REVIEW ARTICLE

Contemporary practice in forensic odontology

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ABSTRACT

Forensic odontology plays a major role in the identification of those individuals who cannot be identified visually or by other means. The unique nature of dental anatomy and placement of custom restorations ensure accuracy when the techniques are correctly employed. It is evident that identification of victims in accidents and natural calamities is of utmost importance and is a challenging task. The teeth may also be used as weapons and under certain circumstances; they may provide information regarding the identity of the biter. Dental professionals play a major role in keeping accurate dental records and providing all necessary information so that legal authorities may recognize malpractices, negligence, fraud child abuse and also, identify an individual. In this article, we will discuss such evolvement of the subject.

Key words: Age estimation, bite mark analysis, dental records, forensic odontology, mass disaster, sex determination

INTRODUCTION

Forensic means legal: A word that comes from Latin, meaning "to the forum". The forum was the basis of Roman law and was a place of public discussion and debate pertinent to the law. Forensic odontology (FO), or forensic dentistry, was defined by Keiser-Neilson in 1970 as "that branch of forensic medicine which in the interest of justice, deals with the proper handling and examination of dental evidence and also with proper evaluation and presentation of the dental findings".[1]

FO involves the management, examination, evaluation and presentation of dental evidence in criminal or civil proceedings, all in the interest of justice. The Forensic Odontologist assists legal authorities by examining dental evidence in different situations. The subject can be divided roughly into three major fields of activity: Civil or noncriminal, criminal and research.[2,3]

Civil class includes malpractice and other aspects of fraud and neglect, in which compensation is sought. Identification of the dead and living also comes under this category. Criminal sector includes identification, which is done by the way of teeth and from bite marks that may be present on the victim, assailant or on some inanimate objects such as food items. Research field encompasses academic courses for undergraduate and postgraduate training, teaching FO to police and new research works.[4]

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Natural teeth are the most durable organs in the bodies of vertebrates and man's understanding of their own past and evolution relies heavily upon remnant dental evidence found as fossils.[5] Teeth can persist long after other skeletal structures have succumbed to organic decay or destruction by some other agencies, such as fire.[6]

In making their painstaking comparisons and reaching their conclusions, the experts did not rely on untested methods, unproven hypotheses, intuition or revelation. Rather, they applied scientifically and professionally established techniques such as x-rays, models, microscopy, photography etc., to the solution of a particular problem, which though novel, was well within the capability of those techniques. In short, in admitting the evidence, the court did not have to sacrifice its independence and common sense in evaluating it.

SCOPE AND PURPOSE OF FORENSIC ODONTOLOGY

Forensic odontologists assist legal authorities by preparing dental evidence in the following situations: [7]

- Management and maintenance of dental records that comply with legal requirements to document all unique dental information: These data are the foundation on which dental identification of the patient is accomplished and potential malpractice litigation is reduced
- Identification of human remains by comparing antemortem and postmortem dental information: These data are useful in cases that involve the death of an individual or multiple deaths in mass fatality incident (MFI) situations
- Collection and analysis of patterned marks (bite marks) on inanimate material or injured tissue: This evidence can be compared with and potentially related to, specific human or animal dentition
- Recognition of the signs and symptoms of human abuse (including intimate-partner violence [IPV], elder abuse and child abuse) and the dental healthcare practitioner's rights and responsibilities when reporting such abuse
- Presentation of dental evidence as an expert witness in identification, bite mark, human abuse, malpractice, fraud and personal injury cases
- Assessment of the age of the person
- Determination of sex of a person.

DENTAL RECORD MANAGEMENT (ANTEMORTEM RECORDS)

The dental record is a legal document owned by the dentist and contains subjective and objective information about the patient. Results of the physical examination of the dentition and supporting oral and surrounding structures must be recorded. In addition, the results of clinical, laboratory tests, study casts, photographs and radiographs become components of the record and should be kept for 7-10 years and records of pediatric dental patients be retained until the patient reaches the age of maturity.[8]

Computer-generated dental records are becoming more common for record keeping. The advantage of maintaining an electronic record is that it can be easily networked and transferred for routine professional consultation or forensic cases requiring dental records for identification. Computer-assisted management technology (e.g. WinID3 dental comparison software bridged with the Dexis digital radiography program) has been an asset in expediting the comparison of antemortem and postmortem dental record information in recent events, including the World Trade Center terrorist attack, the Indian Ocean tsunami disaster and the hurricane Katrina recovery effort. Additionally, software such as Adobe Photoshop and Mideo systems casePACS, facilitates the superimposition of digitally scanned radiographs and photographs for comparison.[7]

IDENTIFICATION

Of all aspects of forensic science, the most widely known and utilized is the identification of both living and deceased persons. Identification is the establishment of a person's individuality. Proper identification is required for legal and humanitarian reasons. Deliberate falsification of identification for fraudulent gain is being attempted on an increasing scale around the world. It may help in the settlement of property, facilitate remarriage of a surviving spouse and allow the cremation or burial of the body, according to relevant religious and cultural customs.[9]

Identification can be done by visual recognition, property identification and scientific methods such as fingerprinting, physical anthropologic examination of bones, dental identification, serologic and genetic (DNA) comparison techniques.[7]

Regardless of the method used to identify a decedent, the results of the antemortem and postmortem data comparison lead to one of the following situations:

Positive identification: There is sufficient uniqueness among the comparable items in the antemortem and postmortem databases and no major differences are observed.

Probable identification: There is a high level of concordance between the two sets of data but, usually without radiographic support. The data is consistent but a lack of quality antemortem and/or postmortem information means one cannot confirm identity.

Presumptive (possible) identification: Enough information may be missing from either source to prevent the establishment of a positive identification.

Insufficient identification: There is insufficient supportive evidence available to compare and arrive at a conclusion based on scientific principles.

Exclusion of identification: Either explainable or unexplainable discrepancies exist among comparable items in the antemortem and postmortem databases. Exclusion may be just as important as a determination of positive identification.[8,9]

Dental identification procedures

Currently, three types of dental identification procedures are considered:[10]

- Comparative dental identification: Attempts conclusive identification by comparing the dead individual's teeth with presumed dental records of the individual
- Reconstructive postmortem dental identification or dental profiling: Attempts to elicit the ethnicity or "race", gender, age and occupation of the dead individual. This is undertaken when virtually no clue exists about the identity of the deceased
- DNA profiling to oral tissues: This method is used

when dental record is not available for comparison. The technique uses modern forensic DNA profiling methods to oral tissues to establish identity.

Role of radiographs

Comparison of antemortem and postmortem radiographs is accurate and reliable method of identifying remains. Observations such as distinctive shapes of restoration, root canal treatment, buried root tips, bases under restorations, tooth-root morphology sinus and jawbone patterns can be identified only by examination of radiographs. In some instances, a single tooth may be all that remains and upon comparison of radiographs, a positive identification can be made.[8]

Original antemortem dental radiographs are of immense value for comparison; therefore, it is essential that all routine radiographs exposed during the course of a dental practice be adequately fixed and washed so that they remain viewable years later. The best results are obtained when the angulation of the film to the x-ray tube is the same as that of the original films.[11]

Mass disaster victim identification

Dental identification has been regarded as one of the primary identifiers in the interpol disaster victim identification protocol. Sometimes, it may prove to be the only method that can be used to make or disprove identification.[12]

The identification of large number of casualties in mass disasters are complex and fraught with hazards, both physically and emotionally.[13] The ultimate aim of disaster victim identification is to establish every victim by comparing and matching accurate antemortem and postmortem data.[14] Most recently, dental identification has proved its worth in helping to identify victims from the Southeast Asia tsunami disaster in 2004.[12]

Mass disasters can be classified into natural calamities, accidents and criminal attacks (terrorist bombings). In this type of situations, physical features are often destroyed. Because teeth are heavily calcified, they can resist fire as well as a great majority of traumas. Generally, teeth and restorations are resistant to heat, unless they are exposed directly to flame.[8] The dental structures may be the only parts of the body not destroyed and they can be used even though they may be scattered over a wide area, such as occurs in aircraft accidents, terrorist attacks, partial incineration, fragmentation and severe decomposition.[15]

In mass disasters, the dental experts may have an integral role in the following areas: [4]

- Recovery of significant material at the site, as they are part of field recovery team
- Preparation, reconstruction, examination and documentation of postmortem material at the mortuary
- Collection and transcription of antemortem dental records at the identification centre and direct communication with dentists supplying the records
- Sorting and comparison of antemortem and postmortem data.

Dental identification uses the teeth, jaws and orofacial characteristics in general as well as the specific features of dental work with metallic or composite fillings, crowns, bridges and removable prostheses as well as distinctive configuration of bony structures of jaw (mandible and maxilla), the presence and shape of teeth including the roots, configuration of maxillary sinuses and long-standing pathology such as prior fractures and orthopedic procedures.[16]

The definite establishment of identity of a body essentially comes from a detailed comparison and matching of tangible antemortem records and postmortem findings. It is important to note that a minimum number of concordant points are not required for a positive identification, which is different from fingerprinting.[17] In some cases, a single tooth can be used for identification if it contains sufficient identifying or unique features. Equally, a full mouth series of radiographs may not reveal sufficient detail to render a positive identification.[18] The certainty of identification and conclusion lies with the forensic odontologist, who must be prepared to justify his conclusions in court.[13]

SEX DETERMINATION

FO plays an important role in establishing the sex of the victims with bodies mutilated beyond recognition due to major mass disaster. Sex can be determined based on data from morphology of skull and mandible, metric features as well as by DNA analyses of teeth.[9]

Craniofacial morphology and dimensions

The use of morphological features of the skull and mandible is a common approach used by anthropologists in sex determination.[10] Forensic anthropologists and forensic odontologists may work together to resolve the problems. Both disciplines are concerned with the analysis of calcified structures of the body, namely the bones and the teeth. The bones and teeth of the craniofacial complex, which are key identification tools for the forensic odontologist, effectively distinguish one person from others and one population from another. They are also used to determine the race, age and sex of a person.[11]

Williams and Rogers got 96% success in determining the sex using different features of the skull and the mandible. They also observed that using constant six traits: mastoid, supraorbital ridge, size and architecture of skull, zygomatic extension, nasal aperture and mandibular gonial angle, the accuracy was

94%. This indicates that craniofacial morphology can be used to determine sex of skeletal specimen with a high degree of precision.[9]

Sex differences in tooth size

Teeth may be used for differentiating sex by measuring their mesiodistal (MD) and buccolingual (BL) dimensions. In most studies, the canines have consistently shown the maximum sex difference. Premolars, maxillary molars as well as maxillary incisors are also known to have significant differences. In a study, Iscan and Kedici could accurately establish sex in 77% of the cases using maxillary and mandibular canines and mandibular second molar.[19]

Sex determination by DNA analysis

Forensic DNA analysis for sex determination can yield highly accurate results. Sex can be determined with very minute quantities of DNA (as little as 20 pg), and from very old specimens of teeth. Amelogenin (AMEL) is one of the major matrix proteins secreted by the ameloblasts of the enamel.[9] Modern DNA extraction methods can isolate genomic DNA from dental cells and the gene amelogenin, which is a sex-linked gene. In addition, microscopic examination of the cells from the pulp can also reveal the presence of Barr bodies in females.[10]

The AMEL gene, coding for a highly conserved protein, is located on the X and the Y-chromosomes in humans. The two alleles are similar for the exonic sequences but differ in the intronic sequences. Thus, the females (XX) have two identical AMEL genes but the males (XY) have two non-identical genes. The fact that the X and Y-specific AMEL genes are 106 and 112 base pairs (bp) in length, respectively, provides a relatively direct procedure to discriminate between male and female AMEL.[10,20]

On a bar-code type of display, a male DNA sample appears as two discrete bands of 106 and 112 bp. A female DNA sample appears as a single band of 106 bp for the AMEL gene. This distinction between human male and female AMEL genes is remarkably specific, sensitive and cost-effective for modern forensics.[20]

Polymerase chain reaction (PCR) is a method of amplifying small quantities of relatively short target sequences of DNA using sequence-specific oligonucleotide primers and thermostable Taq DNA polymerase. Preparing DNA from teeth by ultrasonication and subsequent PCR amplification, Sivagami and coworkers obtained 100 per cent success in determining the sex of the individual.[21]

AGE ESTIMATION

Age estimation is a subdiscipline of the forensic science and should be an important part of the identification process, especially when information relating to the deceased is unavailable.[22]

Human dentition follows a reliable and predictable developmental sequence, beginning about 4 months after conception and continuing to the beginning of the third decade of life when development of all the permanent teeth is completed. The use of radiographs is characteristic of techniques that involve observation of the morphologically distinct stages of mineralization.[8,23]

Use of attrition and development of third molars have been suggested as means of ageing for those individuals over 18 years, but both are unreliable.[12,24] Other techniques such as occlusal tooth wear,[25] incremental lines of cementum,[26] and radiographic method that used pulp size measurement of six teeth observed on periapical radiographs[27] have been suggested by researchers and are reliable methods. Newer techniques such as aspartic acid racemization[28] and translucent dentin[24,29] proved to be highly accurate in adult age assessment.

The following are popular age estimation methods in children

- Atlas approach includes Schour and Massler's method and Moorree's method
- Scoring method for example Demirjian's method.

Demirjian *et al*. tried to simplify chronological age estimation that assesses the mandibular left side teeth. The development of mandibular left teeth was divided into 10 stages numbered "0"–"9". Stage "0" denotes that tooth calcification is yet to begin, stage "5" indicates crown completion while stage "9" represents completion of tooth calcification (complete formation of root apex).

Based on statistical analysis, they provided different maturity "scores" for each tooth for different developmental stages and differentiated between boys and girls. The scores assigned for each 8 teeth are added and a total maturity score is obtained. The total score is substituted in regression formulas to derive the chronological age.[22]

Adult age estimation

Age estimation in adults is challenging when compared to younger age groups. The completion of growth, changes in the dentition used to estimate age, is influenced not only by the age of the individual but also by numerous endogenous and exogenous factors, such as disease, nutrition and physical strain.

Gustafson's method

In 1950, Gosta Gustafson developed a method for age estimation based on morphological and histological changes

of the teeth. They assessed regressive changes such as attrition (A), secondary dentine deposition (S), loss of periodontal attachment (P), cementum apposition at the root apex (C), root resorption at the apex (R), and dentin translucency (T). For each of these regressive changes or variables, different scores ranging from 0-3 were assigned. This applies that attrition could have anyone of four scores (AO, A1, A2, or A3) and similar one of four scores for the other variables. Adding the allotted score for each variable (e.g. A3 + S2 + P2 + C1 + R2 + T1 = X), a total score (X) was obtained. It was found that an increase in the total score (X) corresponds to an increase in age. Age was estimated using the formula: Age = 11.43 + 4.56x.[24]

However, Johanson made few improvements in the method, which were widely accepted. Instead of the original four grades (0-3), he proposed seven grades (0, 0.5, 1, 1.5, 2, 2.5, and 3). Using these seven grades, the formula Age = 11.02 + (5.14A) + (2.3S) + (4.14P) + (3.71C) + (5.57R) + (8.98T) was suggested.[22]

Dentin translucency method

Root dentin starts to become translucent during the third decade of life, beginning at the apex and advancing coronally. The alteration may be due to the decreased diameter of dentinal tubules caused by increased intratubular calcification. Hence, the difference in refractive indices between intratubular organic and extratubular inorganic material is equalized, resulting in increased translucency of the affected dentin. Based on tooth type, a number of regression formulas have been provided for age estimation.[9,22]

Age estimation from incremental lines of cementum

An estimate of age from incremental lines of acellular cementum is possible by using mineralized, unstained cross sections of teeth, preferably mandibular central incisors and third molars. The accuracy is claimed within 2-3 years of the actual chronologic age.[26]

ETHNIC RACE DETERMINATION

Information regarding the race of a person can also be decoded with the help of teeth. Various studies over the period of time had been conducted on this topic. There are certain features noted as in Mongoloid and American Indians, posteriorly concave upper incisors and grooves on rear surface of upper incisors (shovel-shaped appearance) while almost 100% of Europeans has flat lingual surface on the incisor teeth. Almost 100% of Japanese have ridges on lingual surface on the incisor teeth. Besides, the lower first molar of Caucasoid appears long with more tapering form while Negroid molars are small and square. Thus, by focusing on these types of findings on teeth, ethinic race can be established.[9,13]

BITE MARK ANALYSIS

Bite marks have been defined by MacDonald as "a mark caused by the teeth either alone or in combination with other mouth parts". Bite marks are usually associated with sex crimes, violent fights, child abuse and theft.[30]

Bite marks may be present following a fight between adults or children, as part of a sexual or physical assault by an adult on a child, in rape or attempted rape where bites are likely to be noted on the breasts and between homosexuals.[30,31]

The marks, single or multiple in nature, may be of varying degrees of severity, ranging from a mild marking of the tissues to deep perforation of the epidermis and dermis and may be found on breasts, face/head, abdomen, shoulder, upper extremity, buttocks, female genitalia, male genitalia, legs, ear, nose and neck.[32]

On occasion, nonhuman bite injuries are found on victims. Animal bites are usually distinguished from human bite injuries by differences in arch alignments and specific tooth morphology. Animal bites often cause shear rather than impact injuries, producing lacerations of the skin and open wounds.[33] Dog bites, perhaps the most common nonhuman bite, are characterized by a narrow anterior dental arch and they consist of deep tooth wounds over a small area.[8]

Typical presentation of bite mark injuries

The injuries caused by teeth can range from bruises to scrapes to cuts or lacerations. A representative human bite is described as an elliptical or circular injury that records the specific characteristics of the teeth.[34] The injury may be shaped like a doughnut with characteristics recorded around the perimeter of the mark. Alternatively, it may be composed of *two U-shaped arches* that are separated at their bases by an open space. It is possible to identify specific types of teeth by their class characteristics and individual features: [30]

Class features: Incisors produce rectangular marks; canines are triangular or rectangular, depending on the amount of attrition; premolars and molars are spherical or point-shaped.

Individual features: Class features may in turn have characteristics such as fractures, rotations, spacing, etc., Such features are known as individual features and they make the bite mark distinct.

Evidence collection from the bite victim

The best or only opportunity to collect the evidence may be when it is first presented and was observed. If a suspected bite mark is criminal in nature, it should be reported to the police. The list of procedures to properly collect the evidence includes:

(1) *Case Demographics,* i.e. vital information pertaining to the case; (2) *Visual Examination* of the bite mark; (3) *Photography,* i.e. extensive orientation and close-up photographs; (4) *Saliva Swabs collection,* i.e. saliva deposited on the skin during biting or sucking should be collected and analyzed and (5) *Impression taking,* i.e. an accurate impression of the bitten surface by vinyl polysiloxane or polyether may be done.[9]

Evidence collection from the bite suspect

Evidence collected from a victim of a bite mark should be complemented with evidence from a suspect of the perpetrated bite. It includes (1) *Clinical Examination*, (2) *Photographs* of the suspect's teeth in occlusion and in open bite positions, (3) *Impressions* of maxillary and mandibular teeth made with rubber-based material, (4) *Saliva swab* preferably from the buccal vestibule should be obtained for comparing with the swab collected from the bite mark and in addition, (5) *Bite sample,* i.e. suspect's bite is recorded in centric occlusion using either a wafer of base plate wax or a sample of silicone putty material designed for this purpose. This should be photographed immediately after it is recorded.[9]

Bite mark examination is the one aspect of FO requiring an immediate response by the forensic dentist. The marks fade rapidly, both in the living and in the dead, changing appearance in a matter of hours; delay in examination may result in the loss of valuable evidence. The forensic dentist is also responsible for the examination of the dentition of those suspected of bite mark perpetration.[12]

Child abuse

Child abuse is a non-accidental trauma or abuse inflicted on a child by a caretaker that is beyond the acceptable norm of child care.[35] Child abuse has been defined by Vale as "any act of commission or omission that endangers or impairs a child's physical or emotional health and development". Child abuse may be broadly categorized as physical abuse, sexual abuse, emotional abuse and neglect of the child.[32]

In addition to these, bite marks may also be present in cases of child abuse. Those found in infants tend to be on different locations from those in older children or adolescents and may be the result of punishment.[36] In older children, it may occur due to sexual abuse. The marks may be ovoid or semicircular. Bites from adults will often only mark clearly from one arch, while a child who has bitten will frequently mark with both arches.[12]

Kenney and Clark have attributed marks with an inter-canine width greater than 3 cm to adults. A smaller dimension may be the result of self-inflicted bites, as can occur when the child's arm is forced into the mouth to prevent the child from screaming. Children may bite each other casually during play.[9]

CONCLUSION

The fact that physiological variations, pathoses and effects of therapy of dental hard and soft tissues are unique to every individual, forms the basis of this branch of medical science. In cases of medico-legal background, this is also very useful. Since the scope of forensic science is very broad and challenging, dental surgeons trained in FO can make unique contributions in the administration of law and justice. A forensic dentist is concerned with the handling and collation of dental evidence and assists law enforcement agencies in the detection and resolution of criminal and civil proceedings.

A forensic odontologist must have broad background knowledge of general dentistry, encompassing all dental specialties. He must also have the basic knowledge of the role of forensic pathologist and the methods used in autopsy, as dental evidence is the most valuable and reliable method. We need beforehand trained forensic odontologist to be prepared with a skilled team on priority basis. This branch needs further research and recognition in India.

REFERENCES

1. Keiser-Neilsen S. Person identification by means of teeth. 1st edition. Bristol: John Wright and Sons; 1980. p. 190-225.
2. Cameron JM, Sims BG. Forensic Dentistry. 1st edition. Edinburgh: Churchill Linvingstone; 1974. p. 310-403.
3. Neville BW, Damm DD, Allen CM, Bouquot JE. Oral and Maxillofacial Pathology. 2nd edition. Philadelphia (PA): W.B. Saunders Co; 2002. p. 201-9.
4. Dayal PK, Srinivasan SV, Paravathy RP. Text book of Forensic Odontology. 1st edition. Hyderabad: Paras Medical Publishers; 1998. p. 210-20.
5. Tobias V P. The skulls, endocast and teeth of Homo habilis In: Olduvai Gorge. The skulls, endocast and teeth of Homo habilis. 1st edition, Vol. 4. New York: Cambridge University Press; 1991. p. 50-80.
6. Holden JL, Clement JG, Phakey PP. Age and temperature related changes to the ultrastructure and composition of human bone mineral. J Bone Miner Res 1995;10:1400-9.
7. Neville BW, Damm DD, Allen CM, Bouquot JE. Oral and Maxillofacial Pathology. 3rd edition. New Delhi: Elsevier; 2009. p. 113-9.
8. Avon SL. Forensic odontology: The roles and responsibilities of the dentist. J Can Dent Assoc 2004;70:453-8.
9. Acharya AB, Sivapathasundharam B. Forensic odontology. In: Rajendran R, Shivapathasundharam B. Shafer's Textbook of Oral Pathology. 6th edition. New Delhi: Elsevier; 2009. p. 871-5.
10. Sweet D. Forensic odontology. Dent Clin North Am 2001;15:237-51.
11. Luntz LL. History of forensic dentistry. Dent Clin North Am 1977;21:7-17.
12. Leung CK. Forensic odontology. Hong Kong Med Diary 2008;13:16-8.
13. Pretty IA, Sweet D. A look at forensic dentistry- Part 1: The role of teeth in the determination of human identity. Br Dent J 2001;190:359-66.
14. Sirisup N, Kanluen S. Role of forensic doctors in Thailand's

tsunami: Experiences from chulalongkorn medical school. J Med Assoc Thai 2005;88:S335-8.
15. Levine S. Forensic odontology-identification by dental means. Aust Dent J 1977;22:481-7.
16. Thali MJ, Markwalder T, Jackowski C, Sonnenschein M, Dirnhofer R. Dental CT imaging as a screening tool for dental profiling: Advantages and limitations. J Forensic Sci 2006;51:113-9.
17. Body identification guidelines. American Board of Forensic Odontology, Inc. J Am Dent Assoc 1994;125:1244-6, 1248, 1250.
18. De Villiers CJ, Phillips VM. Person identification by means of a single unique dental feature. J Forensic Odontostomatol 1998;16:17-9.
19. Hemant M, Vidya M, Nandaprasad, Karkera BV. Sex determination using dental tissue. Med-Legal Update 2008;8:13-5.
20. Slavkin HC. Sex, enamel and forensic dentistry: A search for identity. J Am Dent Assoc 1997;128:1021-5.
21. Sivagami AV, Rao AR, Vaishney U. A simple and cost effective method for preparing DNA from the hard tooth tissue and its use in PCR amplification of amelogenin gene segment for sex determination in Indian population. Forensic Sci Int 2000;110:107-15.
22. Willems G. A review of the most commonly used dental age estimation techniques. J Forensic Odontostomatol 2001;19:9-17.
23. Whittaker DK. An introduction to forensic dentistry. Quintessence Int 1994;25:723-30.
24. Gustafson G. Age determination on teeth. J Am Dent Assoc 1950;41:45-54.
25. Yun JI, Lee JY, Chung JW, Kho HS, Kim YK. Age estimation of Korean adults by occlusal tooth wear. J Forensic Sci 2007;52:678-83.
26. Aggarwal P, Saxena S, Bansal P. Incremental lines in root cementum of human teeth: An approach to their role in age estimation using polarizing microscopy. Indian J Dent Res 2008;19:326-30.
27. Bosmans N, Ann P, Aly M, Willems G. The application of Kvaal's dental age calculation technique on panoramic dental radiographs. Forensic Sci Int 2005;153:208-12.
28. Ritz-Timme S, Cattaneo C, Collins MJ, Waite ER, Schütz HW, Kaatsch HJ, *et al*. Age estimation: The state of the art in relation to the specific demands of forensic practise. Int J Legal Med 2000;113:129-36.
29. Lorentsen M, Solheim T. Age assessment based on translucent dentine. J Forensic Odontostomatol 1989;7:3-9.
30. Sweet D, Pretty IA. A look at forensic dentistry-Part 2: Teeth as weapons of violence-Identification of bitemark perpetrators. Br Dent J 2001;190:415-8.
31. Pretty IA, Sweet D. Anatomical location of bitemarks and associated findings in 101 cases from the United States. J Forensic Sci 2000;45:812-4.
32. Vale GL, Noguchi TT. Anatomical distribution of human bite marks in a series of 67 cases. J Forensic Sci 1983;28:61-9.
33. Epstein JB, Scully C. Mammalian bites: Risk and management. Am J Dent 1992;5:167-71.
34. Rothwell BR. Bite marks in forensic dentistry: A review of legal, scientific issues. J Am Dent Assoc 1995;126:223-32.
35. Ambrose JB. Orofacial signs of child abuse and neglect: A dental perspective. Pediatrician 1989;16:188-92.
36. Beckstead JW, Rawson RD, Giles WS. Review of bite mark evidence. J Am Dent Assoc 1979;99:69-74.

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