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ABSTRACT

The word 'forensic' has been derived from the Latin word 'Forensis', which implies something pertaining to 'forum'. Forensic Medicine is the application of medical science to legal problems. It is typically involved in cases concerning blood relationship, mental illness, injury, or death resulting from violence. Autopsy is often used to determine the cause of death.

Forensic Odontology refer to the study of teeth or dentistry. 'That 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 in order to assist law enforcement officers and in civil & criminal proceedings.

In addition to a clinical examination and the annotations on a patient's clinical file, the forensic dentist can make use of dento-maxillo-facial radiography. Forensic dental radiology deals with comparison of ante-mortem and post-mortem radiographs. When bodies are to be identified, radiographs are made of the deceased person and compared with any radiographs of the presumed individual when alive.

Radiographs are becoming more and more important in dental identification: as oral health is improving, oral diseases are regressing and consequently therapeutic features for comparison are decreasing.

The positions of the post-mortem skull relative to the radiographic machine and the film, as well as the exposure time, are the greatest problems faced by the forensic dentist. In view of this fact, some recognize that radiographic techniques used in vivo must be adapted.

Keywords: forensic radiology, forensic odontology, forensic dental radiology

INTRODUCTION:

Forensic Dentistry / Forensic Odontology refer to the study of teeth or dentistry. Forensic Odontology, therefore, has been defined by the Federation Dentaire Internationale (FDI) as 'that 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 in order to assist law enforcement officers and in civil & criminal proceedings.' The role of such an expert is to identify bodies and skeletal remains from dental records, reconstruct faces from skulls as well as connect the crime scene with whatever little evidence is available from the scene.[1,2,3,4]

Forensic dental Radiology usually comprises the performance, interpretation, and reportage of those radiological examinations and procedures that have to do with the courts and/or the law.[1]

In 1944, on September 19th Adolph Hitler was driven to an army field hospital at Rastenburg; after the assassination attempt on him after the Second World War. In the hospital three roentgenograms of his skull were obtained with distinctive dental work. These earlier films were compared with those taken of the burned remains found in the ruins of the chancellery garden, and a positive identification was possible. It was used in the **identification of Adolf Hitler and his wife Eva Braun at the end of World War II.**[5]

With the above background, my review is on forensic dental radiology and its various applications in the field of forensic emphasized in further sections.

EQUIPMENTS & TECHNICAL MODIFICATIONS

For accurate assessment of age and other identification details, quite apart from exact reproduction of ante mortem radiographs, necessitates the separation of the skull from the spine so that the skull can be taken to a dental surgery or x-ray department. (Chart-1)

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CHART:1 EQUIPMENTS

A. X-RAY UNIT
- X-ray unit
  - Mobile
  - Stationary
  - Portable
- Panoramic x-ray unit
- Digital x-ray unit

B. FILMS & CASSETTES
- Intraoral films
- Extra oral non-screen films
- Extra oral screen films
  a. Sensitive to blue light
  b. Sensitive to green light
- OPG films

C. INTENSIFYING SCREENS
- Blue light
- Green light

D. ACCESSORIES
AUXILLARY EQUIPMENTS.
- Metal or measure tape
- Radiopaque measure
- Rigid, clear plastic surface
- Plastic foam pads of different shapes
- Plastic bags and rubber gloves
- 'R' and 'L' lead letters.
- A small manual processor for emergency field work

Radiographs may need to be taken at the scene of the accident or crime, at the mortuary, or in the hospital x-ray department or dental surgery.[3] In practicality, for accurate assessment of age and other identification details, quite apart from exact reproduction of ante mortem radiographs, necessitates the separation of the skull from the spine so that the skull can be taken to a dental surgery or x-ray department.[7]Modifications are required in the normal procedures followed, requiring the operator to adopt techniques to suit individual patients.[6]It is also important to note that the beam may travel through structures with different thickness when comparing the ante mortem to the post-mortem exposure, i.e. an inflammatory process or increased cheek thickness may cause a change in the density of the image obtained in the ante mortem radiograph as compared with the post mortem radiograph. Teeth and bones that have been incinerated or immersed in water for a long period of time, or that have been subjected to other effects of nature, may show variation in structural density, or in the material used to restore the teeth.[7]

A dry skull has a lower density than a live skull; therefore, the kVp to be used should be lower. Skulls with vestiges of soft tissue should be exposed with half to two-thirds of the normal exposure time.[6,7]

A portable x-ray apparatus is used. The only radiographic projection possible is an anteroposterior view of the skull. The x-ray cassette protected by a plastic bag is placed under the skull and the x-ray tube positioned as far as possible above the object (anode object distance usually about 80-120 cm).The decomposed object too fragile to be moved requires radiography. This is usually combined with soil and gravel, in which case it is very radiolucent and the exposure factors must be reduced, preferably with a low kilovoltage. Alternately the specimen could be set in concrete like a fossil, here a high kilovoltage giving greater differentials is recommended.[8]

- In the dental surgery or x-ray room:

– The specimen, whether it is a complete skull or a small portion of the mandible, maxilla or facial bones, down even to individual teeth, the main problem is to immobilize and control the position of the object.[6,9]

– This combined with the ultra-mobility of the dental x-ray apparatus, makes careful monitoring essential.[6,9]

- Procedure:

– Leave the specimen on a plastic or other radiolucent rigid surface. Immobilize the specimen in the required position with plastic foam pads or other radiolucent material or cotton rolls.

– Place the film or cassette under the rigid surface.

– Position the x-ray tube as required.[6,10]

SCOPE

The scope of forensic applications of diagnostic dental radiology as currently understood and practiced can be summarized in the following manner: [11,12]

I. IDENTIFICATION

i. Comparative Identification

Individual Identification – Identifying unknown human remains through comparison of post-mortem dental evidence with dental records of the presumed deceased. [11]

Identification in Mass disaster – Assisting at the scene of a mass disaster and in the victim's identification. [13,14]

ii. Reconstructive / profiling

Race – Eliciting the ethnicity/population affinity and assisting in building up a picture of lifestyle and diet with the help of skeletal remains at forensic and archaeological sites. [6]

Sex - Estimation of sex is of immense help in identification of human remains investigation and solving crimes. Determination of sex by anatomical method which includes skull, angle of mandible and tooth morphology.[6,7,11,15]

Age - The age assessment methods are relatively simple and involve the identification of the stage of mineralization on radiographic images followed by their comparison with the standard stage to estimate the approximate age range.[6,7]

II. CHILD ABUSE AND NEGLECT:

Child abuse may be defined as any act of commission or omission that endangers or impairs a child's physical or emotional health and development. Such acts include physical, sexual, or emotional abuse, as well as physical neglect, inadequate supervision, and emotional deprivation. Child abuse is second only to SIDS (Sudden Infant Death Syndrome) as the leading cause of death in children under one year of age. In older children it is second only to accidents. It is now widely agreed that an absolutely crucial factor in the fight against child abuse is early recognition of the problem so that effective intervention can be undertaken.[16,17]

III. MALPRACTICE AND NEGLIGENCE:

A forensic dentist is often called upon to review cases by both defence and plaintiff attorneys because of the courtroom experience of the forensic dentist. Nothing is more difficult and challenging than a dental malpractice case. Evidence review including the defendant dentist records and charts, x-rays, models, hospital reports, etc. are crucial, subsequently treating doctors and their statements will play a vital role in the overall opinions formed. As with all forensic analysis the more data that is provided and the interrelationship between this data provides for the most accurate and truthful opinion in the cases.[16,17,18]

IV. PRESENTING EVIDENCE IN COURT AS EXPERT WITNESSES.[11,12]

ESTIMATION OF AGE FROM TEETH

Various radiographic images that can be used in age identification are intraoral periapical radiographs, lateral oblique radiographs, cephalometric radiographs, panoramic radiographs, digital imaging and advanced imaging technologies.[7]

The radiographic images must be such that they include developing teeth of interest and that all the stages of dental development can be rated according to chosen development standards.[7]

In humans, age determination is done for various reasons. Age determination of cadavers is carried out for reasons such as criminal cases and very mutilated victims of mass disasters, such as fires, crashes, accidents, homicides, feticides and infanticides, etc. In living persons, the age estimation is done to assess whether the child has attained the age of criminal responsibility in cases such as rape, kidnapping, employment, marriage, premature births, adoption, illegal immigration, pediatric endocrinopathy, orthodontic malocclusion and when the birth certificate is not available and records are suspect.[6,7]

In forensic radiology, there is a need to assess the chronological age, which is the actual age of the patient. The stages of tooth formation can be used to estimate the chronological age in young persons by applying the appropriate dental survey.[19]

The triad for odontological age estimation can be listed as:[19]

1) The subject for age estimation

2) Appropriately chosen dental development survey

3) Legal consideration.

The radiological age determination is based on assessment of various features as follows:[19]

1. Jaw bones prenatally (Figure:1)

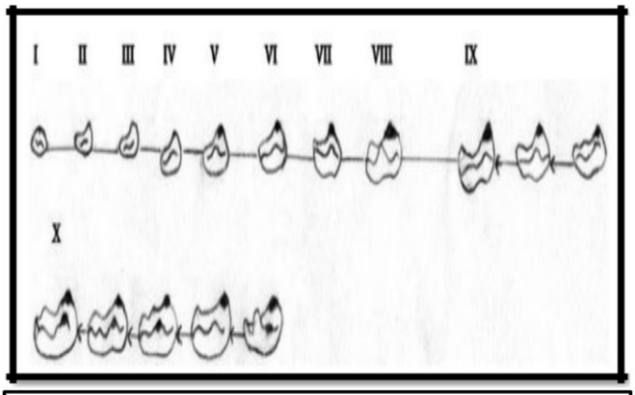

Figure 1: Developmental stages of lower deciduous first molar by Kraus and Jordan. The development is described in ten stages denoted by Roman numerals from I to X; the IXth stage includes three stages and the Xth stage includes five stages

2. Appearance of tooth germs (Figure:2,3,4,5)
3. Earliest detectable trace of mineralization or beginning of mineralization (Figure:4)
4. Early mineralization in various deciduous teeth during intrauterine life (Figure:4)
5. Degree of crown completion (Figure:4)
6. Eruption of the crown into the oral cavity (Figure:4)
7. Degree of root completion of erupted or unerupted teeth (Figure:4)
8. Degree of resorption of deciduous teeth (Figure:4)

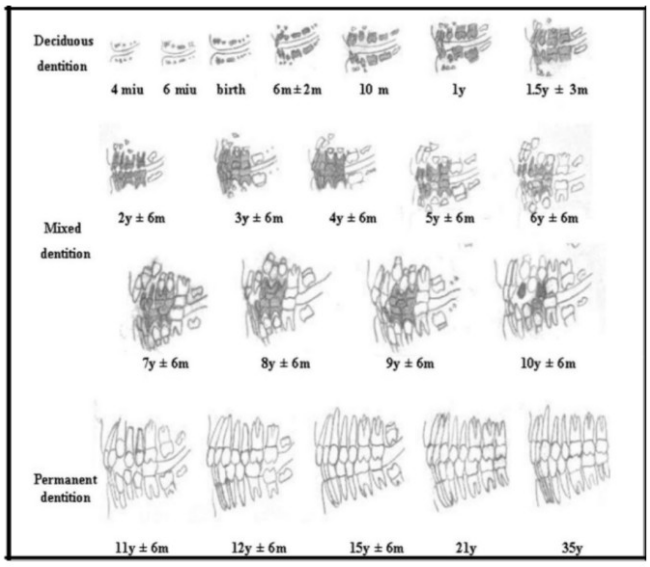

Figure 2: Dental development chart by Schour and Massler (American Dental Association, 1982)

9. Measurement of open apices in teeth (Figure:6)
10. Volume of pulp chamber and root canals /formation of physiological secondary dentine (Figure:7)
11. Tooth-to-pulp ratio (Figure:7)
12. Third molar development and topography (Figure:8)
13. Digitization of the available radiographs for analysis of images to obtain the dental information.
14. Analysis of these various radiographic features in the dentition of an individual corresponding to the phase of human development aids age determination.

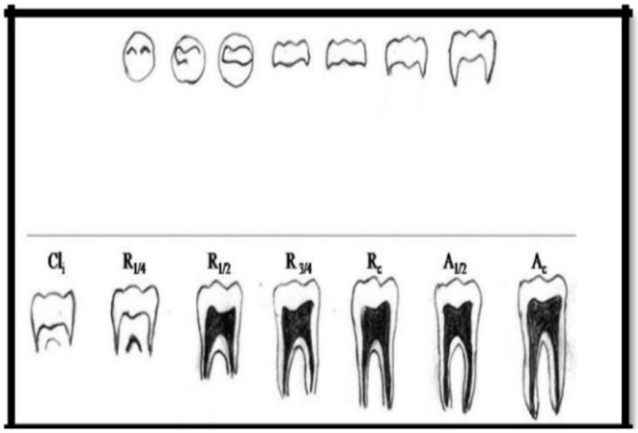

Figure 3: 14 stages of tooth formation of multi-rooted tooth (Moorees et al). Initial cusp formation (Ci), coalescence of cusps(Cco), cusp outline complete (Coc), crown half complete (Cr1/2), crown three quarter complete (Cr3/4), crown complete (Crc), initial root formation (Ri), initial cleft formation (Cli), root length

Age estimation is grouped into three phases: 19

A. Pre-natal, neonatal and post-natal7
   1) Kraus and Jordan method (Figure:1)
B. Children and adolescents
   1) Schour and Masseler method (Figure:2)19,20,21
   2) Moorees, Fanning and Hunt method (Figure:3)22,23
   3) Demirjian, Goldstein and Tanner method (Figure:4)24

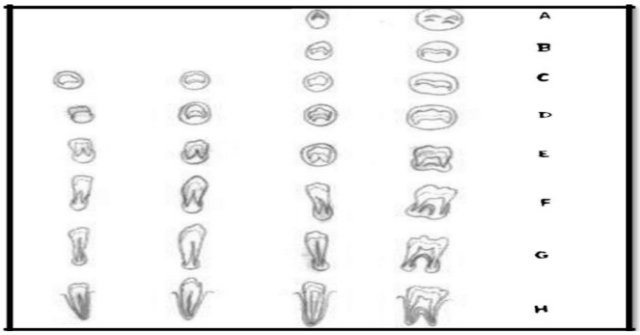

Figure 4: 8 stages (A to H) of mineralization of tooth (Demirjian system). A, beginning of calcification in the form of an inverted cone or cones; B, mineralized cusps are united to show coronal morphology; C, crown half formed, pulp chamber is evident; D, crown formation is completed up to cemento-enamel junction, with beginning of root formation; E, initial formation of the root bifurcation; F, the apex ends in a funnel shape; G, the walls of root canal are now parallel, its apical end partially open; H, the apical end of the root canal is completely closed; the periodontal membrane of uniform width around the root and the apex

4) Nolla's method (Figure:5)[19,25]
5) Age estimation using open apices (Figure:6)[19,25]

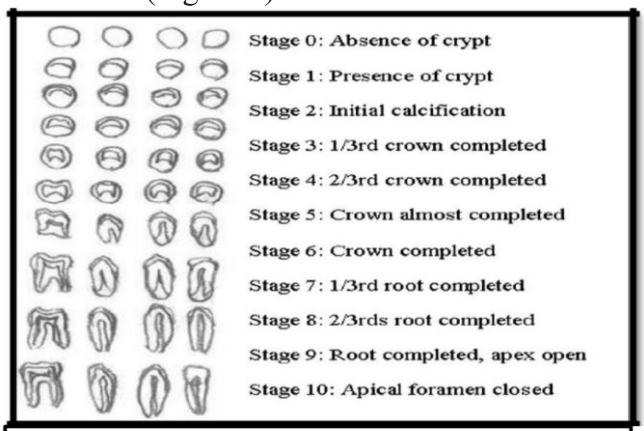

Figure 5: 10 stages of tooth formation with description according to Nolla's method

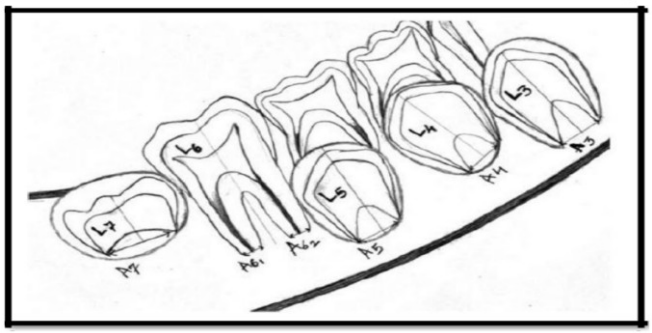

Figure 6: The measurements of tooth, L 5 length of tooth (L1, L2), A 5 distance between inner sides of open apex (A1, A2)

C. Adults [19,20]

1) Volume assessment of teeth (Figure:7) [12,19,20]
2) Development of third molar (Figure:8)[26]

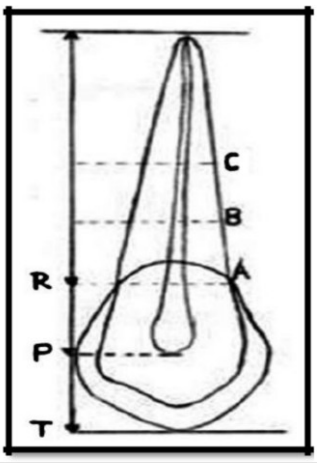

Figure 7: Diagram of premolar showing measurement sites: pulproot length (R), pulp-tooth length (P), tooth-root length (T), pulproot width at cemento-enamel junction (A), pulp-root width at midroot level (C) and pulp-root width at midpoint between level C and A (B)

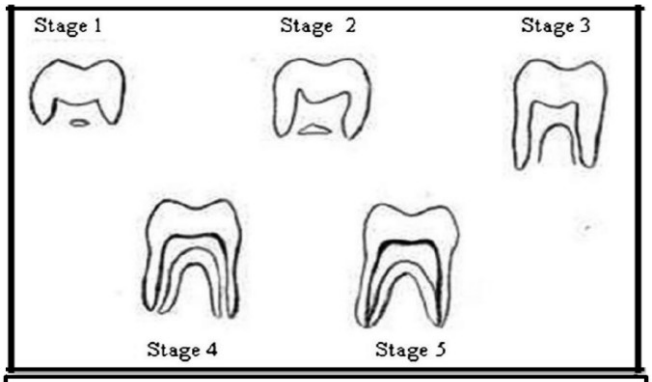

Figure 8: 5 stages of lower third molar root development (Harris and Nortje` method)

RECENT ADVANCES – VIRTOPSY

Virtopsy is one step towards the end of the old age techniques for autopsy being used. (Figure:9)

- Virtopsy basically consists of:

(a) body volume documentation and analysis using CT, MR imaging, and microradiology

(b) 3D body surface documentation using forensic photogrammetry and 3D optical scanning. [27,28]

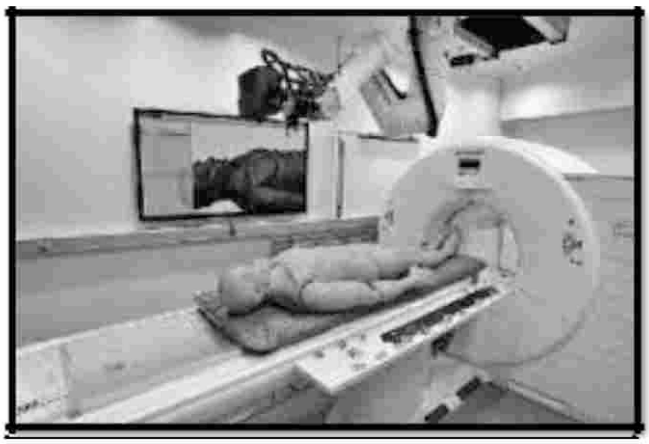

Figure 9: Full CT examination of dead body for virtopsy

ADVANTAGES OF VIRTOPSY PROCEDURE: [29,30]

i. Most effective in study of the wounds including the matching of the probable weapon. The wound can be studied without disturbing the body architecture.

ii. No scalpel method, so no hazard of infections from the blood or other tissue fluids.

iii. No mutilation of the body. so, can be examined again without any autopsy artifacts.

iv. Less time consuming and body can be released immediately after the scanning.

v. Better acceptance for the relatives of the diseased and also by the religious customs as incisions not are used.

SUMMARY AND CONCLUSION

Forensic odontology includes: dental identification, age and sex estimation of an individual from teeth, identification in mass disasters, identification from bite marks, lip prints and blood groups etc. Imaging techniques are a powerful tool in forensic science. Medical examiners and forensic anthropologists are required to interpret findings from imaging studies to further medico legal investigations. Often, the forensic investigators call on the radiologist, whose expertise proves valuable in forensic investigations and findings.

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