Review Article

ROLE OF ODONTOLOGY IN DETERMINATION OF IDENTITY IN FORENSIC SCIENCE- AN OVERVIEW

Rahul Sood[1], Priya Mamachand[2], Rakhi Sood[3], Pragati Parasher[4]

[1]Professor and Head, Dept. of Oral and Maxillofacial Surgery, Magaraja Ganga Singh Dental College and Research Center Sriganmganagar Rajasthan, [2]Department of Oral Medicine and Radiology, Manav Rachna Dental College, Faridabad, [3]Department of Periodontics, [4]Dept. Of Prosthodontics and Implantology, B.R.S Dental College and Hospital, Sultanpur

Abstract:
Human identification is one of the most challenging subjects that man has been confronted with. The role of forensic odontology has increased in contributing in this regard as very often teeth and dental restoration are the only means of identification. Dental identification of humans occurs for a number of different reasons and situations like mass disasters (aviation, earthquakes, tsunamis), in crime investigations and in case of disfigured bodies due to fire and motor vehicle accidents. The various methods employed in forensic odontology include radiographs, antemortem & postmortem photographs, tooth prints, rugoscopy (study of palatal rugae patterns), chieloscopy (study of lip prints) and molecular methods like polymerase chain reaction for pulp DNA analysis. The investigative methods applied in forensic odontology are reasonably reliable, yet the shortcomings must be accounted for to make it a more meaningful and relevant procedure.
Key words: Forensic odontology, personal identification, rugoscopy.

Corresponding author: Dr. Rahul Sood, Professor and Head, Dept. of Oral and Maxillofacial Surgery, Magaraja Ganga Singh Dental College and Research Center Sriganmganagar Rajasthan.

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INTRODUCTION

Forensic odontology is derived from latin, meaning forum or where legal matters are discussed. In 1970 , Keiser-Neilson defined forensic odontology as the branch of forensic medicine which in the interest of justice , deals with the proper handling and examination of dental evidence and proper evaluation and presentation of the dental findings.[1] Forensic dental examination takes an equal footing with its species as obstetric-gynaecologic, venereal and other expertise. Forensic dentists are resposible for 5 main areas of practice:

1. Identification of found human remains
2. Identification in mass fatalities
3. Assessment of bite mark injuries
4. Assessment of cases of abuse (child, spousal, elder)
5. Age estimation

HISTORY

Identification using dental evidence is not new. There are historical reports of identification by recognizing specific dental features as early as 49th century.[2] During the

U.S revolutionary war, none other than Paul Revere- a young dentist helped identify war casualities by their bridge work.[3,4] In 1898 Dr. Oscar Amoedo wrote the first treatise on forensic odontology entitled L'Art Dentaire en Medicine Legale. He is since known as the father of forensic odontology.[5]

DENTAL IDENTIFICATION

Identification is crucial when the deceased is decomposed, burned, dismembered, or skeletonised. Dental identification is based on the fact that teeth are such physical characteristics that endure throughout the decomposition process, can withstand extreme temperature and are recognizable postmortem.[6] The contribution of dentistry to human identification takes two main forms:

1. The identification of human remains existing antemortem, and
2. A postmortem dental profiling in cases where there are no antemortem records.

The antemortem records are compared with the dental status of the cadaver giving strong evidence of the identity of the cadaver. In case there is no dental anamnesis, a through dental profile is completed. This in turn helps the specialists to sort the existant antemortem material and select the information that most fits to the profile of the cadaver.[7]

COMPARATIVE DENTAL IDENTIFICATION

Clearly, individuals with numerous and complex dental treatments are often easier to identify than those individuals with little or no restorative treatment. Typically human remains when found are reported to the police who then initiate a request for dental identification. Often a presumptive or tentative identification is present (ie. wallet or driving licence maybe found on the body) which will enable antemortem records to be located. The forensic dentist produces the postmortem record by careful charting and written descriptions of the dental structures and radiographs of the cadever. Once the postmortem record is complete, a comparison between the two records can be carried out.[8] During this procedure the features that are compared are: presence or absence of teeth, shape, size, position, dental restorations, maxillary sinus, TMJ, and other bone peculiarities.[6]

POSTMORTEM DENTAL PROFILING

When the antemortem information is unavailable, a postmortem dental profiling can still contribute to establishing the identity. It can provide information on the_deceased's age, ancestry background, sex and socio-economic status.[8] In some cases its possible to provide additional information regarding occupation, dietary habits, habitual behaviors and occasionally on dental or systemic diseases.

Studying the facial skeleton contributes to information on sex and ancestry and can help determine race within the three major groups: Caucasoid, Mongoloid and Negroid. Other characteristics, such as cusps of carabelli, shovel-shaped incisors and multi-cusped premolars can also assist in determination of ancestry.[8] With the analysis of specific genes in the DNA, particularly the genes located on different chromosomes for males and females, can help distinguish between males and females. The amelogenin gene (AMEL) is located on the X chromosome in females and on the X and Y chromosome in males. The length of the gene on the X chromosome is 106 base pairs and on the Y chromosome 112 base pairs. Thus, on a bar-code type display of the DNA the difference in the length of the two genes is visible.[9]

The presence of erosion can suggest alcohol or substance abuse, an eating disorder or even hiatus hernia while stains can indicate smoking, tetracycline use or betel nut chewing.[10] The quality, quantity and presence or absence of dental treatment may give an

indication of socio-economic status or likely country of residence.[11]

Dental materials have provided clues to assist identification. One of the authors (DS) has used SEM-EDX to identify the composition of a glass-ionomer restoration and then traced this back to a prison where the filling was placed. Dental records secured the identification of the individual.[8] In cases due to the reduction of the number of restorations postmortem identification becomes difficult. In this instances, the digitalization of putative ante- and postmortem radiographs, contribute to a computer-aided identification. In particular, the root morphology and the spatial relationship of teeth roots and their supportive structures in ante- and postmortem radiographs are being assessed with the utilization of a computer software and compared.[12]

Edentulous patients represent a problem for the identification process of human remains because even if there are antemortem radiographs there are morphological changes in the jaw bone due to the resorption of the alveolar ridges, that render the identification difficult. Lateral skull radiography appears useful in such cases, because of the reproductability of the method. Even lip prints and palatal rugae patterns are considered to be unique to an individual and hence hold the potential for use in identification of an individual. Denture marking system either in the form of a surface marker (engraving the casts, scribing the denture) or with an inclusion method (metallic labels, microchips) also makes their identification easier.[6,13]

DNA IN FORENSIC ODONTOLOGY

Forensic science is ever in persuit of the perfect tool in human identification. The resilient nature of the dental hard tissues to environmental assaults ensure that teeth represent an excellent source of DNA material.[14] With the advent of the polymerase chain reaction, a technique that allows amplification of DNA at preselected specific sites, this source of evidence is becoming increasingly popular with investigators. In the authors' laboratory, the cryogenic grinding method is employed to extract the genomic DNA from the calcified tissues. Silva et al have emphasized that[15] in addition to genomic DNA, cells contain mitochondrial DNA (mtDNA), the sequence of building blocks of which can be determined to assist in identification. The main advantage of mtDNA is that there is a high copy number in each cell caused by the high number of mitochondria present in most cells. This infers that in cases where genomic DNA cannot be analyzed, possibly because it is too degraded, mtDNA may be present in sufficient quantity. In addition to its higher copy number, mtDNA is maternally inherited. This maternal inheritance pattern confers the same mtDNA sequence, barring mutations, upon siblings and all their maternal relatives. This has important implications for the identification of individuals for which there is no antemortem comparison sample.[8]

DENTAL IDENTIFICATION IN MASS DISASTERS

The indian ocean tsunami of 26 December 2004 created unprecedented challanges for forensic identification of dead bodies. Identification of victims was their main purpose. This is probably the most eminent example on the success of forensic odontologists in identifying large number of victims in short time. The forensic dentistry team was divided into two parts i.e. dental examination and dental radiology. Facial bilateral dissection was performed to examine the maxilla and mandible. The teeth were rinsed/ brushed for clear examination. Teeth that might have recieved root canal treatment were identified for further radiographic investigation. Two untreated teeth with large pulp were selected for DNA profiling. If teeth

were not available then femur shaft or rib was selected. Two bitewing radiographs were taken and labeled. Teeth were then sent for DNA profiling. After final check of the documents and radiographs, body was released to refrigirated containers.[16] As of 27 july 2005, 7 months after the disaster, TTVI had identified 2010 victims[17] of which 61% of victims were identified by TTVI using dental examinations, 19% using finger print records, 1.3% using DNA analysis, 0.3% using physical evidence and 18% of cases with more than one type of evidence.[18]

Forensic odontologists have contributed to the resolution of many other mass disasters where often the dental structures and restorations maybe the only parts of the body not destroyed, such as in aircraft accidents, terrorist attacks,etc.[19] The identification process in mass disasters is fundamentally the same as that in a routine comparative dental examination, but the inherent problems are magnified. Problems of body fragmentation, mutilation, commingling and incineration, idiosyncratic dental records from numerous regions, poor working conditions and psychological stresses all confound the identification process. The key to successful mass disaster identification is preparedness. Many jurisdictions have dental identification teams and disaster plans in place. Mock disaster scenarios that help dentists prepare for the disaster situation have proven to be successful.[20,21]

TOOTH AND SKELETAL CHARACTERISTICS IN AGE DETERMINATION

Dental structures can provide useful indicators to the individual's chronological age.[22] The age of children (including foetuses and neonates) can be determined by analysis of tooth development and subsequent comparison to development charts, usually to an accuracy of approximately 1.6 years.[23] An interesting fact to keep in mind is that the total number of teeth in a child's mouth only changes when the superadded teeth (the molars) erupt. The permanent molars erupt in a fairly regular mathematical rhythm of approximately 6,12 and 18-24 years. Thus the total number of teeth would change only at these ages.[24] Mincer et al advocate that maxillary third molars slightly precede the completion of mandibular third molars and that root formation of third molars in males occurs earlier than in females thus their developmental status can also be used to assign age to young adults which claims an accuracy of plusminus 4 years.[6,8] Periodontal disease progression, excessive wear, multiple restorations, extractions, bone pathosis and complex restorative work may indicate an older individual. Accuracy using these highly-variable markers is in the range of plusminus 10-12 years.[8]

Recent research indicates that studying the tooth cementum annulations on photomicrograph maybe used more reliably for age estimations.[25] The predicted age of the individual thus obtained is:

Number of incremental lines (n) = X/Y

Where X is the total width of cementum from dentinocemental junction to cementum surface and Y is the width of cementum between the two incremental lines. By adding average age of eruption in years for each tooth as presented in Gray's Anatomy[26] in the counted number of incremental lines, the chronological age of the individual was obtained.

$E = n + t$

where, estimated age = number of incremental lines (n) + eruption age of tooth (t).[27]

Tooth prints are enamel rod end patterns on the tooth surface. These patterns are unique to an individual tooth. This uniqueness of the tooth print is used as a valuable tool in forensic science for personal identification. Amino acid racemization studies are also used to determine age. Aspartic acid has been reported to have the highest racemization rate

of all amino acids and to be stored during aging. In particular, L-aspartic acids are converted to D-aspartic acids and thus the levels of D-aspartic acid in human enamel, dentine and cementum increase with age. The D/L ratio has been shown to be highly correlated with age.[28] Dentinal translucency is one of the morpho-histological parameters considered best and simple for dental age estimation . By convention, translucency has been measured using calipers. Acharya described a method to measure translucency on sectioned teeth using commercially available computer hardware and software.[29] With advances in computing technology, digital evaluation of translucency can be more easily accomplished today.[30]

BITE MARK ANALYSIS

Bite marks are an important and sometimes controversial aspect of forensic odontology. although there are many cases in which bite mark evidence has been critical to the conviction or exoneration of criminal defendants, there is continuing dispute over its interpretation and analysis.[31] Bite marks most often appear as elliptical or round areas of contusion or abrasion, occasionally with associated indentations.[31] For bites on human skin, a potential bite injury must be recognised early, as the clarity and shape of the mark may change in a relatively short time in both living and dead victims. Souviron has pointed out that refrigeration time, temperature, humidity, light, and gravity are further variables that affect bite mark.[32]

Since a large propotion of individuals(80-90%) secrete the ABO blood groups in their saliva, swabbing the area and a control area elsewhere on the body should be completed before the body is washed.[33] Photography is the primary means of recording and preserving the bite mark and is critically important in documenting the evidence.[34] When there are indentations in the skin, or to preserve the three-dimentional nature of the bitten area, impressions should be taken to fabricate stone models. This is done by fabricating custom impression trays and taking an impression of the mark and surrounding skin with standard dental impression material. These impressions are then poured in dental stone to produce models. after the initial analysis is complete, there may be a need to preserve the actual skin bearing the mark. A ring of custom tray material can be made to fit like a hoop closely approximating the skin, which can then be attached to the skin using cyanoacrylate adhesive and stabilised with sutures. When the pathologist completes the autopsy, the bite mark can be excised with the supporting framework in place.[35] Some forensic dentists used the dorion method, which advocates the removal of bitten tissue for microscopic examination. Others use advanced techniques such as scanning electron microscopy, computer-enhanced digitization, and xeroradiology. Computerised bite analysis software also exists. Once a suspect is apprehended, the forensic dentist makes one or more impressions of the suspect's teeth comparing them to the recorded bite marks, and if called to testify, renders an opinion of the probability of the match.

CONCLUSION

It is important to recognize the value of dental forensic identification from the early ancients to the present. From natural disasters to atrocities to mysterious disappearances, dental remains have been a universally used tool to determine identification, lifestyles, culture, and societies of the deceased, especially in the identification of those individuals who cannot be identified visually or by other means. The concept of fusing dental evidence in forensic investigation has kindled so much interest in the recent past that forensic odontology is even suggested as the single positive identification method to solve certain forensic cases. In spite of having progressed in leaps

and bounds through various techniques in the identification of accident victims and in investigative criminology, forensic odontology is still bound by precincts. The demand for accurate forensic investigation will increase the scope of this interesting science in India. In India, the undergraduate program must be improved by including preclinical lectures on forensic odontology and a structured postgraduate training program should be developed. The establishment of referral centers with well-equiped dental labs (at least at the district levels) , Standardization of the techniques and, most importantly, improvements in record keeping (for example, have a standard check of dental records in hospitals and private clinics, issue identification numbers/ allot dental or medical identification cards to patient, etc) should be implemented. For an efficient forensic investigation, we need a dental team, comprising personnel from all branches of dentistry, working in close association with experts from other branches of forensic science.

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