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Review Article

DENTOMAXILLOFACIAL RADIOLOGY IN FORENSICS- A REVIEW

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ABSTRACT

Radiology has been used extensively in conventional dental identification, anatomically based identification and identification using maxillofacial skeletal landmarks.1Radiographs carry great evidence to act as antemortem records and also assist in identifying the persons age, gender, race, etc. Forensic dentistry is also emerging as a new branch in forensics. Forensic dentistry is an emerging new branch in forensics in which forensic dentist must be aware of different techniques and resources to incorporate the technology in order to achieve success in human identification. So, expertise knowledge and proper application of maxillofacial radiological techniques hasa valuable role in forensic identification and solvingmedico-legal cases.[2] The purpose of this paper was to revisit the methods where radiographic methods may be used to determine identity of an individual using craniofacial structures.

INTRODUCTION

Forensic maxillofacial radiology is a specialized area of medical imaging utilizing radiological images pertaining to the law.The importance of maxillofacial radiographic techniques in clinical forensic medicine is widely recognized.[1,2,3] Forensic radiology comprises the performance, interpretation and reporting of diagnostic radiological data. The indication of radiology in forensic sciences have been started over a century since a radiograph was initially introduced as evidence in a court of law and now have expanded with new technologies and techniques for capturing radiographic images with great ease[4,5]. Forensic science deals with the identification of the dead using numerous techniques. Forensic odontology has a lot of scope in human identification which include the Methods like rugoscopy, bite marks, , photographs, chieloscopy etc. are used for identifying the individuals.[5]Most of these methods rely largely on the preservation of soft-tissue components of the body in question and cannot be used if the remains are burnt, decomposed, mutilated, and destroyed.In the human body, teeth and facial bones are resilient and withstand the decompositional/ destructional forces well even under extreme forces and/ or temperature variations. As radiographs are able to capture their distinct anatomical features, they become an invaluable tool in forensic sciences. Radiographic identification has long been in use and the technique is efficient, comparatively easy, records can be obtained in both living and dead, and is economical than DNA technology.[6]

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Now-a-days, forensic radiology is evolving as a branch of forensic dentistry, in which radiographs play a vital role in identification of the living and dead.[2] Comparative identification utilizing dental radiographs is now common in the evaluation of human remains. When the identity is suspected, and comparative means of identification are contemplated, the basic algorithm for dental radiographic identification is: (1) examine the ante mortem radiographs for quality, type and time of examination; (2) examine the post mortem specimen and expose radiographs that will duplicate the areas of interest seen in the ante mortem films using similar image geometry, suitable exposure factors and archival processing; (3) use a system of marking or mounting the films so that their identity as post mortem or ante mortem films is known; (4) visually analyze the radiographs, taking into account ancillary information such as dental chart notations, dental models and photographs; (5) tabulate the points of concordance and explain, if possible, discordant points between the ante mortem and post mortem radiographic examinations; (6) make a decision as to whether the materials provided allow the observer to make a positive identification, a possible identification or a negative assessment (no identification).[1]

1895	Discovery of X-rays	Wilhelm Conrad Roentgen
1896	X-rays to visualize the lead bullets in the head of a dead person. (GREAT BRITAIN)	Prof. Arthur Schuster
1898	Issue of the American X-ray Journal	Dr.Fovaud'Courmelles
1921	compared the radiographs of the frontal sinuses	Schuller
1927	complete radiological identification of the skull by using pneumatic air spaces of the sinuses	Culbert and Law

The discriminatory individuality of the human dentition is well documented in the seminal work of Adams [7,8] and the reliability of dental radiographic identification is well documented in the literature either using conventional dental radiographs [9,10] or in web-based digital models. [11,12]

Historical Milestones in Forensic Radiology[2]

Forensic odontology

"Forensic odontology is the branch of dentistry which in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings."(Federation Dentaire International 1995 – FDI)[13]

Forensic odontology has three major areas of utilization:
(1) Diagnostic and therapeutic examination and evaluation of injuries to jaws, teeth and oral soft tissues, (2) Identification of individuals, especially casualties in criminal investigations and/or mass disasters, and (3) Identification, examination, and evaluation of bite marks which occur with some frequency in sexual assaults, child abuse cases, and in personal defense situations.[5]

Forensic Identification:[14]

Forensic Identification is a process which involves different procedures and techniques to confirm an subject or person in both living and deceased conditions.

Conditions that demand identification are:

- Medico-legal cases.
- Natural disasters like tsunamis, earthquakes, explosions, etc.
- For confirming death in monetary issues.
- Religious and social purposes.

Dental Identification

Dental identification is based on comparison and exclusion of the radiographs exposed prior to death (antemortem) to those exposed after death (postmortem). This data is assessed based on factors like teeth present, teeth missing, crown structure, root morphology, pulp anatomy, occlusion, wear and tear of tooth structure, pathology, different treatment procedures, etc. Proper comparison and interpretation of these factors leads to successful identification.[3,8]

The American Board of Forensic Odontology (1986)[9] has given the following four situations regardless of the factors and methods used in comparing ante- and postmortem radiographs:

Positive Identification: Comparable items are sufficiently distinct in the ante- and postmortem databases; no major differences are observed.

Possible Identification: Commonalities exist among the comparable items in the ante- and postmortem databases, but enough information is missing from either source to prevent the establishment of a positive identification.

Insufficient Identification Evidence: Insufficient supportive evidence is available for comparison and definitive identification, but the suspected identity of the decedent cannot be ruled out. The identification is then deemed inconclusive.

Exclusion: Unexplainable discrepancies exist among comparable items in the ante- and postmortem databases.[15]

Maxillofacial Radiology in Forensics

- Age estimation
- Gender determination
- Personal identification

Age Estimation

Age Estimation is an important step in constructing a biological profile from human skeletal remains. Age estimation rooted on tooth morphology can be broadly categorized as

1. Morphological methods are further sub-classified as clinical, histological and biochemical examination.
2. Radiological evaluation offers certain advantages over morphologic analogue, most importantly by allowing both *in vitro* as well as *in-ivo* studies.

Conventional radiographic methods of age estimation pose a variety of pitfalls such as processing and magnification errors, storage for longer duration and image transfer are the significant disadvantages. Though the shortcomings with these various methods are few, the discrepancies associated with them are to be weighed cautiously to make forensic odontology a more accurate and reliable.[16]

Dental Age Estimation Methods[17]

Various methods are utilized for determination of age from dentition. Age assessment methods are classified as:

According to the state of development of the dentition

1. Methods applied to the Forming dentition
2. Methods for the fully formed dentition. (ADULT)

According to the Technique of investigation

1. Clinical or visual
2. Radiographic
3. Histological
4. Physical and chemical analysis

Radiological Age Assessment Parameters:[16,18]

1. Jaw bones pre-natally;
2. Appearance of tooth germs;
3. Earliest detectable trace of mineralization or beginning of mineralization;
4. Early mineralization in various deciduous teeth
5. Degree of crown completion;
6. Eruption of the crown into the oral cavity;
7. Degree of root completion of erupted or unerupted teeth;
8. Degree of resorption of deciduous teeth;
9. Measurement of open apices in teeth;[16,19]
10. Volume of pulp chamber and root canals/formation of physiological secondary dentine tooth-to-pulp ratio;
11. Third molar development (Digitization of the available radiographs for analysis of images to obtain the dental information)

Radiological Age Assessment

Analysis of these various radiographic features in the dentition of an individual corresponding to the phase of human development aids in age determination.[16,20]

Age estimation is grouped into three phases

1. Pre-natal, neonatal and post-natal;

2. Children and adolescents; and
3. Adults.

For age Determination, two Methods are Commonly used

''ATLAS METHOD'' - in which radiographic dental development (mineralization) is compared with published standards

''SCORING METHOD'' -, in which dental development is divided into various stages and the scores that are evaluated through statistical analysis.[16,21]

Pre-Natal, Neonatal and Post-Natal Age Estimation[22]

Radiographically, the mineralization of deciduous incisors starts at the (16th week) of intrauterine life. A radiograph of the mandible of the foetus taken at the 26th week of intrauterine life shows advanced mineralization in anterior teeth. The mineralized outline for the two cusps of the deciduous first molar, the one cusp outline for the deciduous second molar and the crypt of permanent first molar are seen.

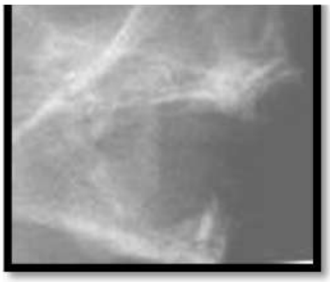


Fig 1 Radiograph of upper and lower jaws of a fetus at the 16th week of I.U showing the initial mineralization of deciduous incisors

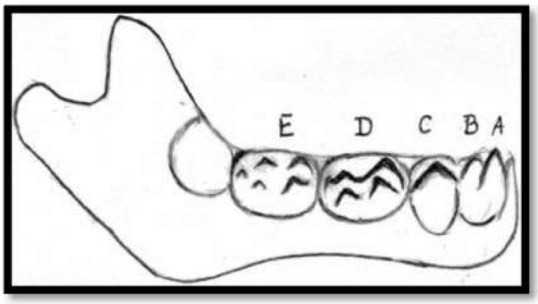


Fig 2 Diagrammatic representation of a radiograph of a mandible 30th Week of I. U shows 3/ 5 crown completion for anterior teeth, the fused cusps of deciduous first molar, five cusps of the deciduous second molar and the crypt of permanent first molar with no evidence of mineralization

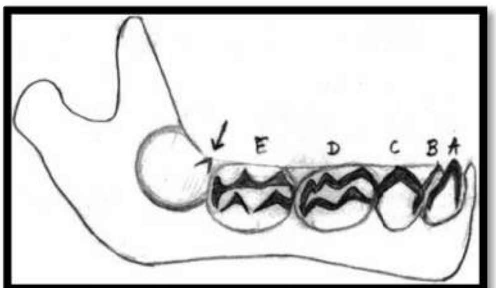


Fig 3 Completely fused cusps for deciduous first and second molar, and within the crypt of permanent first molar there is evidence of one mesial cusp tip

Stages by Kraus and Jordan: 1965[23]

Kraus and Jordan studied the early mineralization in various deciduous teeth as well as in the permanent first molar in the intrauterine life.

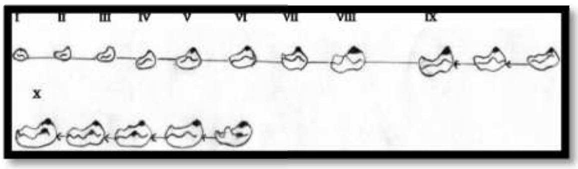
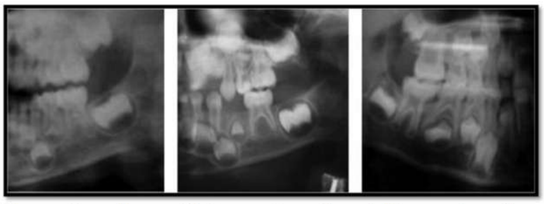


Fig 4 Stages by Kraus And Jordan

Developmental stages of lower deciduous first molar by Kraus and Jordan. The development is described in 10 stages denoted by Roman numerals from I to X; the IXth stage includes 3 stages and the Xth stage includes five stages

Age Estimation in Children and Adolescents[24]

Dental age estimation in children and adolescents is based on the time of emergence of the tooth in the oral cavity and the tooth calcification.The radiographic analysis of developing dentition, especially when there is no clinical evidence available (2.5–6 years) as well as the clinical permanent tooth emergence in various phases, will help in age determination.



a) 2 years 6 months, (b) 3 years 9 months (c) 6 years 8 months

Fig 5 Age estimation in various phases

Methods applied for age determination in children and adolescents:[16]

1. Schour and Masseler method (1941)
2. Nolla's method (1960)
3. Moorees, Fanning and Hunt method (1963)
4. Demirjian, Goldstein and Tanner method (1973)
5. Cameriere' s method of Age estimation using open apices (2006)

Schour and Masseler Method (1941)[25]

They have their origin in work by LOGAN AND KRONFIELD, which was carried out in 1933.These charts do not have separate surveys for males and females.

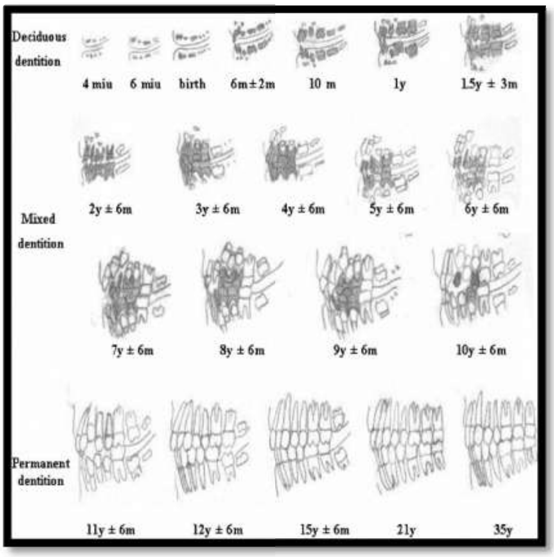


Fig 6 Dental development chart by Schour and Masseler (American Dental Association, 1982).

In 1941, Schour and Masseler studied the development of deciduous and permanent teeth, describing 21 chronological steps from 4 months to 21 years of age and published the numerical development charts for them. The American Dental Association (ADA) has periodically updated these charts and published them in 1982 making it possible to directly compare the calcification stages of teeth on radiographs with the standards.

Fig 7 Cropped radiographic images showing dentition in various stages of development corresponding to given age of person (5 years and 5 months)

Nolla's Method (1960)[26]

Nolla evaluated the mineralization of permanent dentition in TEN STAGES. The method can be used to assess the development of each tooth of the maxillary and mandibular arch. The radiograph of the patient is matched with the comparative figure. After every tooth is assigned a reading, a total is made of the maxillary and mandibular teeth and then the total is compared with norms of upper and lower teeth. The advantages of this method are that it can be applied to an individual with or without the third molar and that females and males are dealt with separately.

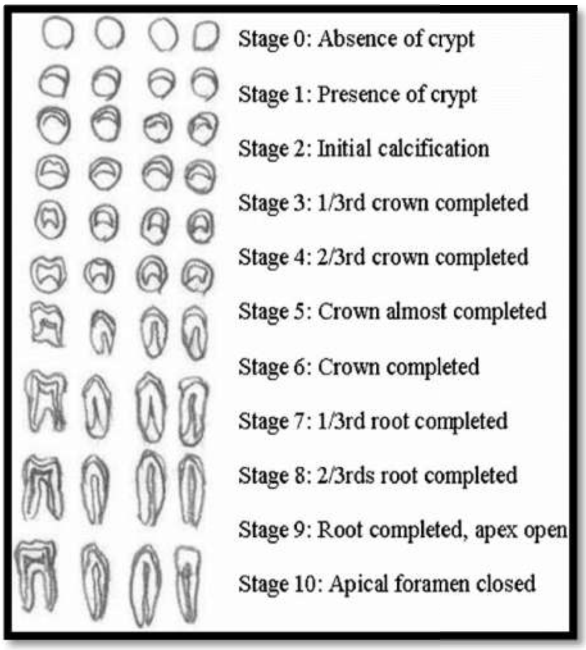


Fig 8 Nolla's Method

Moorees, Fanning and Hunt Method (1963)[27]

In this method, the dental development was studied in the 14 STAGES of mineralization for developing single and multirooted permanent teeth and the mean age for the corresponding stage was determined and compared with the mean age table formulated for male and females. Moorees *et al* used panoramic radiographs or lateral oblique radiographs for their study. The earliest age in the survey was 6 months and the data also include the development of the third mandibular molar. Notably, female development was ahead of the male and the root formation stages showed variation compared with crown formation stages.

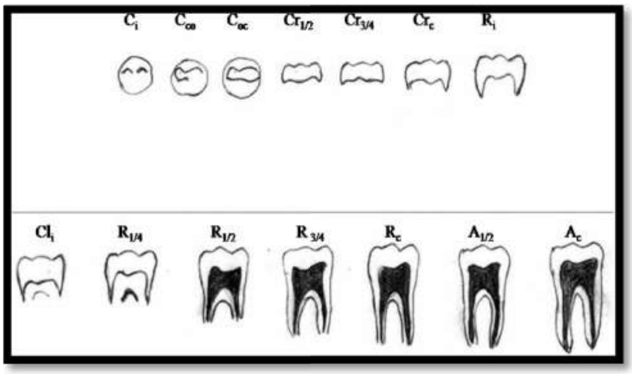


Fig 8 Mooree's Method

Demirjian, Goldstein and Tanner Method (1973)[28]

Demirjian, Goldstein and Tanner rated SEVEN mandibular permanent teeth in the order of central incisor (I1), lateral incisors (I2) canine (C), first premolar (PM1), second premolar (PM2), first molar (M1), second molar (M2), and determined EIGHT STAGES (A to H) of tooth mineralization together with stage zero for nonappearance as follows: If there is no sign of calcification, the rating 0 is given; the crypt formation is not taken into consideration. If the first molar is absent, the central incisor can be substituted. This method is the most highly developed of all dental age surveys; the only drawbacks are that the survey does not include the developing third molar and the mandibular teeth need to be present for the survey to be applicable.

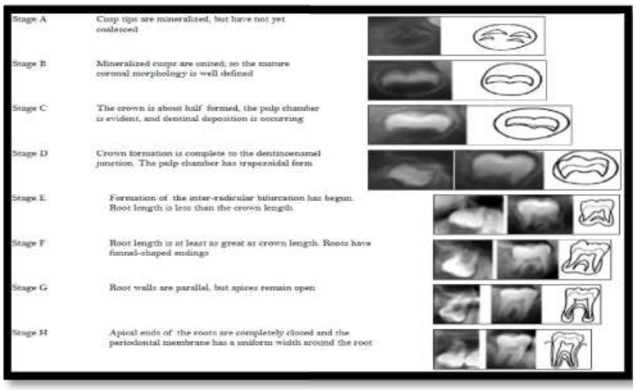
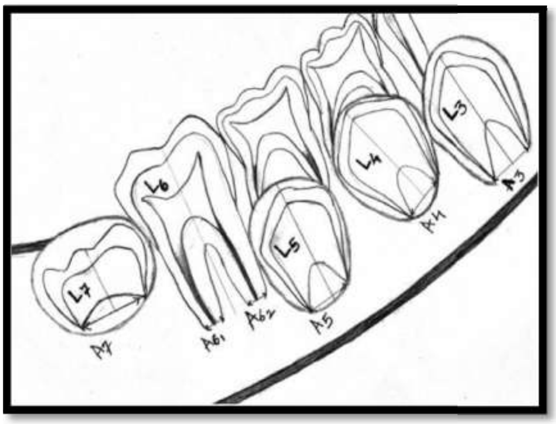


Fig 9 Demirjian, Goldstein and Tanner Method (1973)

Cameriere' S Method of Age Estimation Using Open Apices (2006)[29]

Various studies assessed the relationship between the age and measurement of open apices in teeth. The seven left permanent mandibular teeth were valued. The number of teeth with root development completed with apical ends completely closed was calculated (N0). For the teeth with incomplete root development, that is with open apices, the distance between inner sides of the open apex was measured (A). For the teeth with two roots, the sum of the distances between inner sides of two open apices was evaluated. The dental maturity was calculated as the sum of normalized open apices (s) and the numbers of teeth with root development complete (N0).



Xi= Ai/Li

Fig 10 Showing the measurements of tooth, L_i length of tooth (L1, L2), A_i distance between inner sides of open apex (A1, A2)

Age Estimation in Adults[16]

Clinically, the development of permanent dentition completes with the eruption of the third molar at the age of 17–21 years, after which the radiographic age estimation becomes difficult. The two methods commonly followed are

Volume assessment of teeth

a. Coronal pulp cavity index Ikeda *et al*. (1985)
b. Pulp-to-tooth ratio method by Kvaal (1995)

Development of third molar

a. Harris and Nortje method (1984)
b. Van Heerden system. (1985)

Coronal Pulp Cavity Index- Ikeda et al. (1985)

The correlation between the reduction of the coronal pulp cavity and the chronological age was examined using panoramic X-ray photographs. For each radiograph, only mandibular premolars and molars were considered, as the mandibular teeth are more visible than the maxillary ones. The side where the pulp chamber was more visible was chosen. Panoramic radiography was used to measure the length (mm) of the tooth crown (CL, coronal length) and the length (mm) of the coronal pulp cavity (CPCH, coronal pulp cavity height or length).The tooth-coronal index (TCI) was computed for each tooth and regressed on the real age of the sample.

TCI = Coronal Pulp Cavity Height (CPCH)/ Coronal Length (CL)

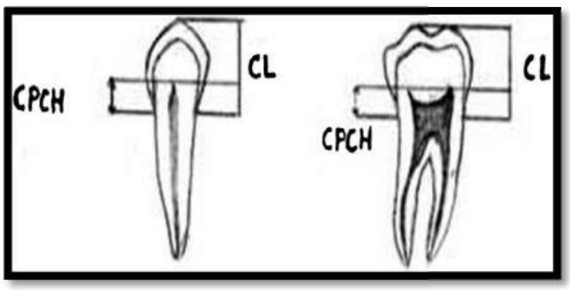


Fig 12 Coronal Pulp Cavity Index

Simple linear regression analysis was carried out by regressing the proportional coronal pulp cavity length on the actual age for each group of teeth for males and females and for the combined sample.

Pulp-To-Tooth Ratio Method-Kvaal's Method (1995)[31]

The age estimation in adults can be achieved by radiological determination of the reduction in size of the pulp cavity resulting from a secondary dentine deposition, which is age of the individual according to Kvaal's Method: In this method, pulp-to tooth ratio were calculated for six mandibular and maxillary teeth, such as maxillary central and lateral incisors; maxillary second premolars; mandibular lateral incisor; mandibular canine; and the first premolar. The age is derived by using these pulp to-tooth ratios in the formula for age determination given by Kvaal *et al.*Using intraoral periapical radiographs, pulp-root length (R), tooth length (P), tooth-root length (T), pulp-root width at cemento-enamel junction (A), pulp-root width at mid-root level (C) and pulp-root width at midpoint between levels C and A (B) for all six teeth were measured.Finally, mean value of all ratios are were calculated and formula was derived from regression analysis**.**

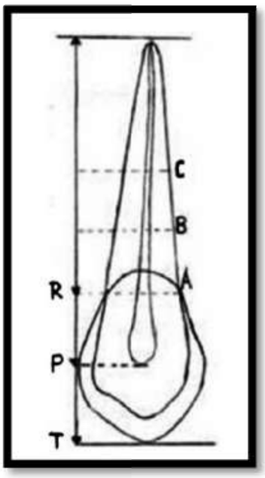


Fig 11 Kvaal's Method

Development of Third Molar: Harris And Nortje method (1984)[32]

The radiographic age estimation becomes problematic after 17 years of age as eruption of permanent dentition completes with the eruption of the third molar. Later, the development of the third molar may be taken as a guide to determine the age of the individual.

Third molar development by HARRIS AND NORTJE method: Harris and Nortje have given 5 stages of third molar root development with corresponding mean ages and mean length:
STAGE 1 : cleft rapidly enlarging—one-third root formed, (15.8+/-1.4 years, 5.3+/-2.1 mm);
STAGE 2 : half root formed(17.2 +/-1.2 years, 8.6+/- 1.5mm);
STAGE 3 : two-third root formed(17.8+/-1.2 years, 12.9+/-1.2 mm);
STAGE 4 : diverging root canal walls (18.5 +/-1.1 years, 15.4+/-1.9 mm);
STAGE 5 : converging root canal walls (19.2+/-1.2 years, 16.1+/-2.1 mm)

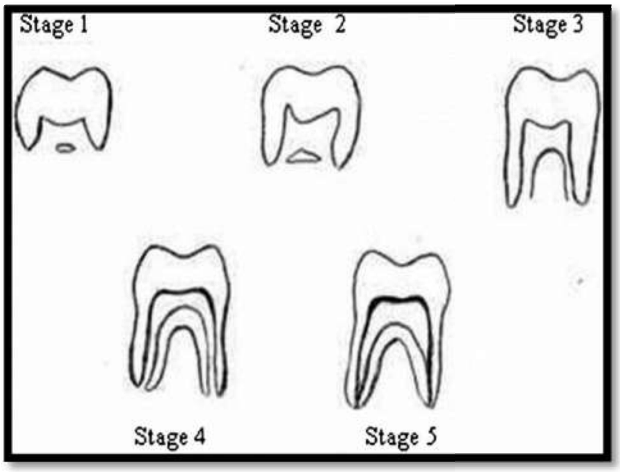


Fig 13 Harris and Nortje Method (1984)

Van Heerden system. (1985)[33]

Van Heerden assessed the development of the mesial root of the third molar to determine the age. He described the development of the mesial root in five stages using panoramic radiographs. The males and females were surveyed separately and no significant differences were found between them.

Table 3 Stages of mesial root development of third molar Van Heerden method

Stages	*Description*	*Length (mm)*	*Age (y)*
Stage 1	Crown complete, radiographic evidence of root formation	3.5-5.3	16.8–16.9
Stage 2	Root length >1/3 <1/2	7-8.6	17.5
Stage 3	Root length >2/3 but not complete	10–12.9	17.8–17.9
Stage 4	Root fully formed with open apex	12-15.4	18.4–18.5
Stage 5	Apex closed		

Fig 14 Van Heerden System

Gender Determination[2,16]

Subsequent to drastic events such as natural disasters, outbreak of wars or air traffic accidents, positive identification of victim's gender becomes the most difficult task to encounter in forensics. It has been reported that the accuracy rate of sex determination is 100% from a skeleton, 98% from both the pelvis and the skull, 95% from the pelvis only or the pelvis and the long bones, 90–95% from both the skull and the long bones and 80–90% from the long bones only.However, in mass disaster scenarios were only fragmented bones are available; gender estimation becomes a tedious process. To tackle such situations gender determination should be done using fragmented bones. In this digital era, Dentofacial Radiography has become one of the routine procedures in dental and medical hospitals as a part of primary investigations, thereby maintanence of the antemortem records helps in identifying the individuals. [34]

Characteristics	Male	Female
Skull size	Larger	Smaller
Supraorbital ridge	More pronounced	Less pronounced
Orbits	Square, lower, smaller with rounded margins	Round, higher, larger, sharp margins
Forehead	Steeper, less rounded	Vertical, round
Fronto-nasal junction	Distinct angulation	Smoothly curved
Condyles	Larger	Smaller
Cheek bone	Heavily, laterally arched	Lighter, more pronounced
Zygomatic arch	More pronounced	Less pronounced
Gonial angle	Less obtuse, prominent	More obtuse
Palate	Larger, broader, prominent	Smaller, parabola shaped
Frontal sinus	More developed	Less developed
Nasal aperture	High and narrow margins	Lower and broader
Mandible size	Larger	Smaller
Ascending ramus	Greater breadth	Smaller breadth
Body height	Greater at symphysis	Smaller at symphysis
Chin	Square	Rounded

Fig 15 Sexual Dimporphism in Skull[35]

Mandibular Measurements

For the purpose of sex determination six measurements are commonly used which include ramus length and breath, gonion-gnathion length, gonial angle, bigonial breadth and bicondylar breadth. SaraswathiGopal *et al.,* 2016[36], Gamba *et al* 2014[37] have determined the sexual dimorphism using these landmarks in the ramus of the mandible and have reported significant values. Usually, the overall size and bone thickness of the male skeleton is greater than that of the female; which is related to sex, nutrition and physical activity.

Normally males have greater masticatory force than females that influences the bone size. As regards to gonial angle, it was found that females had a downward and backward rotation in mandible while males had a forward rotation in mandible ,with the gonial angle values in females higher than in males.

Foramen Magnum (FM)

The FM is a three-dimensional aperture within the basal central region of the occipital bone and also is a transition zone between the spine and skull. Its position between the brain and spinal cord plays an important role as an anatomic landmark. Cranial base is relatively thick/compact and protected due to its anatomical position, thus this area of the skull tends to withstand physical insults relatively than many other areas of the cranium, thus preserving this area for forensic examination. Therefore, the FM is a particularly interesting structure for anatomy, forensic medicine, and anthropology. Firstly, Teixeria in 1982 reported that the measurements regarding the FM can be helpful in estimation of sex and since then various studies have been published about the evaluation of FM dimensions for sex estimation in different populations. Afterwards, it has been concluded that the measurements of its size and intracranial volume are reliable for determination of sexual dimorphism.[38,39,40] Various studies have found statistically significant differences between males and females for foramen height, breadth, and area. Various studies have found statistically significant differences between males and females for foramen height, breadth, and area. Saraswathi Gopal *et al*[41] in their retrospective 3D CBCT study had obtained clinical significance of 67% accuracy. Raghavendra Babu[39] *et al* in their study using dried skulls found that predictability of Foramen magnum in the determination of sex as 65.4%, whereas Uthman42 in his CT study found an overall accuracy of 67% respectively. Higher mean values of length, breadth, circumference and area of FM was found in males than in females and the most reliable indicator to predict the gender was FMA (Foramen Magnum Area). Considering the high sex predictability of FM dimensions, the foramen measurements can be used to supplement other sexing evidence available, so as to precisely ascertain the sex of the skeleton.

Frontal Sinus

Frontal sinus is one of the paranasal sinuses of the skull which is a primary tool for personal identification, but the significant dimorphic characteristics in its measurements can also be used for sex determination as well. The frontal sinuses can provide significant evidence for forensic identification.43 The frontal sinus index (FSI) (height/width ratio) as a maturity indicator or tool for sex determination. The points analyzed on lateral cephalometric radiographs are the Nasion - Sella line horizontally. Benghiac A.G. *et al* 44 in CBCT study concluded that the FSI can be used as a reliable tool for sex determination.

Personal Identification

Is the process of linking an unknown body or skeleton back to an individual of known identity, and is important for both legal and humanitarian reasons

Anthropologists - assist to narrow the pool of potential matches:

- Using the biological profile
- Individual skeletal variation
- Post-Mortem interval
- Comparing Ante-mortem and Post-mortem skeletal information[46]

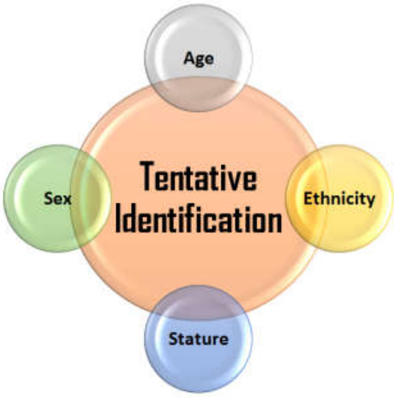


Fig 16 'Big Fours' Of Personal Identification

Proposing National Identification Number on Dental Prostheses As Universal Personal Identification Code – A Revolution In Forensic Odontology[46]

During the reconstructive identification process, all necessary information is gathered from the unknown body of the victim and hence that an objective reconstructed profile can be established.

Denture marking systems (Figure 17) are being used in various situations, and a number of direct and indirect methods are reported

Materials used in orthodontic appliances coded with the identification number

Surgical plates coded with the identification number

Fig 17 Denture Identification Systems by Rajendra.K.Baad *et al* in 2015

Frontal Sinus and nasal septal patterns

The frontal sinuses can provide significant evidence for forensic identification. The frontal sinus characteristics and its applicability for criminal investigations have been studied for many years, particularly in edentulous individuals. Its use in successful identifications has been widely accepted by anthropologists, radiologists, pathologists and the court of justice as judicial evidence with scientific validity. The irregular forms of the frontal sinuses, initially observed in anterior-posterior radiographs have been extensively studied since the first assumption that these are found to show an individual pattern like fingerprints. It has been proven that there are not two people with the same frontal sinuses, even being monozygotic twins.[47,48]

To describe the use of CBCT as an alternative to obtaining images of the frontal sinuses it is proposed the adoption of some anatomic references to do the axial slicing, which should have its plan being tangent to the upper limit of the orbital cavities, as well as the sagittal slicing, which should be done under the midline, so that all sinus boundaries would be observed while error margin in obtaining comparative images would be reduced. The identification results from the morphometric comparison of the frontal sinuses ante- and post-mortem, with regard to forms, size and contours in the images available. The study performed by Saraswathi Gopal et al49 (Figure 18) in 2016 using CBCT to determine the uniqueness and reliability of combined frontal sinus (FS) and nasal septum (NS) patterns as observed on full skull projection for personal identification. The study by Saraswathi Gopal *et al*[49] (Figure 19) in 2016 was performed on CBCT to determine the uniqueness and reliability of combined frontal sinus (FS) and nasal septum (NS) patterns as observed on full skull projection for personal identification. The nasal septum was classified according to deviations in septa as straight, simple deviation to the right or left side, sigmoid & reverse sigmoid types. Another study conducted in CBCT by Saraswathi *et al*[50] in determining frontal sinus dimensions in 100 sample size to determine personal identification by evaluating frontal sinus patterns using cone beam computed tomography with an accuracy of 79.6%.

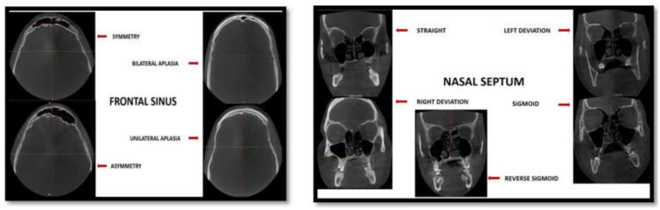


Figure 18 Dr.Saraswathi Gopal *et al*; Significance of Frontal Sinus And Nasal Septum Patterns In Personal Identification In Forensics: A

Implant Backtracking

Dental implants have become a common procedure in the recent decade due to its minimal risk and decreasing cost. Dental evidence is widely used in forensic identification because of its low cost, availability of past dental records and its uniqueness to each individual most of the dentition is entirely constructed by recent years, dental implants are more often used as a tool in forensic identification. Some implants have perforations, grooves, apical chambers, and threads which are visible only at certain rotation or angulations. These features may be unique and enable recognition of specific products.

A recent study conducted on implant backtracking by Dr. Saraswathi Gopal *et al*[51], showed accuracy in identifying persons based on implants design. This study included40 implant images will be correlated on basis of implant shapes, size and designs with the implant catalogue/ Library tool, and the implant brand will be recognized. Out of 40 implant images assessed, a positive correlation was seen in 33 cases. The study found that dental implants could be radio graphically differentiated by company type.

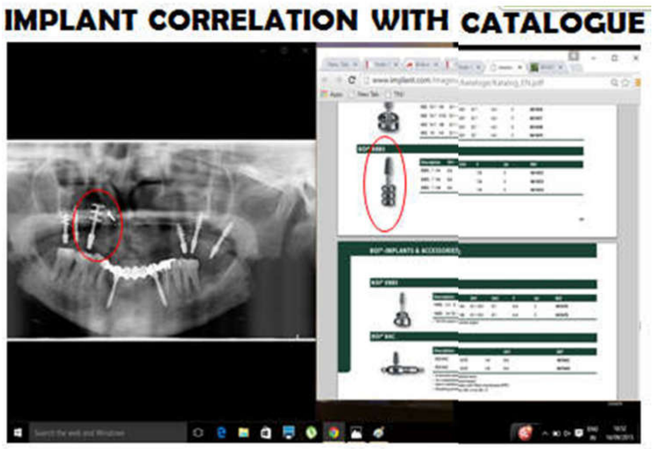


Fig 19 Implant Correlation with Catalogue : Dr. Saraswathi Gopal *et al*[51], Implant Backtracking –A Valuable Tool In Forensic Identification

CONCLUSION

Forensic radiology has humble and ancient origins. Ancient writings have provided evidence that medical principles have been applied to legal issues for thousands of years. It was not long after Roentgen discovered "a new kind of ray" that innovative forensic scientists established its value in forensic science.Imaging techniques are a powerful tool in In forensic odontology, radiographic examination plays a key role in positive identification of unknown human remains. There are interesting imaging technologies on the horizon such as automated dental identification systems however, ultimately it is the decision of the radiologist who decides technique to be used. Radiologic imaging is better defined as the practice that lies at the many interfaces of medicine and law. Radiologic imaging plays a vital role at many of those intersections, from the identification of dead to the authentication of the individual and is regarded as a priceless art. In India the role of forensic radiology is on the way to rise. Many projects related to forensic radiology such as age and gender determination and personal identification are in prospect for educational and research purposes.

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