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Evidence-Based Forensic Dentistry

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Preface

Why this book, *Evidence-Based Forensic Dentistry*? This specialized branch of dentistry has the potential to solve the legal issues with oral-dental structures and related issues encountered during forensic investigations. The research and experimentation in this field can all lead to improvements in dentistry. This book draws on our own studies and related studies of other researchers—particularly over the last 9 years.

Identification of unknown individuals and the determination of their age, race, and sex are among the most important functions of forensic odontology. Fundamental applications of forensic dentistry include mass disaster investigations, evaluating bite marks, bite mark evidence in death investigations, and child abuse investigations. The field of forensic odontology has come up with a long approach in recent years. New and unique discussions offer information that will benefit professionals faced with many of the current aspects of the science. This book covers all standard examination procedures of dental evidence, including identification of unknown individuals (age, race, sex). It also includes special chapters on the proper handling of records; writing a legal report about dental age, sex, bite mark, etc.; forensic dental radiography; new methods of dental age estimation; jurisprudence and legal issues; oral fluid in forensic odontology; teeth and oral fluid in toxicology; real cases of dental identification; dental age estimation; bite marks and child abuse, etc.; technological advances in forensic odontology; and oral-dental autopsy. The aim of this book is to include comprehensive, step-by-step instructions on how to practice each stage of forensic odontology and dental toxicology.

The editors and contributors have endeavored to appear objective and rational about the development and future of forensic odontology and dental toxicology and other closely linked forensic and dental disciplines. We can be good forensic experts if well-proven scientific principles are applied from the initial step, and continued throughout, which is important to ensure a successful result. Whether you are a dental examiner, a dentist, a pathologist, a law enforcement officer, or a legal professional who needs to know about the proper handling and evaluation of dental evidence, a legal or police science

professional who needs to know how to deal with the proper presentation of dental findings in a court of law, or a dentist who wants to use one's own training and experience in an exclusive, interesting, and challenging way, this book is for you investigators.

We would like to thank our family, especially our parents, and our professors. Finally, we thank the publishers for supporting our venture.

Copenhagen, Denmark — Balwant Rai
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Forensic Odontology: History, Scope, and Limitations

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1.1 Introduction

Forensic odontology involves the correct collection, management, interpretation, evaluation, and presentation of dental evidence for criminal or civil legal proceedings: a combination of various aspects of the dental, scientific, and legal professions (Hinchliffe 2011). Forensic dentistry may be defined as the specialized branch of dentistry that applies dental knowledge to civil and criminal problems. The JBR Group in forensic odontology, India (leader and founder, Dr. Balwant Rai) has simply expanded this definition to include the unique needs of the forensic odontologist in medicolegal and other services. While it is true that the primary mission is to support requests for aid in forensic dental identification, we must understand that dental identification is only one of a number of major areas in forensic dentistry. These include dental identification, age estimation, sex determination, cheiloscopy and palatoscopy, molecular biomarkers, bite mark analysis, human abuse and neglect, dental malpractice and negligence, and dental anthropology and archaeology. The forensic odontologist helps legal authorities by examining dental evidence in different conditions. The subject can be roughly divided into three major fields of activity: civil or noncriminal, criminal, and research (Cameron and Sims 1974).

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1.2 History (Frness 1970; Keiser-Neilsen 1968, 1980; Valerie and Souviron 1984)

The establishment of forensic odontology as a unique discipline has been attributed to Dr. Oscar Amoedo (considered the father of forensic odontology), who identified the victims of a fire accident in Paris, France, in 1898. The following timeline highlights key moments in the history of forensic odontology:

1453: First reported case of dental identification: The Earl of Shrewsbury, who fell in the Battle of Castillon, was identified.

1775: Dr. Paul Revere, the first forensic odontologist, identified the remains of a victim based on the retrieval of a prosthesis he had constructed.

1849: The first conviction based on dental evidence occurred; the evidence was crowns from charred remains of the victim.

1850: In Boston, Dr. John Webster was convicted of murder based on dental evidence. He was later hanged.

1884: R. Reid, a dentist, read an important paper to the British Dental Association meeting in Edinburgh about the applications of dental science in the detection of crime.

1887: Godon in Paris recommended the use of teeth in the identification of missing persons, depending on accurate records being kept by dentists.

1897: One hundred twenty-six Parisian socialites were burned to death in a few minutes in the Bazar de la Charité. At the request of the consul, who knew many of victims, Dr. O. Amoedo (a Cuban dentist who worked in Paris), aided by two French dentists, Drs. Devenport and Brault, examined and identified many of the bodies. This incident was published as the first text in forensics dentistry on a mass disaster.

1898: Dr. Amoedo wrote his thesis on the value of dentistry in medicolegal affairs; he is universally recognized as the father of forensic odontology.

1932: Edmond Locard recommended the use of lip prints in identification.

1937: A murder trial ended in a conviction based on bite mark evidence for the first time.

1946: Welty and Glasgow devised a computerized program to sort 500 dental records.

1963: Hands, eyes, ears, scalps, and filled teeth had been removed after death to conceal their identity by J. Taylor.

1967: Linda Peacock had a bite mark along with other evidence that led to a young man's murder conviction.

1967: According to Keiser-Nielsen (1967), forensic dentistry is defined as the "proper handling and examination of the dental evidence, in the interests of justice, so that the dental finding may be properly presented and evaluated."

1972/1973: The International Reference Organization in Forensic Medicine and Sciences (I.N.F.O.R.M.) published a compendium of 1,016 references concerning dental identification and forensic odontology compiled diligently by Dr. William and covering over 120 years.

1973: The basic practice of forensic odontology has changed little except that advances in dental materials and laboratory techniques and improvements in scientific and photographic technology have established proof and presentation much closer to forensic science as defined by Harvey. Harvey demonstrate that the fact that the external physical appearance of bitemarks changed with time, and the causative factors precipitating these changes were largely unknown. It will be examined later that the dramatic realization of the possible value of bite marks has assumed a great importance in identification in the last 10 years.

1.3 Dental Identification

Dental identification assumes a main role in the identification of remains when there are postmortem changes, tissue injury, and a lack of fingerprints or other identifying methods. The identification of dental remains is of key significance in cases where the deceased person is decomposed, skeletonized, or burned. The main advantage of dental evidence is that it is frequently preserved after

death and not affected by adverse conditions. The basic principles of dental identification are those of comparison, of exclusion, and of making a profile (Rai et al. 2006; Spitz 1993). In spite of the method used to identify a individual, the results of the comparison of antemortem and postmortem data lead to one of these four conditions (American Board of Forensic Odontology 1986):

1. Positive identification: Comparable items are sufficiently distinct in the antemortem and postmortem databases; no major differences are analyzed.
2. Possible identification: Commonalities exist among the comparable items in the antemortem and postmortem databases, but enough information is missing from either source to prevent the establishment of a positive identification.
3. Insufficient identification evidence: Insufficient supportive evidence is available for comparison and definitive identification, but the suspected identity of the decedent cannot be ruled out. The identification is then deemed inconclusive.
4. Exclusion: Unexplainable discrepancies exist among comparable items in the antemortem and postmortem databases. Sometimes explainable discrepancies are present, such as changes in restorations related to the passage of time, avulsion of a tooth or teeth secondary to the trauma at the time of death, or additional treatments by a second party that were not registered in the antemortem record. In all these cases, the discrepancies can be explained and identification can still be made.

1.4 Dental Record as a Legal Document

The dental record is a legal document owned by the dentist and all dental professionals and consists of subjective and objective information about the patient. It contains a physical examination of the dentition and supporting oral and surrounding structures, results of clinical laboratory tests, study casts, photographs, and radiographs. It should be kept for 5–30 years. Corrections in the record should not be erased, just corrected with a single line drawn through the incorrect material. Computer-generated (i.e., digital) dental records are becoming more common for dental records. Thus, proper dental documentation is needed for forensic odontology.

1.5 Mass Disaster Identification

Different mass accidents form the majority of cases in which dental identifications are required, mainly aircraft accidents, fires in and collapse of heavily occupied buildings, among others. The forensic odontologist is generally a member of the investigating team, the composition of which varies depending on the nature of the disaster. Usually, teeth and restorations are resistant to heat if they are exposed directly to flame. Preservation is therefore possible in most cases (Rai and Anand 2007a).

Dental identification has been considered one of the main members of the INTERPOL (INTERPOL 2008) disaster victim identification protocol. The orodental structures and dental restorations may be the only parts of the body not affected. 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 rarely the case that the two match in all aspects, so some judgment is required.

1.6 Age Assessment (Rai et al. 2009, 2010; Willems 2001)

There are a number of medicolegal reasons and criminal cases necessitating the estimation of an individual's age. Orodental structures can provide useful indicators as to the individual's chronological age. The age of children can be determined by the examination of tooth development and a subsequent comparison with development charts, usually to an accuracy of approximately 2.3 years. The use of attrition and the development of third molars have been suggested as means of aging those individuals over

Fig. 1.1 Bite marks

18, but both are unpredictable. Advanced techniques like aspartic acid racemization and translucent dentine have been proposed and have proven to be highly accurate in adult age assessment.

1.7 Bite Mark Evidence

Bite mark evidence may be present in cases of sexual or physical assault by an adult on a child; in rapes or attempted rapes, where bites are likely to be noted on the breasts; in violence between homosexuals; and in family or domestic violence (Pretty and Sweet 2000; Sweet and Pretty 2001). The marks, single or multiple in nature, may be of varying degrees of severity, ranging from a mild marking of the tissues to a deep perforation of the epidermis and dermis, and may be found on breasts, face/head, abdomen, shoulders, upper extremities, buttocks, female genitalia, male genitalia, legs, ear, nose, and neck (Pretty and Sweet 2000; Sweet and Pretty 2001; Vale and Noguchi 1983). Its examination is the one aspect of forensic odontology requiring an immediate response by the forensic odontologist. Sometimes nonhuman bite injuries are found on victims. Animal bites are usually distinguished from human bite injuries (Fig. 1.1) by differences in arch alignments and specific tooth morphology. Dog bites, perhaps the most common nonhuman bite, are characterized by a narrow anterior dental arch and consist of deep tooth wounds over a small area. Cat bites are small and round, with pointed cuspid tooth impressions caused by the conical shape of these teeth (Spitz 1993). As the introduction of molecular biology to dental identifications, the use of DNA in bite mark cases was found in an effort to eliminate the subjectivity associated with conventional analysis (Pretty and Sweet 2000).

1.8 Child Abuse

Abuse of a child by a caretaker is defined as physical force that is outside the acceptable norm of child care. The head and facial areas are regularly injured in such cases (Ambrose 1989). Human bite marks are often seen in abuse cases, frequently attended by other injuries. Those found in infants tend to be on different locations from those in older children or adolescents, and this is unclear because most injuries to children result from punitive measures. The marks may be ovoid or semicircular.

1.9 Facial Reconstruction and Superimposition

If the postmortem profile does not obtain the provisional identity of the deceased, it may be important to reconstruct the person's appearance during life. This is the responsibility of forensic artists and forensic odontologists, who utilize the dental parameters to aid with facial reconstruction (Gatliff 1984) (Fig. 1.2). Antemortem photographs have been used to allow facial

Fig. 1.2 Facial reconstruction

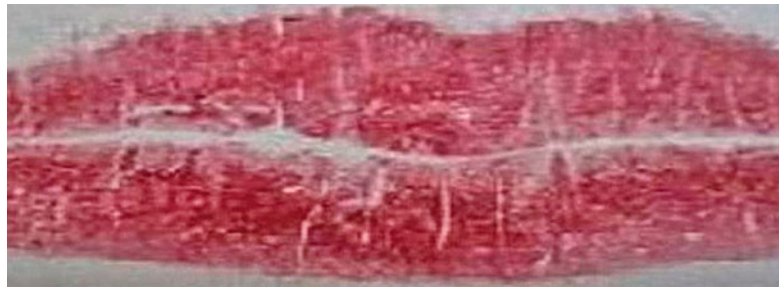

Fig. 1.3 Lip prints

superimposition of skeletal and teeth fractures in cases of identification. This technique requires the availability of appropriate antemortem photographs that show views of the individual's teeth (Austin-Smith and Maples 1994).

1.10 Sex Determination

The dimorphism of the canines, the mandibular canine index, and the BR (Balwant Rai) formula have been used as valid tools in the forensic and legal identification of an individual (Rai et al. 2004). Different molecular techniques have been used for sex determination from teeth. Sex determination from pulpal tissue depends on the presence or absence of an X-chromosome. Sex determination from human tooth pulp in individuals is possible up to a period of 4 weeks after death. But teeth can also serve as an excellent source of genetic material, and nonrestored teeth are even more appropriate for DNA analysis than restored teeth (da Silva et al. 2007).

1.11 Cheiloscopy and Palatoscopy (Caldas et al. 2007; Rai and Anand 2007b)

Lip prints (Fig. 1.3) and palatal rugae patterns (Fig. 1.4) are considered to be unique to an individual and hence hold potential for identifying an individual. Cheiloscopy is appropriate in identifying the living, since lip prints are usually left at crime scenes and can provide a direct link to the suspect. Palatal rugae, also called plica palatinae transverse and rugae palatine, refer to the ridges on the anterior part of the palatal mucosa, each side of the median palatal raphe and behind the incisive papilla. Catastrophic accidents involving plane crashes, fires, and explosions can destroy the fingerprints, but, interestingly, palatal rugae

Fig. 1.4 Palatal rugae patterns

patterns are preserved. Once the palatal rugae are 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. They help in the identification of an individual.

1.12 DNA Profiling (da Silva et al. 2007)

Different biological materials may be employed for the isolation of DNA to be used in laboratory tests for human identification, including teeth, bone tissue, hair bulbs, biopsy samples, saliva, blood, and other body tissues. Many varied techniques were applied to identify thousands of victims of the 2004 South Asian tsunami disaster, such as forensic pathology, forensic dentistry, DNA profiling, and fingerprinting.

1.13 Limitations of Forensic Odontology

Although there are few shortcomings associated with the various methods used in forensic odontology, the inconsistencies associated with them are to be weighed cautiously to make forensic odontology a more accurate, reliable, and reproducible investigatory science.

1. Palatal rugae cannot be used in cases of edentulous mouths, when antemortem records are not available, when palatal pathology exists, and with fire, decomposition, and skeletonization since the palatal rugae are often destroyed.
2. Lip prints cannot be used 20 h after the time of death, with lip pathologies like mucocele and clefts, or with any postsurgical alteration of the lips, scars, etc.
3. Bite marks cannot be used 3 days after the time of death or with a decomposed or burned body.
4. Errors may develop while taking radiographs and photographs, resulting in low-quality documents. Errors may develop in sample collection, processing, and interpretation. Any bacterial contamination and another person's DNA can alter the interpretation.

Conclusions

The contribution of a forensic odontologist in medicolegal proceedings can be of great importance.

References

Ambrose JB (1989) Orofacial signs of child abuse and neglect: a dental perspective. Pediatrician 16(3–4):188–192

American Board of Forensic Odontology (1986) Guidelines for bite mark analysis. J Am Dent Assoc 112(3):383–386

Austin-Smith D, Maples WR (1994) The reliability of skull/photograph superimposition in individual identification. J Forensic Sci 39(2):446–455

Caldas IM, Magalhães T, Afonso A (2007) Establishing identity using cheiloscopy and palatoscopy. Forensic Sci Int 165:1–9

Cameron JM, Sims BG (1974) Forensic dentistry. Churchill Livingstone, Edinburgh

da Silva RHA, Sales-Peres A, de Oliveira RN, de Oliveira FT, Sales-Peres SH (2007) Use of DNA technology in forensic dentistry. J Appl Oral Sci 15:156–161