



Research Article

FORENSIC ODONTOLOGY- A PEDIATRIC DENTIST'S FUTURISTIC VISTA

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ABSTRACT

Background: Forensics is an ever evolving science useful in personal identification in cases of unforeseen events and misdeeds. Forensic odontology has a fair share of significance in clinical forensic sciences because of the unique ability of oral and peri-oral structures to withstand extreme conditions when compared to many other tissues of the body.

Main body: The knowledge of forensic odontology can be applied in the identification of children with minor modifications and adjustments. Children are often easy targets in many crimes and they have a higher tendency to get involved in accidents more frequently than adults. The anatomy and physiology of a child differs a lot from an adult. Simple application of knowledge of forensic sciences may not be enough for child in majority of the conditions and it becomes necessary for the forensic personnel to learn about the minor variations and current updates in the field and act accordingly when dealing with a child.

Conclusion: A pediatric dentist is in a cardinal position when dealing with a child, and this review is a detailed description about the scope and application of forensic odontology in children along with current updates in the field.

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INTRODUCTION

Forensic odontology is a specialty in dentistry which occupies primary niche within the total spectrum of methods applied to medico-legal identification (Saraf et al 2011). The permanent teeth develop throughout the first two decades of life and the physiological variations, pathoses and effects of dental therapy will be recorded in the hard tissues through-out the life and beyond (Sweet and Bower 1998). Forensic odontology relies on the indestructibility of the tooth in various environments and its scientific advancement is designed to extract identifiable information from oral structures (Whittaker 1994).

Main text

Historical Perspectives

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).

In 1837 England, Dr. Edwin Saunders examined 1046 children's oral cavities and established that eruption pattern of the teeth was better criterion for age in children than was their height in order to forbade children below 16 years for working in textile mills (Cottone 1982).

In 1898, the first treatise on forensic odontology was written by Dr. Oscar Amoëdo, who is also known as Father of Forensic Odontology (Stavrianos et al 2010).

In 1967, a 14 year old girl, Linda Peacock had a bite mark on right breast which was recognized and confirmed as human bite mark and led to conviction of the suspect (Stavrianos et al 2010).

The science of forensics was applied also in identification of an unknown child's body in the tragic sinking of Royal mail ship 'The Titanic' using the tooth remains of exhumed body in 1998 (Tittley et al 2004).

Scope of Forensic Odontology in Pedodontics

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

Dental Identification

Identification of a deceased individual or the identity of a mark left by his or her teeth is the purpose of forensic dentist (Sweet and Bower 1998). The science of forensic odontology is considered as most reliable and scientific method for identification especially in mass disasters (Prajapati et al 2018). Human dentition may be subjected to breakdown throughout life, but outlast all other body tissues after death. And further dental restorations and prostheses are extremely resistant to physical and chemical deterioration which further

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add to the uniqueness of the dentition (Cottone 1982). Metcalf (2008) has suggested the most common points for identification which include- Number of teeth, presence of restorations and prostheses, dental caries, malposition and rotations, anomalous tooth formation, root canal therapy or pulp therapy, bone patterns, occlusion, oral soft tissue pathology, habits, socioeconomic pattern of the dentition.

Comparative Identification

This is a method of identification where the identifier has two sets of data, ante mortem and post mortem data. The forensic expert needs to compare and weigh the data and draw conclusions. The American Board of Forensic Odontologists recommends only four conclusions when reporting dental identification (1994)- (i) Positive identification, (ii) Possible identification, (iii) Insufficient evidence, (iv) Exclusion.

Disaster Identification

Majority of jurisdictions basically recognize 3 methods of identification- Visual, Finger printing and Dental (Cottone 1982). The forensic investigation teams participate in 3 phases during disasters. The first phase is the autopsy of space. The second is to create the list of speculated victims and the collection of ante mortem material. Finally, the realization of autopsy/Necrotomy. It is stated that in mass disasters, 70% of victims are recognized with the help of dental evidence (Stavrianos *et al* 2010).

Two cases are published widely in last century regarding the role of dentist in identifying the remains of children. Silk Air Flight M185 crash where the largest body belonged to a child of Caucasian origin identified as 3 year old German (Stavrianos *et al.* 2009).The Inglorious Titanic disaster where the fourth body recovered was of an unknown child of estimated age two years who was actually buried without his real identity. Later in 1998, the 'Titanic Ancient DNA Project' revealed the baby's identity with help of teeth and DNA (Deoxyribonucleic Acid) from the tooth (Titley *et al.* 2004).

Dental Profiling

Dental profiling is the process where the triad of information-age, gender and ethnic origin can be obtained from data based on dentition thereby restricting the population pool to which the person may belong to (Sweet and Bower 1998).

Ethnic Origin

Physically humans are a diverse species. Traditionally, the human species has been categorized in to 3 races- Caucasoid, Mongoloid and Negroid (Titley *et al.* 2004; Stavrianos 2009).Recently it is shown that specific species information which can determine species will be available even up to 12 months after death (Sweet and Bower 1998).

Gender Determination

Gender determination can be done by morphological or molecular analysis (Ramakrishnan K *et al* 2015) The sexing from craniofacial morphology of skull and mandible is a common approach used by anthropologists but it is not reliable until well after puberty. Canines were considered sexually more dimorphic than other teeth (Ullinger *et al* 2005). Molecular analysis involves the study of DNA from extracted pulp, Buccal mucosa. Barr bodies, F-bodies, SRY gene, AMEL gene can be used for sex determination (Ramakrishnan K *et al* 2015). The Amelogenin or AMEL gene found in the

human enamel has different signature (pattern of nucleotide sequence) in male and female enamel. Females have two identical genes on X chromosomes and males have 2 different, one on X-chromosome and other on Y- chromosome. (Hemanth 2008).

Age Estimation

Teeth follows a reliable and predictable developmental sequence beginning about 4 months after conception and continuing to the beginning of third decade of life, when development of all the permanent teeth is completed (Sweet and Bower 1998). The dental radiographic assessment of age of the child seems to be more reliable than skeletal age as the development and formation of a tooth is more controlled by genes than environmental factors (Panchbhai AS 2011). Age estimation is grouped in to three based on the age

- A. pre-natal, neonatal and post-natal: Stages by Kraus and Jordan
- B. children and adolescents
 - i. Schour and Masseler method- 21 chronological steps from 4 months to 21 years
 - ii. Nolla's method - Mineralization of tooth is divided in to 10 stages, age was estimated using a standard chart given by Nolla
 - iii. Moorees, Fanning and Hunt method -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.
 - iv. Cameriere method Age estimation using open apices- The dental maturity was calculated as the sum of normalized open apices (s) and the numbers of teeth with root development complete (N0). The values are substituted in the following regression formula for age estimation.

Adults: Some of the methods used for age estimation are Glesier and Hunt, Demirjian *et al*, Gustafson and Koch, Harris and Nortje and Kullman *et al* (Panchbhai AS 2011).

Palatal Rugoscopy in Identification

Rugae are strong indicators of ethnicity, gender differentiation and study of growth changes in the anterior maxilla (Chatterjee and Khanna 2011).Palatal rugae like finger prints, do not change during the life of the individual and are protected from trauma and high temperatures owing to its internal position in the oral cavity and protected by lips, cheek, tongue, teeth and bone and prosthetic devices (Indira 2012). Thomas CJ and Kotze TJ (1983) studied the rugae patterns of South African population to analyze the interracial difference. They found that rugae were unique to each ethnic group and that they can be used successfully as a medium of genetic research. Thomas CJ and Kotze TJ (1983) have classified rugae according to shape as curved, wavy, straight, circular and non-specific. Rugae were classified based on length by Lysell (1955) in to primary (> 5mm), secondary (3-5mm), fragmentary (<2mm). Sharma P *et al* (2009 b) stated in their study that total number of primary rugae found to be more in females than in males. Thabitha *et al* (2015) in children of Nalgonda population, have found that no two palates showed similar type of rugae in either gender. Despite the controversy about the stability of qualitative and quantitative characteristics of rugae (Palatoscopy) and the extent of differences between ethnic

groups and sex, the uniqueness to individuals has been recognized in forensic sciences as providing potential source of identification (Chatterjee and Khanna 2011).

Lip Prints in Identification

Lip prints are normal lines and fissures in the form of wrinkles and grooves present in the zone of transition of human lip, between the labial mucosa and outer skin, the examination of which is referred to as Chieloscopy. Fingers, palms alveolus and palate develop during same embryonic period (Hinchliffe 2009). The secretions of oils and moisture form sebaceous and sweat glands in the edge of lips enable development of latent lip prints, analogous to latent finger print. The middle portion of lip is taken in to account, since this portion is always visible in traces (Sharma *et al* 2009 a). Tsuchihashi (1974) classified lip prints in to different types. They are: Type 1- Clear cut grooves running vertically across the lips, Type 1'- similar to type 1 but do not cover entire lip, Type 2- Fork grooves in their course, Type 3- Intersected grooves, Type 4- Reticular grooves, Type 5- Undetermined. Soujanya A *et al* (2016) stated that Type 2a (proximal branched grooves) and Type O (described by Saad *et al* in 2005 as a new pattern devoid of all prints) lip pattern can be considered as genetic marker for transmission of cleft lip and plate to off springs. Palatoscopy is more reliable in necrotomy where as chieloscopy is more reliable in identification of living people (Sharma *et al* 2009 a).

Role of Forensic Science in management of Child abuse and Neglected cases.

Studies worldwide have shown that there is insufficient knowledge about child abuse recognition and management among health workers (Cottone 1982). The abuse may result in contusions, burns or lacerations of the tongue, lips, buccal mucosa, palate (soft and hard) gingiva, alveolar mucosa or frenum and fractured displaced or avulsed teeth or facial bone and jaw fractures (Rai 2011). Pedodontist is in a strategic position to recognize abused and neglected children. While detection of dental care neglect is an obvious responsibility of the dental clinician, different types of child abuse may also be noticed in the patients visiting dental clinic. Therefore dentist should not only diagnose those problems, but also must report, treat and prevent further complications (Uldum 2010). Adults who abuse their children may claim or even think that it is not abuse but refer it is as corporal punishment, a way of teaching their children good behavior. But Corporal punishment is incompatible with international standards of human rights (Owais *et al* 2009).

Sexual abuse involves any sexual exploitation (consensual or non-consensual) with the child (Massoni *et al* 2010). The American Academy of Pediatrics (1999) statement "Guidelines in the evaluation of sexual abuse of children" provides information regarding these examinations. Oro facial symptoms of diseases like Gonorrhea, Condylomata acuminata, Syphilis, Erythema and Petechiae can be seen in children abused sexually (Massoni *et al* 2010). Pediatrician should be aware that physical or sexual abuse may result in oral or dental injuries or conditions that sometimes can be confirmed by lab findings. When questions arise or when consultation is needed, a pediatric dentist or a dentist with formal training in forensic odontology can ensure appropriate testing diagnosis and treatment. Pediatric dentists and oral and maxillofacial surgeon whose advanced education programs include a mandated child abuse curriculum can provide valuable information and

assistance to physicians about oral and dental aspects of child abuse and neglect (Kellogg 2005).

Bite marks

Bite mark can be defined as a pattern produced by human or animal dentition and associated structures in any substance capable of being marked by these means (Strom 1963; Beena *et al* 2012). The theory of uniqueness is the strong point used in analysis of bite marks to convince the court of law that a dentition of one individual is different from other human dentition (Mahajan 2012). Children often bite each other in nursery school settings. Few authors have suggested that the inter-canine width is considered reliable to know if the bite is of child or adult dentition. If width is less than 2.5-3cms probably it was bite of child or small adult, less than 2.5 cms suggests deciduous dentition and 3.0-4.5 cms is suggestive of human adult (Massoni 2010; Beena *et al* 2012). Most bite marks are obtained from cases of sexual violence (Massoni 2010). During biting the assailant will frequently be struggling so teeth may produce scrape marks (Sweet *et al* 1998). Human bite marks are usually superficial but animal bites usually result in deep penetrations and being accompanied by lacerations or tissue avulsions (Massoni 2010). Inter-canine distance can be a simple reliable parameter to differentiate between bite marks of humans and domestic dogs of different breeds (Kashyap 2015). It was found that most often female children of age group 11-15 years and male victims of age 4-10 years are inflicted with bite marks (Beena *et al* 2012). The analysis of bite marks is broadly split in to two main components. First is the metric analysis that involves the measurements of specific traits and features. Second is the comparison of the configuration and pattern of the bite injury to that of suspect's teeth. The individualizing characteristics on teeth can be divided in to two main categories- developmental and acquired. Developmental features include prominent marginal ridges, additional cusps, talon cusps, macro or microdontia and genetic abnormalities of tooth form. Acquired include restorations, fractures, occlusal adjustments and occlusal wear (Beena *et al* 2012).

The role of saliva is diverse and is explained in next section. Bite marks can also be used in psychological analysis. Walter RD (1985) elaborated three motivational dimensions – anger impulsive biting, sadistic biting and ego cannibalistic biting where each bite has specific characteristics. The American Board of Forensic Odontostomatology (1986) established the following steps as guideline to standardize the analysis of bite marks which include History, Photographs, Extra oral examination, Intra oral examination, Impressions, Sample bites, Study casts.

Special Aids and Updates

Along with the regular methods of collection of data, certain special methods and aids will help in easier data collection and recording especially in children who have lower levels of cooperation than an adult person.

Photography

Photographs of dental remains can show more about the dentition than the chart. They provide graphic evidence which can be more readily understood than a detailed verbal description (Cottone 1982).

Photographic Superimposition

It employs superimposition of a skull photograph and clinical photograph of same person. A transparency of clinical picture is placed over the photograph of skull and anatomical structures are compared (Cottone 1982).

Overlays

For comparison, photographic negative or tracings may be super imposed over photograph. The technique most often used in bite mark analysis in which photographic negative and wax bite obtained from suspect is matched against a 1:1 photograph of bite marks. An overlay contains outlines of the perimeters of the suspect's anterior teeth that would most likely be seen in a resulting bite mark (Whittaker DK 1994; Cottone 1982).

Radiology

Dental radiographs in personal injury and malpractice cases provide graphic, objective evidence which can rarely explainable in written dental record. The diagnosis of physical abuse is confirmed and categorized using radiographs especially in cases of "Battered child syndrome" (Cottone 1982).

Panaromic Tomography

Radiographic methods other than conventional radiographic examination are highly reliable and circumvent several of the inherent problem in the post-mortem examination. With this technique no discussion is required as the head portion of the body is introduced in to the area of x-ray scan (Cottone 1982).

Craniofacial Superimposition Technique

It is employed for the identification of unknown skulls or living persons. The method of craniofacial identification from portraits, sculptured bust and from death masks has been documented as early as the late eighteen century (Scully and Nambiar 2002). In forensic odontology, it is a technique where by an image of the bite mark inflicted on the deceased child is directly compared with bite marks obtained from the suspect for identification (Mahajan 2012).

DNA in Dental Identification

Teeth represents excellent source of DNA material (Cottone 1982; Sweet *et al* 1999). DNA profiling is a standard forensic DNA system used in human identification criminal case work, as well as paternity testing world-wide (Datta and Datta 2012). Pulpal tissue is considered as best source of dental DNA because of its neuro-vascular nature. DNA can be obtained from intact, carious as well as root filled teeth implying that pulp tissue is not necessarily the only source of dental DNA but hard tissue such as dentine and cementum are equally viable (Presecki 2003).DNA can be preserved in teeth and bones for a long period and ancient DNA (a DNA) analysis can be carried out in samples of hundreds to tens of thousands of years old (Datta and Datta 2012). In any given cell there are two types of DNA. Genomic or nuclear DNA located in nucleus which is commonly used in forensics and second is mitochondrial DNA present in mitochondria. Each cell has a copy of mitochondrial DNA (mt DNA). Also mt DNA is exclusively inherited from the mother, no contribution from father whatsoever. Due to this they can be used to establish identity in cases even where there is a gap of several generations (Presecki *et al* 2003).

Saliva

Saliva role initially in bite marks cases was limited to the blood typing of saliva stains using ABO antigen groups. Saliva deposited by a biter could be collected, using a double swab technique, and would yield DNA for forensic analysis (Beena *et al* 2012).

Recently it was suggested that streptococcus bacteria that can be isolated from the mouths of most humans and are genotypically extremely diverse. And some predominant genotypes are retained on teeth of biter for prolonged periods of time. They can be relied on if there is appropriate collection and storage of bacteria samples from the bite (Hinchliffe 2011).

Enamel rod End Patterns

Formation of enamel is a highly organized process in which the ameloblasts lay down the enamel rods in an undulated and intertwining path. This is reflected on the outer surface of the enamel as patterns of the ends of a series of adjacent enamel rods (Joshi and Bhosle 2014).Manjunath *et al*(2008)have coined a term 'Amyloglyphics' which means the study of patterns of enamel rods (amelo-enamel; glyphics-carvings). These tooth prints are unique to a tooth. Jyothi PS and Bhosle SS (2014) have examined 30 tooth prints which were unique and distinctly dissimilar both between the teeth of different individuals and of the same individual. This uniqueness of the tooth print could be used as a valuable tool in forensic science for personal identification. This technique is simple, inexpensive, can give rapid results and can also be performed by non professionals.

Tongue Prints

Tongue is a unique organ easily accessible for examination. The dorsal surface of tongue is unique between individual and even twins show variations between the tongue prints. Though further research is required to authenticate the use of tongue print, few studies have showed its use to be comparable to other biometric tools.

CONCLUSION

Studies have suggested towards less knowledge in forensic in dental fraternity (Almutairi *et al* 2018; Gambhir *et al* 2016). Further the knowledge about its application in children can be still less. The present review is an effort to explain the scope of forensic odontology from a pediatric dentist's perspective with an 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.

Abbreviations

1. DVI – Disaster Victim Identification
2. DNA - Deoxyribonucleic Acid
3. a DNA- ancient Deoxyribonucleic Acid
4. mt DNA- Mitochondrial DNA
5. AMEL- Amelogenin

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