degree of calcification of the enamel prisms brought on by biological stress brought on by a sudden environmental shift.

The neonatal line, which may be observed in histological sections, distinguishes between prenatal and postnatal enamel. Dentin also exhibits a comparable hypo-mineralized line; however, due to enamel's non-reparative nature and mineralization pattern, compared to the neonatal line in dentin, the neonatal line in enamel is more noticeable and reliable. Because the primary tooth germs and the first permanent molar begin mineralizing during the 20th week of pregnancy and continue for some time after delivery, all of these teeth have a neonatal line. Growing teeth exhibit a neonatal line, which denotes a live birth and separate life.

Under both ordinary and polarised microscopes, the scalloped neonatal line pattern found in canines and molars may be explained by the shape of the terminal secretary end piece of the ameloblasts. The decalcified portion of the enamel's superficial surface also exhibits similar scalloping, with ameloblasts visible embedded inside the concave edges. The neonatal line, which initially appeared as a scalloped line, as mineralization progresses, straightens out. These lines become more recognizable with increasing apposition of enamel.This explains why the neonatal line in the ground sections of incisors, which under a light microscope looked to be a straight line, showed up as scalloping under a scanning electron microscope. Since the neonatal line provides the baby's actual age in days, it appears that measuring the length of an infant's existence throughout the prenatal period using this baseline is more accurate.

According to evidence from recent research, neonatal lines can only be seen under a light microscope if there has been significant postnatal enamel deposition.The majority of infanticides occur immediately after birth, but it takes a few days of survival before the neonatal lines can be established, which is the main obstacle to using the neonatal line for the evaluation of postnatal survival of infants. In actuality, this implies that the neonatal line won't be visible under light microscopy until the infant has survived for about three weeks [5]. Light microscopy can generate false-negative results because this marker is not visible [4]. It can be noticed 1–2 days after the baby is born if electron microscopy is being utilized.The axis of the tooth slice, the thickness of the section, and the type of light source all have a role in the neonatal line's detection. This line often appears, although its absence does not indicate stillbirth [5].

AGE ESTIMATION FROM INCREMENTAL LINES:

Using a method outlined by Boyde in 1963, the dental developmental time may be extended beyond that which may be obtained by correlation with conventional charts. The technique depends on the identification of the neonatal line in teeth beginning at birth and calls for a microscopic examination of the incremental markings found in longitudinal ground sections of the teeth. Even if there is a minor variance across people and species, the precise period of enamel production is constant for a given person. The rate of enamel production in primary dentition ranges from 2.5 to 4.5 micrometers per day [5].

Retzius incremental lines in the enamel, von Ebner incremental lines, and Owen contour lines in the dentin, respectively, show the daily incremental deposition of enamel and dentin [3]. The number of tiny incremental lines crossing the enamel prisms is tallied up to the margin of the enamel front as it forms, beginning with the neonatal line. Given this, the cross-striation count along the prism's length between the neonatal line (also known as the birth line) and the last layer of formed enamel or dentin (also known as the death line) will show the expected age of the child on day[5]. On the basis that each increment symbolizes the accumulation of enamel over a day, the number of increments is used to signify the age in days. Additionally, certain medications like tetracycline as well as substances like lead, strontium, and fluoride will result in recognizable incremental lines. These incremental lines will aid in determining the death age. Taking ground-off portions of the teeth will allow for the study of these lines . It is hard to determine how many days have passed since the end of enamel production if the tooth showing the neonatal line has stopped growing enamel (i.e., has no enamel front that is forming). The direct age count is therefore irrelevant. However, it could be possible to move the counting process to a different tooth that was still forming its enamel when the patient passed away. The method makes the assumption that the stimulus that results in the development of a distinct incremental line affects all the teeth that are growing at the moment the stimulus takes place. A layer of enamel that was developed at the same time in different teeth will thus be represented by the location of a certain stria. Following the identification of the stria that connects all teeth, the age estimation is carried out. The number of daily increments between the neonatal line and a certain stria is calculated between a piece of a tooth that was still growing at birth. The daily increment count is continued from the same exact stria as previously until the forming enamel front is reached after transferring to a piece cut from a later forming tooth. The age on a given day will be represented by the sum of the daily increments [3].

AGE ESTIMATION BASED ON THICKNESS OF ENAMEL AND DENTIN FROM THE NEONATAL LINES:

By measuring the thickness of the neonatal line's enamel and dentine and dividing that measurement by the proper daily rate of production, Miles in 1958 was able to calculate the age at death. By dividing the observed distance by the appropriate daily rate of development, the age at the moment of death may be calculated [3]. Schour and Hoffman measured the space between the Retzius lines in 1939 and discovered that it was around 16 microns [6].

AGE ESTIMATION FROM DEVELOPING HUMAN DENTITION:

In 92 instances ranging in age from seven weeks in utero to three years old and gathered from three distinct sources, PEB Calonius et al**.** conducted research in 1970 to estimate age using histological methods in serial sections. Bone, dental, and accessory salivary gland development markers were observed. The development of the enamel, the quantity of hard tissue that forms in the crowns, the creation of the roots, and the geography of the tooth germs have all been examined and recorded. Three major groupings were created out of all the observations [6]:

a) **Gross anatomic characteristics:**Before dental development, they were employed for early intrauterine life. The upper and lower jaw primordia might be detected around the 5th or 6thweek of embryonic development. Except for the midline zone, the upper and lower jaws are developed by the seventh week. The gross anatomical features were not recorded in this investigation, despite the fact that they were beneficial, because histological examination was preferable to gross or radiographic examination.

b) **Developmental characteristics:** Even though development is a succession of slow changes, several phases may be seen in the growth of the salivary glands, the mineralization of the bones and teeth, and the maturation of the enamel.

c) **Topographic characteristics:** These qualities were helpful in interpreting the autopsy evidence. Teeth were identified and anteroposterior connections were established using the link between the glandular and adipose tissue of the palate, as well as the relative size and arrangement of the nearby tooth germs.

The degree of enamel maturation has been defined as the primary histologic criterion in this study for age determination. The protein of the matrix experiences a rise in solubility throughout maturity, presumably as a result of partial breakdown brought on by enzymatic degradation or the protein's thixotropic characteristics. The occlusal to the cervical regions of the body seemed to mature first. Only 0.2 percent insoluble protein remained in mature enamel's organic matrix in decalcified areas. The quantity of enamel matrix is still a helpful indicator of age [6].

RADIOGRAPHIC METHOD

The non-invasive and simple radiography approach plays a significant role in the legal ramifications of infanticide and foeticide. Because of the level of calcification and occlusal eruption, age assessment using radiography is thought to be more feasible. According to radiographic studies, the mineralization of deciduous incisors begins during the fourteenth and sixteenth week of intrauterine life. On a radiograph, tooth germs may appear radiolucent before starting to mineralize; successive radiographs of the mandible will show deciduous teeth at various levels of calcification depending on the fetus's prenatal age [7]. In the mandibular anterior teeth, which were radiographed at the 26th week of intrauterine life, there is advanced mineralization.Two cusps of the deciduous first molar's mineralized outline, one cusp of the deciduous second molar's outline, and the crypt of the permanent first molar are all visible. The mandibular front teeth's 3/5 crown complete is seen on a radiograph of the fetus obtained during the 30th week of intrauterine life, and the deciduous first molar cusps have fused. The five-cusped primary second molar is visible, while the permanent first molar shows no signs of calcification. The radiograph of a newborn fetus indicates that the first and second molars, which are deciduous, have entirely fused cusps, while the second molar, which is also deciduous, lacks continuity across the occlusal surface. The first permanent molars begin to mineralize around 32 weeks [8]. Kraus and Jordan conducted one of the first research in this area in 1965. They observed early mineralization in a number of deciduous teeth as well as in permanent first molars while observing the tooth development in 95 fetuses. Mesiodistally, calcification advanced more quickly than vertically. Mesiobuccal, mesiolingual, distobuccal, and distolingual cusps of the molar teeth of the maxilla and mandible underwent calcification first. Roman numbers I to X were used to represent the 10 phases of the evolution; the IX stage had three substages, and the X stage had five substages [10].

METRIC METHOD

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MORPHOLOGIC METHOD

The emerging status of deciduous teeth has often been utilized in forensic inquiry to determine the age at death. With a ±1-month disparity between estimated and chronologic ages, it was discovered that the age estimates were accurate for growing deciduous teeth. Due to the increased rate at which tooth length changes, the projected precise age at which deciduous teeth begin to erupt is often greater than that of permanent teeth. Sema et al**.** claim that dimensions of a single central incisor, the first tooth in the deciduous dentition to erupt, can be used to estimate the age of a fetus and an infant. These measurements include the mesiodistal (MD), buccolingual (BL), crown height (CH), crown thickness (CT), and root height (RH).The two key steps for determining a given age are calcification and root development. Before root creation begins, it is believed that the crown thickness may be calculated; once root formation has started, the height of the root can be measured rather than the crown thickness. Around 44.45 0-2 weeks, the central incisor's root growth begins. It follows that when calculating the ages of foetuses and babies, 44.45 weeks is an appropriate time frame. The age calculation for the fetal and newborn age groups is shown to be accurate within 0–2 weeks using the four age formulae provided by this study for a link of age with tooth dimensions [4].

Regression formulas [4]:

Age = 44.45 + 8.186 RH

<u>For maxillary central incisors:</u> Age = 17.785 – 2.026 sex + 4.978BL + 0.744 CT

<u>For mandibular central incisors:</u> Age = 20.703 – 3.293 sex + 5.407 BL + 1.671 CT

CONCLUSIONS

The human fetal age estimation comes under great medicolegal consideration. It is always crucial that the remains be presentable in order to use the features to determine the gestational period with accuracy. The majority of the information regarding dental growth is based on formative and developmental changes, which are thought to be effective age predictors from conception until the early twenties. Several sequences have been seen, including the growth of soft tissue, mineralization of histology samples, the gradual creation of enamel and dentin, the eruption of teeth into the dental cavity, and the apical closure of roots.

LIST OF ABBREVIATIONS

SEM: Scanning Electron Microscope
MD: Mesio-Distal
BL: Bucco-Lingual
CH: Crown Height
CT: Crown Thickness
RH: Root Height

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