

Relevance of Forensic Odontology in Pediatric Dentistry – A Review

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Introduction

Forensic is derived from a word “forensics” which means “before the forum,” a place where legal matters are discussed. Forensic dentistry is the legal field of dentistry which analyses dental evidence in the interest of justice. According to FDI, Forensic Dentistry is defined as a branch of dentistry which, in interest of justice, deals with proper handling of dental evidence, evaluation and representation of dental findings. Forensic identification is a multidisciplinary process which involves team work comprising of forensic anthropologists, forensic dentists, law enforcement officials, forensic pathologists, criminalists, and other specialists. Paediatric dentistry is that speciality concerned with treatment of dental diseases in children. This speciality is also utilized for age estimation studies which includes eruption sequence, Schour and Massler chart, Demirjian’s method using dental maturation chart and Nolla’s stages of calcification. This speciality plays an important role in recognizing child abuse. The aim of this article is to discuss the

relevance of various aspects of forensic odontology in paediatric dentistry.

Historical Prespective

The first evidence of dental findings being used in a forensic manner is associated with emperor Nero of Rome as early as 45-70 AD, where several theories were proposed and facts remain unclear till date (Cottone 1982).

Dr.Paul Revere was the first forensic odontologist. He found the body of Dr.Joseph Warren in 1775 through silver and ivory bridges that he had made 2 years back. First dental evidence was used in Webster-Parkman case in U.S. Court.

L’Art Dentaire en Medicine Legale was the first dissertation on forensic odontology written by Dr.Oscar Amoedo in 1898. Dr.Oscar is called as father of Forensic Odontology.

Bite marks were used as evidence in 1937 in a person,Chantilly. Welty and Glasgow in 1946 created a system in computer that dental data of 500 cards could be sorted in 1 min. Kieser-Nielsen assessed the uniqueness of

teeth mathematically. Vale et al (1976) indicated 6 possible positions of each tooth to demonstrate individuality. Sogannaes et al (1982) demonstrated the uniqueness of bite marks even in identical twins by computer comparison.

Sweet and Pretty considered the size, shape and pattern of the incisal or biting edges of upper and lower anterior teeth to be specific to an individual. Videotape analysis of bite mark evidence was introduced in a California court. David et al. have used scanning electron microscopy in bite mark analysis.

Role of pedodontist in forensic odontology

Forensic dentistry can be defined as it is a branch of forensic science that utilizes dentistry to identify human remains and bite marks, using both physical and biological dental evidence. Crime against a child may take place within the house or family.

As no fingers are identical, neither two mouth nor two teeth are exactly identical. Gustafson (1962) suggests that the role of dentistry in forensic science for identification of humans came to existence only towards the end of the 19th century.

A dentist plays an important role in identification of victims. Tooth is unique and resistant to destruction. It is a cornerstone in positive identification of persons depending on the characteristics of teeth and jaw. An antemortem and post-mortem record makes the identification process easier.

As dental trauma is a regular feature in children due to accident, sports, and child abuse, a pedodontist should have knowledge in forensic dentistry for proper recording of findings to help investigate the legal officers. Forensic odontologists should know the legal aspects of investigations. Hence the role of a pedodontist is to identify the child victims visually or by other means. Paediatric dentists can furnish worthy information to

physicians about oral and dental manifestations of child abuse and neglect.

Scope of forensic odontology in pedodontics

1. Dental identification
2. Child abuse and neglect
3. Bitemarks in identification
4. Special aids in identification

Technologic Aids in Forensic Investigation

A. Photography: It is the most important skill for odontologist and pathologist to photographically record injuries as they appear on skin. Frequently photographs are the only permanent record of the injuries to the victims.

Various techniques that are used in forensic photography:

1. Visible light photography
 - a. Digital photography
 - b. Visible light colour photography
 - c. Visible light black and white photography
2. Alternate light imaging and fluorescent techniques
3. Non-visible light photography
 - a. Reflective long-wavelength ultraviolet photography
 - b. Infrared photography.

B. Radiography: Radiographs of the antemortem and post-mortem records are compared to identify remains. These are also based on the stage of crown and root formation, tooth eruption, and stage of mixed dentition. The teeth and bones of the craniofacial complex are used to determine the age, sex, and race of a person to differentiate one individual from others and one population from other. The parameters used for radiographic interpretation are morphology of tooth and roots, retained tooth, supernumerary tooth, missing tooth, tooth fracture, periodontal bone loss, any pathology related to bone, shape of the cavity, restorative and endodontic fillings, and prostheses.

C. Conventional Radiography: Conventional radiography is used to compare the antemortem images with post-mortem images. Anatomical findings like the morphology of pulp, alveolar bone, and changes due to dental treatment can be observed using conventional radiography.

The followings steps are used in this technique:

1. Digital radiographs with a scanner and a video camera or acquisition of images from X-ray coupled with CD-ROM.
2. Processing of images based on image superimposition and subtraction using the proper software.

D. Computed Tomography (CT): CT is a good radiographic technique to use in forensics because of less superimposition and small differences in the density of structures. CT has added advantages like segmentation, good quality, colour, transparency, and manipulation in various measurements. Post-mortem facsimile image can be created using antemortem CT image by using accurate craniometric points.

E. Identification by frontal sinuses pattern: This is a well-developed technique for identification in forensic anthropology. Antemortem and post-mortem radiographic and tomographic images can be compared by observing the differences in morphology, number of cells, and their presence.

F. General identification through radiology: The development of bone is continuous and finish with the epiphyseal union. Different radiological methods are used for age estimation. Digital radiographs can be used to identify and compare the relationship of root and supporting structures of the teeth in antemortem and post-mortem records. If there is the absence of an antemortem record, the post-mortem record is used to exclude identity by using other antemortem record.

G. Computer Software Technology: Special software was designed called the Palatal Rugae Comparison Software to match the clinical photographs taken using a SLR digital camera. The software recorded an accuracy of 99% in the identification of individuals whereas manual methods have shown high false positive and negative cases. Computer software technology is also used for forensic facial reconstruction. Computer programs create three dimensional reconstructions by manipulating scanned photographs of the cranial remains and stock photographs of the facial features. Based on an analysis of two large datasets, individual dental patterns were determined using a special computer program (Odonto Search) and were found to be generally unique, or at least very uncommon.

H. Palatal Rugae Pattern: Palatoscopy or palatal rugoscopy is the study of palatal rugae in order to establish a person's identity. It is a viable alternative for identification purpose. It is the ideal forensic identification parameter because of its uniqueness, post-mortem resistance, and stability. Once formed, they do not undergo any changes except in length, due to normal growth, remaining in the same position throughout an entire person's life. There may be less pronounced changes in burn victims. In edentulous cases, the evidence can be taken not only from the hard palate directly, but also from the mucosal surface of the dentures.

I. Lip Prints: Lip grooves are permanent and unchangeable like fingerprints and palatal rugae. The identification of lip patterns is possible from 6th week of intrauterine life. The mucosal area which is covered with wrinkles and grooves is used for identification. Cheiloscopy is determined by lip anatomy, thickness,

and position. Lip prints should be photographed and enlarged.

Significance in Paediatric Dentistry

Creating social awareness along with special emphasis on the following areas:

1. **Child Abuse/Neglect:** A dentist who handles children should be able to identify child abuse and neglect and hence plays a significant role in the eradication of this crime.
2. **Mass Disaster:** Children also become victims in mass disasters and their identification can be done by a skilled pedodontist.
3. **Accidental And Non-Accidental Oral Trauma:** Trauma to oral and orofacial structures can be due to negligence mal practice or abuse.
4. **Age Determination:** Human dentition and bite marks can be used for age estimation.
5. **Bite Marks Evidence:** Bite marks in children may be signs of child abuse, which should be brought under the law.
6. **Lip Print Identification:** No individuals will have same pattern of lip prints hence this innovation is successfully employed in the identification.
7. **Poisoning:** Metallic poisoning which could be accidental or intentional shows several oral manifestations.
8. **Dental Records:** Routine dental findings saved as odontograms could be used in forensic dentistry.
9. **Bite Marks:** A bite mark is defined as an elliptical or circular injury that records the specific characteristics of tooth/teeth. Bite marks in children could be a sign of child abuse or malpractice. Since each individual has a characteristic bite pattern, analysis of bite mark could be done by matching the bite mark impression collected from the victim against modals of the suspect. Hence bite mark analysis remains as a

unique entity in the science of forensics. Analysing the bite mark can be done skilfully by an experienced forensic odontologist. First of all, the mark should be identified as a bite mark followed by differentiating it from animal bites. An adult and a child's bites should be differentiated along with the exclusion of self-inflicted bites. Finally, there should be enough evidence to convict the suspect.

Applications of forensic odontology in paediatric dentistry

- a. **Dental identification:** Tooth is one of the most indestructible structures and usually resistant to post-mortem decomposition. Human dentition is never same in two individuals. Morphology and arrangement vary from person to person. Thus, teeth are considered more unique and have been used as cornerstone in positive identification of living or diseased person. Dental impressions can serve as invaluable tool because they are more unique than DNA. Same genetic makeup is shared by identical twins, but their impressions differ. Most materials used in dentistry are also resistant to post-mortem decomposition. Dental evidence is helpful in identity of badly burned, traumatized, decomposed, or skeletonized remains and in mass disasters.
- b. **Comparative identification:** The post-mortem dental remains are compared to antemortem dental records to confirm the identity. Due to less restorative therapy and radiographic indications, no or minimal comparable data may be available in children below 5 years of age. Normal maturational changes may alter the dental records. Even if no filling exists or treatment need is low, bitewing radiographs are almost always a part of dental record if the child has reached the age of 5–6 years. Comparative identification includes oral autopsies such as removal

of tongue and contents of floor of mouth in tunnelling fashion to obtain post-mortem radiographs or records. There are separate post- and ante-mortem units as a part of identification team.

- c. Reconstructive identification:** This is considered when virtually no clue exists about the identity of the decedent. This is also termed as “dental profiling”, which attempts to elicit ethnicity, race, sex, and age of dead individual.
- d. Ethnicity:** Because of human diversity, several nonmetric features such as shovelling, Carabelli's trait, three cusped maxillary second molar, mandibular molar groove pattern, and four cusped mandibular molars can be helpful in eliciting the ethnic origin by their presence or absence. Several features must be considered together before concluding ethnic origin.
- e. Sex determination:** In young adults, mesiodistal and buccolingual dimensions are important in sex determination. Canine exhibits greatest sexual dimorphism because it is highly resistant to disease and post mortem insults. Dental index (mandibular canine index [MCI]) had shown 86% of success rate in sex determination. It is measured by calculating mesiodistal mandibular canine crown width and mandibular canine width. The standard MCI value is 0.274. Higher MCI value indicates male and lower value indicates female. Barr bodies remain stored in dehydrated pulp till 1 year. Barr bodies show sexual diagnostic characteristics when heated up to 100°C for 1 h. DNA analysis for the presence or absence of Y chromatin is definitive method of determining sex. Advance methods include use of AMEL gene and polymerase chain reaction (PCR). AMEL gene codes for “amelogenin” a major matrix protein secreted by ameloblasts. This gene is located on X- and Y-chromosomes. Females will show two identical

AMEL genes while as males show two nonidentical genes. DNA amplification by PCR gives 100% success in sex determination.

- f. Age Estimation:** Estimation by skeletal means/craniofacial structures such as long bones, closure of fontanelle/sutures, and ossification of hand-wrist bones, and mandibular features can be used in age estimation. Age assessment in prenatal, neonatal, and early postnatal period can be very accurate due to various events taking place such as primary tooth germ formation, deciduous teeth enamel formation completion, and permanent first molar formation.

Neonatal line is termed as indicator of birth. The presence of neonatal line indicates a live birth. However, false result can be obtained as it takes around 3 weeks after birth to form. It has legal implications in feticide and infanticide. In children and adolescents, tooth eruption and tooth calcification, these events are important in age estimation. Convenient clinical method and can be assessed visually and radiographically, helpful in observation for several years, and not altered by local factors. Modified Demirjian's method uses the development of mandibular teeth on the left side divided into eight stages each.

The **Regression Formula** given below for age determination in Indian children was formulated by Acharya

$$\text{Male age} = 27.4351 - (0.0097 \times S_2) + (0.000089 \times S_3)$$

$$\text{Female age} = 23.7288 - (0.0088 \times S_2) + (0.000085 \times S_3)$$

Gustafson's method is used in adults includes various events such as

1. Attrition (A)
2. Secondary dentin deposition (S)
3. Loss of periodontal attachment (P)
4. Cementum apposition at the root apex (C)
5. Root resorption at the apex (R)

6. Dentine translucency (T)

Acellular cementum incremental lines are used in age estimation. Mineralized unstained cross-sections of teeth are used. This method gives accuracy to within 2–3 years of actual age. Hypo mineralized bands in the incremental line indicate pregnancy, skeletal trauma, and renal disorders which can be related to person's life history, facilitating identification.

Amino acid racemization is used as biochemical indicator of age. Aspartic acid has a rapid rate of racemization (high in root dentin). It gets spontaneously converted from one type (L-aspartic acid) to another (D-aspartic acid) with increasing age. Thus, there is a constant change in the ratio of L- and D-aspartic acid at different ages. This D/L ratio may be used for age estimation. This method estimates age within ± 3 years of actual age.

g. Dental DNA for identification: DNA has a greater likelihood of survival than fingerprints, scars, and facial appearance. DNA serves as a basis of all blood group types, red cell antigens, and protein isoenzymes. Teeth are an excellent source of DNA. Rich sources are odontoblasts, peripheral nerves, fibroblasts, undifferentiated mesenchymal cells, endothelial cells, and nucleated components of blood in pulpal soft tissue. Dental DNA helps in identification and can be collected by tooth sectioning, tooth crushing, or cryogenic grinding technique.

h. Palatal rugae pattern: “Palatal Rugoscopy” can be an ideal parameter for identification because rugae do not undergo any change except in length. These can also resist decomposition to an extent. They remain in same position throughout entire life of a person and reappear after trauma or surgery.

i. Lip Prints: Study of lip prints is termed as “Cheiloscopy.” Lip prints are said to be permanent and unchangeable. Identification of pattern is possible

from 6th week of intrauterine life. These can serve as important evidence left at crime scene. Disadvantages are major trauma to lips result in scarring. Surgical treatment also affects the size and shape of lips. Prints may differ in appearance depending on pressure applied or direction.

j. Crime Investigation: Forensic odontologist has a vital role in crime investigation. Preservation of dental records and proper storage of evidences for further investigations should be done. Crime investigation includes bite marks and child abuse.

k. Bite Marks: Apart from identification, forensic odontology is also applied in investigation of crimes caused by dentition such as bite marks. McDonald defines bite mark as “A Mark Caused By The Teeth Either Alone Or In Combination With Other Mouth Parts.” Bite marks can be found on injured tissue or an inanimate material such as foodstuffs. These may accurately depict the unique pattern of biter's teeth. Bite marks are often associated with violent fights, child abuse, sex crimes, or sporting events. They can be self-inflicted and can be collected at the scene of crime from foodstuffs or fruits, etc. Pedodontist should meticulously observe and document bite marks and are encouraged to be knowledgeable about such findings and their significance.

l. Bite Marks Appearance: Initially, indentations are seen due to the pressure applied by teeth. Soon these indentations disappear due to elasticity of skin and oedema occurs over the bite area. The oedema usually obscures the bite marks completely. When oedema subsides, subcutaneous bleeding is apparent as contusions or bruises. When the bite intensity is more lacerations can be seen. Avulsion is the most extreme form where part of tissue is bitten off.

m. Identification Of The Injury As A Human Bite

Mark: A deciduous dentition bite mark consists of smaller, rounded, bow-like arches with smaller teeth, and spacing between them. Grossly bite marks appear circular/elliptical with central ecchymosis. Classical features/appearance of incisors (rectangular marks), canines (triangular/rectangular), molars, and premolar (spherical/point) differ from each other. Individual features such as fractures, rotations, and spacing can be helpful to identification. A classical bite mark consists of oval or circular mark consisting of two opposing arcades, separated by a small open space at their bases, diameter of 25–40 mm, central bruising and clear tooth marks, and dental characteristics that may give high evidentiary value.

n. Bite Mark Investigation: Following confirmation of the injury as a bite mark further investigation should include collection of evidence from the victim and records from the suspect. Dental record for bite mark includes photography, impression, models, and saliva swab collection. Photographs should be taken first as it does not affect any other recording such as impressions and taking swabs Photographs should be taken daily for 3 days for documentations. Polyvinyl Siloxane impression should be made for bite mark immediately after swabbing it.

o. Bite Mark Analysis: Recognition of uncommon characteristics of bite mark helps in accurate identification. Inter-canine distance method is usually recorded for recognition of a child's dentition to an adult dentition as the distances <30 mm belongs to a child and a distance above that to an adult. Other methods such as odontometric triangle method and comparison technique can also be used (i.e., comparison of bite mark measurements with suspect's impression models). Direct comparison can be carried

by placing suspect's model on the bite mark. In indirect method, suspect's model is traced onto clear acetate and compared with photographs. Computer software programs can also be used for comparison.

Conclusion

Dental evidence plays a major role in establishing the identity of unknown body and living victims of child abuse, sexual abuse and other domestic violence. A pedodontist plays an important role in child abuse and neglect, bite mark analysis, criminal/natural deaths and injuries etc. Hence, a pedodontist is concerned with correct management, examination, evaluation and preservation of child dental evidence in criminal or civil legal preceding's in interest of justice. This present review explains scope of forensic odontology from a paediatric dentist's perspective with insight into current updates in this field which may help in arriving at a proper and accurate conclusion when working with children. A further research in each of the areas can be undertaken which will expand the scope and pave way for better and reliable outcome.

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