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Age Estimation via Orocraniofacial Based on Direct Observation and Radiography

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Abstract

Determining the estimated age in forensics is very important because it involves legal accountability. The method of determining age estimation can be done by direct measurement of the orocraniofacial bone or by using radiography. This article examines theseveral studies as well as parameters for determining age estimation using orocraniofacial. Search for published articles on Elsevier, Pubmed, Google Scholar, Research Gate, and NCBIon range2007-2021 years. The results show that it is more advisable to determine the age estimate by direct measurement compared to using radiography because it is prone to distortion.

Introduction

Estimation of an individual's age has become an important part of forensic practice in recent decades. Forensic age estimation is needed to identify remains or skeletal finds. On the other hand, age estimation is very important as a form of legal responsibility for an individual, for example in individuals without legal documents, cases such as child labor, child abuse, child marriage, child adoption, kidnapping, and crimes committed by teenagers. The significance of the criminal decision may determine whether the case is filed in juvenile court or vice versa. When a child commits an offense, it is very important to know the age of the perpetrator and victim. In several countries there are cases of children whose birth dates have not been clearly recorded. In 2012 the United Nations Children's Fund (UNICEF) reported that there were around 230 million children under five whose births had not been recorded throughout the world (Yalcin & Bozan, 2020).

Methods

The method used to determine orocraniofacial age estimates can be done by taking direct measurements of the orocraniofacial bones or by using radiography. Analysis of determining individual age estimates using panoramic radiography has shown significant results to show changes related to age and gender. In this way, radiography becomes a useful tool in studies designed for age estimation and sex determination. However, several studies show that the method of determining an individual's age using radiography can cause distortion so that the measurement results become inaccurate. Another method that can be used is by carrying out direct measurements on the skeleton (Cummaudo et al., 2021). This method can be used to avoid distortions that can occur using the radiographic method, but if using the direct measurement method, the researcher must know information about certain orocraniofacial patterns that indicate determination. exact gender and age estimation. Because of the importance of choosing a method to determine an individual's age estimate, an appropriate method is needed so that the measurement results obtained are accurate. In this article, several studies and parameters for determining age estimation using orocraniofacial will be reviewed. This literature review is an attempt to summarize orocraniofacial parameters that can be used to determine age estimates either through direct measurements of the orocraniofacial bones or radiographs.

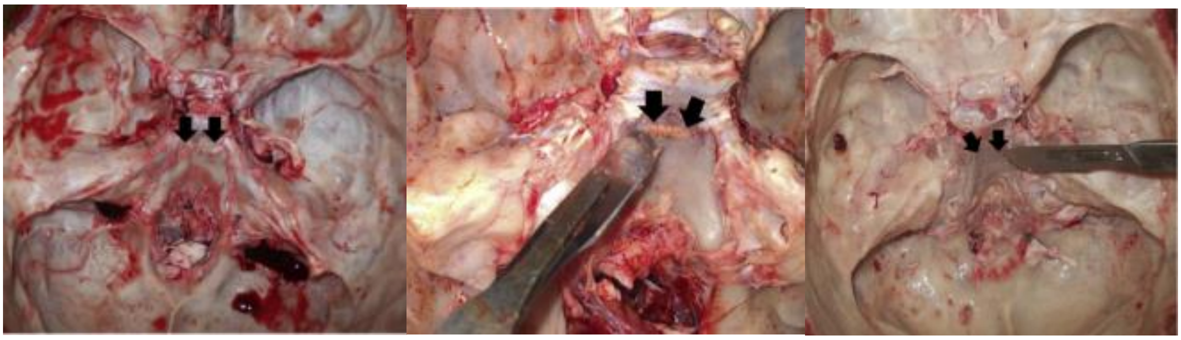
Result and Discussion

Direct Orocraniofacial Measurements

Spheno-Occipital Suture

The fusion condition of the spheno-occipital synchondrosis is suggested as a reliable indication of age. Nevertheless, there is a lack of consensus about the extent of suture closure seen, which is influenced by the technique of evaluation (such as direct inspection, imaging, or histological analysis) and the expertise of the investigator (either in forensic pathology or anatomy). Furthermore, it is probable that genetic and cultural variables have a substantial effect in defining the arrangement and sealing of cranial sutures.

The length of the suture cartilage slice was quantified and the firmness was assessed using a scalpel. The measurement findings are categorized into three groups: (1) Open: Open suture or less than 1/4 that has calcified; (2) Semi-closed: More than 1/4 and less than 3/4 of the cartilage has calcified; (3) Closed: More than 3/4 has calcified.



a b c

Figure 1. The base of the skull shows an open spheno-occipital suture (A); The base of the skull shows a semi-closed spheno-occipital suture (B); The base of the skull shows a closed spheno-occipital suture (C)

Source: Pate RS, Tingne CV, Dixit PG. Age determination by spheno-occipital synchondrosis fusion in Central Indian population.

A study conducted in India has found that when the synchondrosis is fully fused, males are typically older than 15 years. On the other hand, when there is partial or no fusion, boys tend to be less than 19 years. Similarly, in the case of females, if the synchondrosis is fully fused, it indicates an age of over 13 years. On the other hand, if there is partial or no fusion, it suggests an age below 17 years.

Palatine Suture

The complete elimination of the four maxillary sutures, specifically the incisor suture, anterior median palatine suture, posterior median palatine suture, and transverse palatine suture. The minimal age for determining if the incisor suture is destroyed is 20 years. Examine for any damage or erasures in the back stitching of the median palatine (PMP), transverse palatine (TP), and anterior median palatine (AMP). If the 3 sutures are not obliterated, the anticipated age range is 20-24 years. Complete eradication of PMP, followed by a minimum age requirement of 29 years. Obliteration occurs within the greater palatine foramen (GPF), thereby indicating a minimum age of 30. The obliteration of the TP is less than 50%, followed by those aged between 30 and 40 years. If the obliteration of TP is greater than 50%, then the minimum age required is 41 years. AMP does not cause any noticeable obliteration, hence it is suitable for anyone under the age of 50. If TP exhibits complete obliteration, including obliteration in the internal and posterior meningeal arteries, and even if there is obliteration in only a 1 cm segment of the anterior meningeal artery, the minimum age for such obliteration to occur is 50 years. If the AMP obliteration is greater than 50%, then the minimum age required is 50 years.

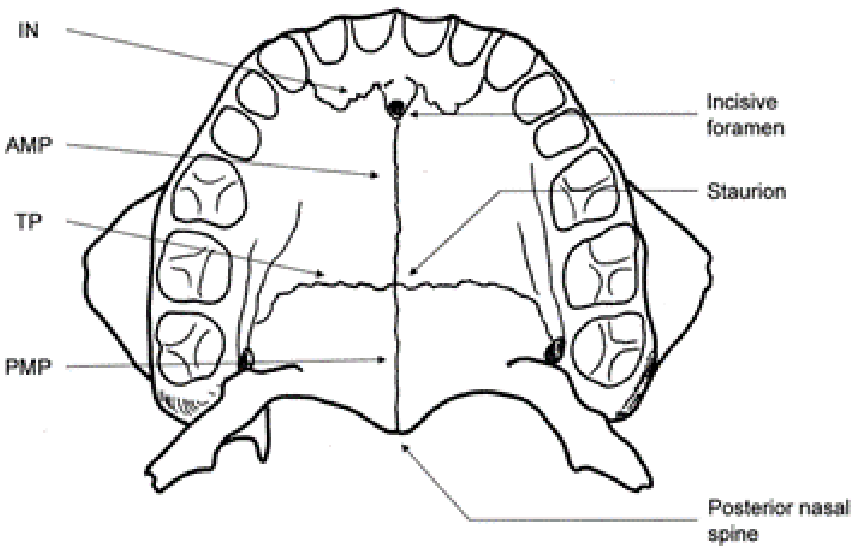


Figure 2. Front view of palatine suture

Table 1. Five Age Classes of Palatine Sutura Measurement

Age Class	Age Interval (years)	Age Group
I	≤ 20	Infants and teenagers
II	21-39	Young adults
III	40-59	Adult
IV	60-79	Old adults
V	≥ 80	Adults are very old

Endocranial and Ectocranial Sutures

The Acsádi & Nemeskéri (1970) approach use a 5-point scale (ranging from 0 to 4) to evaluate 16 portions of the endocranial suture. 0 (suture open): denotes the portion of the suture where there is still a gap between the margins of the adjacent bones. 1 (incipient closure): exhibits a suture that is fully closed without any indication of gaps, yet remains distinctly visible as an unbroken line. 2 (closure in progress): indicates the suture line has been disturbed, resulting in full obliteration without any identifiable sutures, or occasionally with closure in certain areas but not yet in others. 3 (advanced closure): indicates the presence of dots only at the suture line, resembling punctuated dots on paper. 4 (closed suture): denotes total obliteration, with no discernible location.

The endocranial suture consists of 16 sections, with the coronal and lambdoidal sutures being separated into 3 equal portions on each side. The sagittal suture is symmetrically bifurcated.

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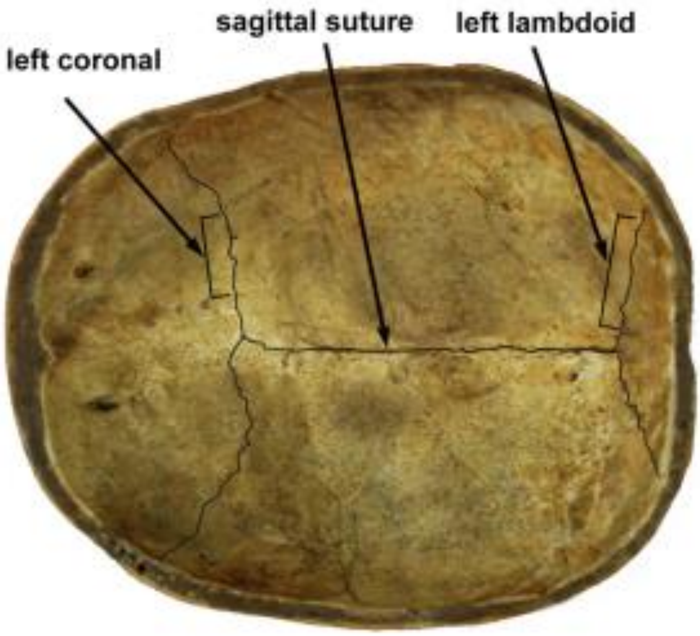

Figure 3. Endocranial Sutura

Table 2. Sagittal Suture

Sagittal Suture				
	S1	**S2**	**S3**	**S4**
Ectocranial (Age by year)	61-65	61-65	61-65	46-50
Endocranial (Age by year)	61-65	46-50	41-45	26-30

Table 3. Coronal Suture

Coronal Suture			
	C1	**C2**	**C3**
Ectocranial (Age by year)	61-65	>70	>70
Endocranial (Age by year)	56-60	51-55	36-40

The Meindl & Lovejoy (1985) study employed a technique that involved analyzing the closure of 10 ectocranial sutures using a 4-point scale (ranging from 0 to 3). 0 (open): no obliteration observed on the outer edge of the skull. 1 (minimum closure): signifies a little to moderate amount of closure in the form of a bone connection along the suture, with up to 50% reduction in size on that side. 2 (substantial closure): Over 50% of that side has closed, however certain areas of the suture remain open and visible. 3 (full obliteration): signifies the total closure of the suture on that particular side.

The length of the suture on 10 sides of the cranial vault (V) and lateral anterior (LA) sections, measured in centimeters, was assessed.

Table 4. Lamboidal Suture

Lamboidal Suture			
	L1	**L2**	**L3**
Ectocranial (Age by year)	51-55	61-65	61-65
Endocranial (Age by year)	41-45	51-55	66-70

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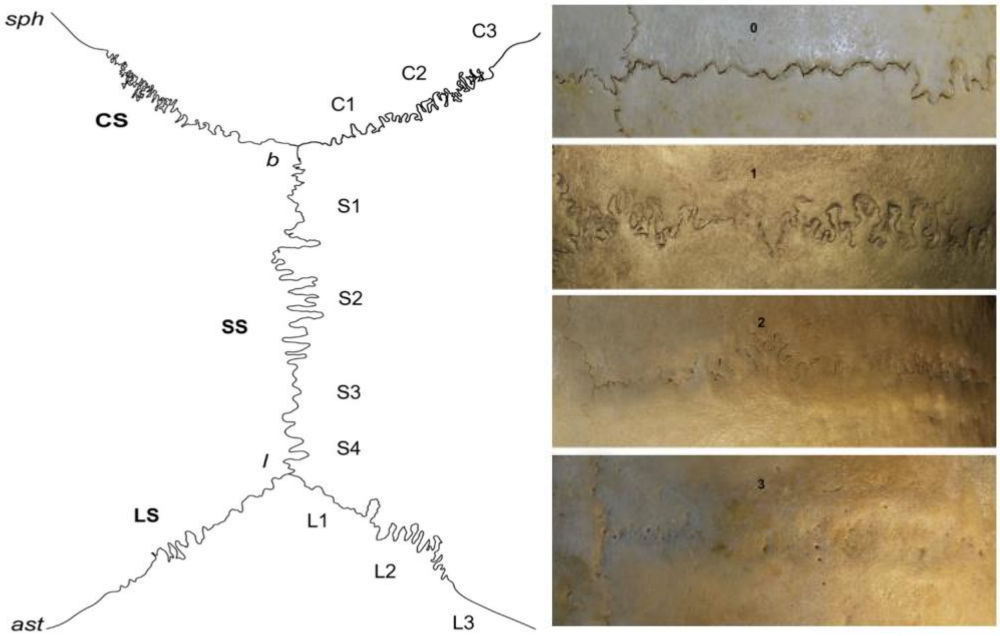

Figure 4. Suture

Table 5. Temporoparietal Suture

Temporoparietal Suture	
Ectocranial (Age by year)	>70
Endocranial (Age by year)	66-70

Gonial Angle

The gonial angle was determined by measuring the angle between the base of the mandible and the posterior border of the ramus using a protractor scale (Ruengdit et al., 2020). The protractor was positioned over the mandibular angle such that the base of the protractor aligned with the base of the mandible. Angles are measured and expressed in degrees.

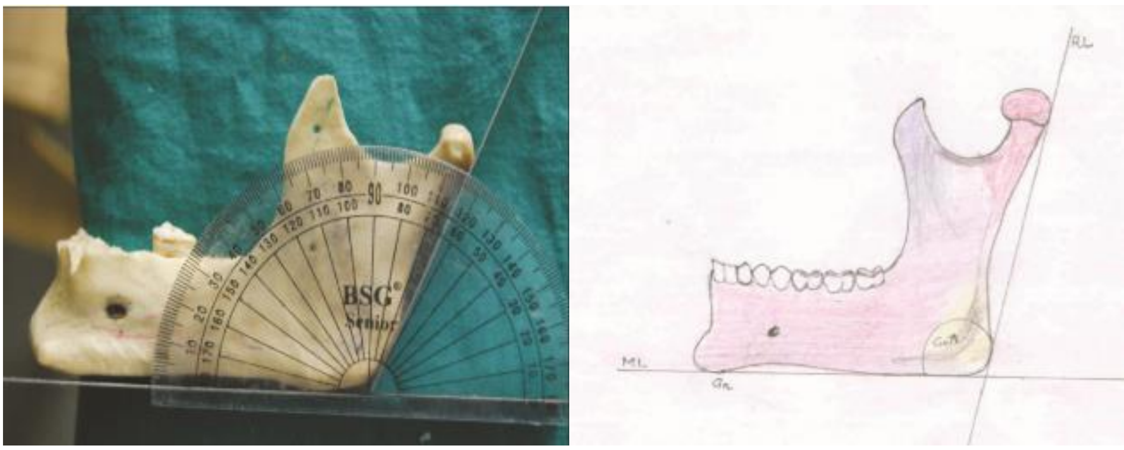

Figure 5. Anthropometric methods used in the determination of gonial angles

Measurement based on Radiography

Gonial angle using Panoramic

The initial characteristic evaluated using panoramic radiography is the gonial angle. The gonial angle is created at the point where anteroposterior tangents cross with vertical lines. The ramus line (RL) is determined by measuring the distance from the back of the mandibular condyle

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processus to the lower border of the ramus, following the posterior boundary of the ramus (Parinduri, 2018). The mandibular line (ML) is a line that is drawn forward along the lower edge of the mandibular body through the gnation, which is the midway at the base of the mandible in the sagittal plane. The Gonial Angle (GA) is determined by the point where the RL and ML cross (Thompson & Black, 2006).

Figure 6. Measure Gonial Angles

The gonial angle contributes to the facial contour and appearance of an individual. Various variables, including diet, hormones, and masticatory muscle activity, can impact the development of the gonial angle in the mandible (Embriologi & Mulut, 2018). The alterations in the gonial angle can serve as a reliable measure of mandibular development in the field of orthodontics. In addition, the gonial angle can serve as a measure for observing morphological changes in the mandible that occur with advancing age (Akhlaghi et al., 2010). The mandible will undergo age-related modification. The process of remodeling can induce alterations in the morphology of many regions of the mandible, including the gonial angle, antegonial angle, mental foramen, mandibular foramen, and mandibular canal. As one ages, the gonial angle tends to decrease (Leversha et al., 2016).

Ramus Height and Bigonial Width using Panoramic

The height of the ramus is determined by measuring the distance between the highest lateral point and the lowest lateral point on the back border of the ramus. Bigonial breadth is measured as the linear distance between the right and left gonials. The height of the Ramus and the width of the Bigonial often expand as a person gets older (Shah et al., 2020; Leonardelli et al., 2021; Damera et al., 2016).

Panoramic radiography has several benefits, including its extensive coverage, little radiation exposure for patients, and quick picture capture. Furthermore, this approach has the benefit of avoiding any interference caused by overlapping images (Pate et al., 2018). Additionally, it allows for precise and consistent measurement of specific spots through contrast, brightness augmentation, and picture magnification (Pillay et al., 2017). The drawbacks of this technique include geometric magnification and distortion, where the vertical dimensions differ somewhat from the horizontal dimensions. Additionally, the method is very susceptible to location mistakes due to the relatively tiny picture layer. The research done by Beauthier et al. (2010), asserts that panoramic radiography is employed for the assessment of mandibular asymmetry, however many diagnoses are consistently present.

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Figure 7. Measurement of ramus height and bigonial width

Gonial Angles using Cephalometry

The individual's occlusal condition and age exert an impact on changes in mandibular morphology. As individuals age, the mandibular bone undergoes a process of remodeling. The morphology of the mandible, particularly the gonial angle, is associated with the function and form of the masticatory muscles. The measurement of gonial angles was conducted on lateral cephalometric radiographs with a mathematical protractor (Upadhyay et al., 2012).

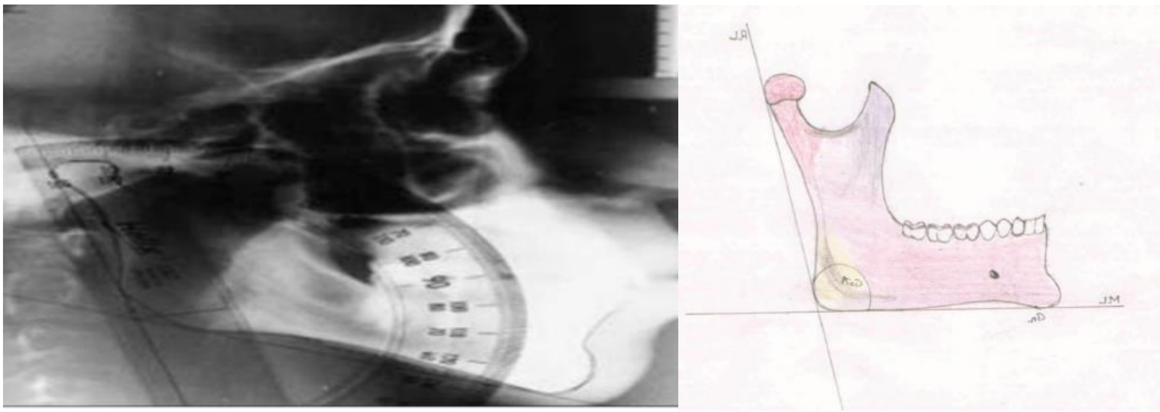

Figure 8. Radiographic methods used in the determination of gonial angles

Mandibular Condyle Correction using CBCT

The formation of the mandibular condyle is intricately linked to the maturation and progression of the mandible. The pictures are assessed and categorized based on the disparity in density between the cortical bone around the condyle and the adjacent regions. The correction of condyles can be described in three steps (Wardhani et al., 2015). (a) Type I: No correction in condyles; (b) Type II: Bone that is on the superior surface of the condyle looks less dense than the structure around the condyle; (c) Type III: The surface of the condyle looks similar or its density is higher than the surrounding cortical area.

Lei et al.'s research shown that the development of cortical bone in the subchondral region occurs initially in males between the ages of 13 and 14, and in girls between the ages of 12 and 13. Ossification of cartilage does not occur till the individual reaches the age of 20-25 years. Arnett observed that the process of cortication in the condyle took place between the ages of 15-16 years. If the condyle did not undergo cortication, it was considered immature (Bayrak et al., 2018).

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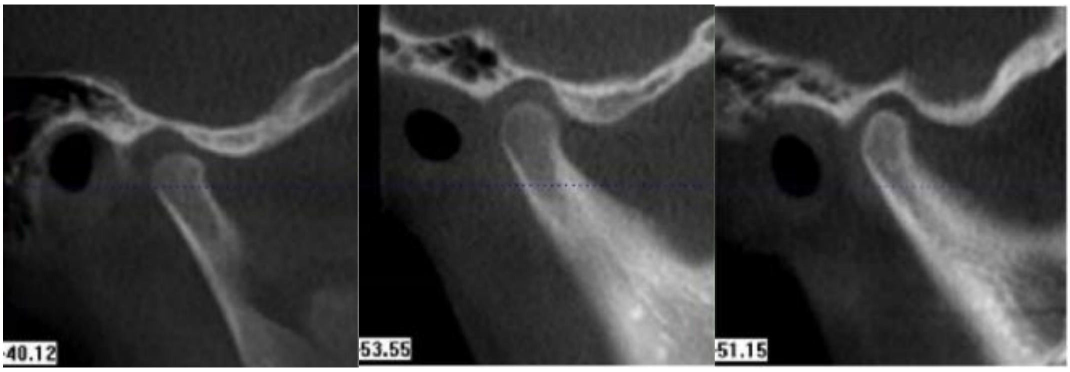

Figure 9. Types of mandibular condyle correction in the sagittal cone-beam computed tomography (CBCT): Type I, Type II, Type III

Articular eminence cortication using CBCT

The formation of the articular eminence is influenced by the functional stimulus exerted by the condyle, which can subsequently lead to changes in the depth of the glenoid fossa. The development of the articular slope and height is typically finished by the age of around 20. The density contrast between the articular eminence and surrounding regions near the condyle is categorized into three distinct stages (Aps, 2019): (a) Type I: The surface of articular eminence appears to have the same or higher density compared to the surrounding cortical area; (b) Type II: The surface of articular eminence appears to have a lower density than the surrounding cortical area; (c) Type III: Articular eminence is not corticated (Yalcin & Bozan, 1985)

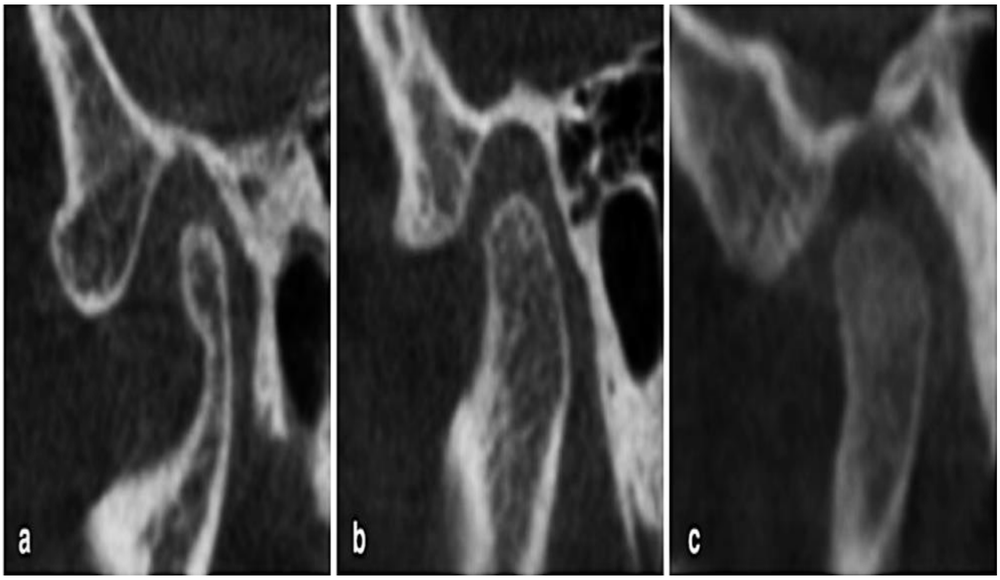

Figure 10. Types of articular eminence correction through cone-beam computed tomography (CBCT): Type I, Type II, Type III

Conclusion

Determining individual age estimates using orocraniofacial parameters is very helpful in the forensic identification process. To determine an individual's age, there are two methods that can be used, namely using direct skeletal measurement methods and using radiography. Orocraniofacial parts that can be measured directly on the skeleton include the sphenooccipital suture, palatine suture, endocranial suture and ectocranial suture. The sphenooccipital suture has a higher level of accuracy for determining age estimates when compared to other types of suture. The palatine suture has a low level of accuracy because the closure pattern cannot be known for certain and there are many variations. Meanwhile, the endocranial suture has a higher level of accuracy when compared to the ectocranial suture.

Radiographic methods that can be used to determine age estimates include panoramic, cephalometric, or CBCT. The radiographic method is usually used when using the mandible as a measurement parameter. The CBCT radiographic technique is considered to have a higher level of accuracy than the panoramic and cephalometric techniques. Panoramic radiography and cephalometric techniques can experience distortion in the imaging results, which can make measurement results inaccurate.

Several studies consider that direct or clinical methods are more accurate when compared to radiographic methods. This is due to the bias that can be caused when using radiographic imaging. However, it is possible that there will be observation errors when using the direct method, resulting in bias in determining age estimates. Therefore, it can be concluded that the selection of indicators for determining age must also be accompanied by the selection of an appropriate measurement method so that errors in determining age can be minimized.

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