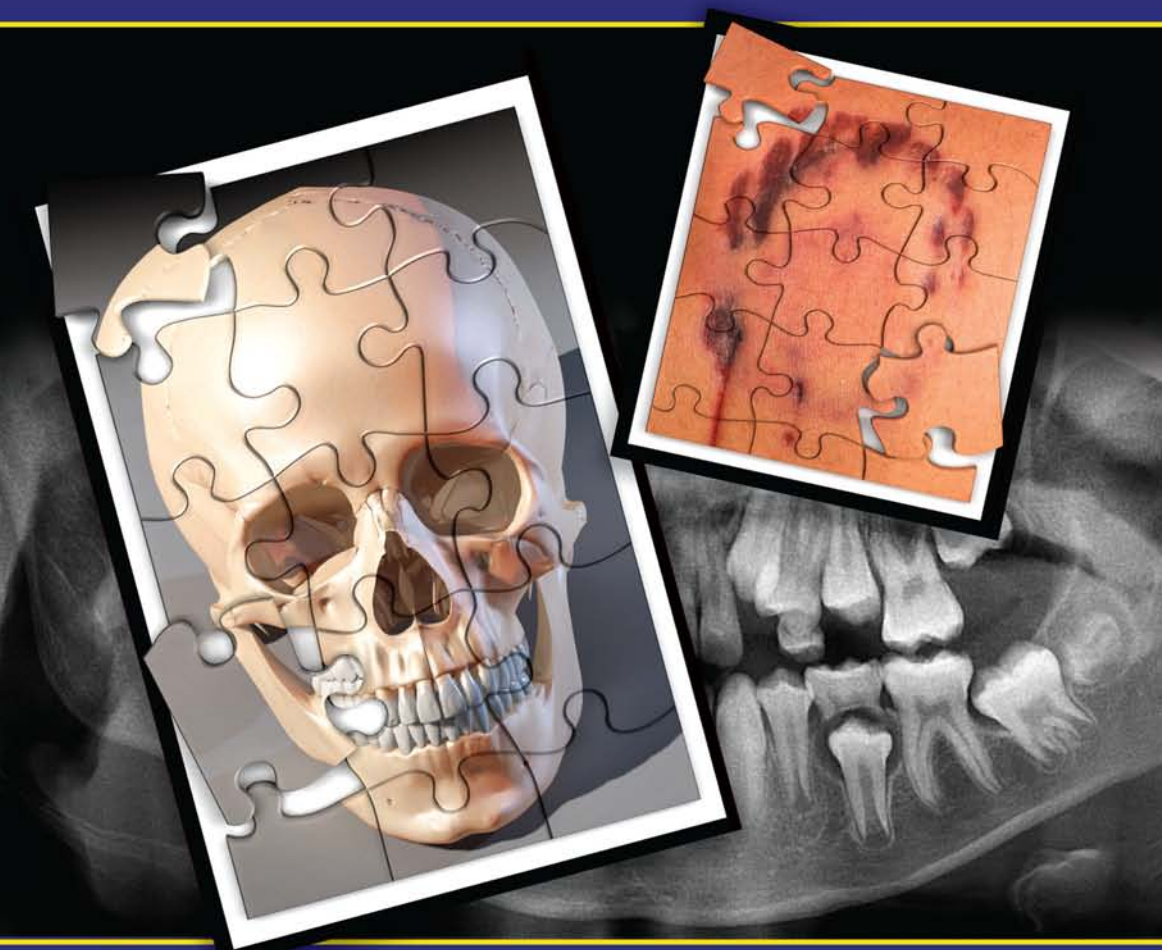
Forensic Dentistry

Second Edition



Edited by

David R. Senn and Paul G. Stimson

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Dedication

This dedication necessarily encompasses many people and a few memories.

First, we wish to remember our former editor of the first edition, Curtis A. Mertz, D.D.S. Dr. Mertz died at the end of 2007. He was one of the founding fathers of the American Board of Forensic Odontology (ABFO) and did his fair share to get the first edition completed and published.

We also want to remember and salute that small group of concerned odontologists who met on Fire Island, New York, after the impetus for the formation of various forensic boards was announced. This group consisted of Dr. Edward D. Woolridge, at whose home the meeting was held, and Drs. Lowell J. Levine, Robert B. J. Dorion, Arthur D. Goldman, Curtis A. Mertz, George T. Ward, and Manual M. Maslansky. They planned and developed the framework for the ABFO. Several others, including one editor and another contributor to this book, were invited to be included in the original group. The board was incorporated in the District of Columbia with the first certificates awarded on February 18, 1976. This board has grown and developed and now includes diplomates from many American states and Canadian provinces. Unfortunately, the board lost its only European diplomate, the late Dr. Michel Evenot of France. We are proud of the progress the board has made and its continuing support of educational and research efforts. The ABFO is the only forensic odontology board accredited by the Forensic Specialties Accreditation Board.

We want to especially dedicate this book to each of you who hold it in your hands. If you are a forensic odontologist, you must strive to constantly improve the science and the field, as did *your* mentors, with lectures, papers, and in person. In order for forensic odontology to progress to a specialty of dentistry there must be a consistent stream of new ideas and original and applied research. If you are not a forensic odontologist and are referring to this book, we welcome you to this challenging and fascinating field. It is our hope that the material presented in this book will be, in some way, helpful to you for your inquiry.

As coeditor of the first edition with Dr. Mertz, I welcome Dr. Senn as coeditor of the second edition. He was my student in pathology in dental school and has gone the extra mile for this second edition. His efforts are reflected in the high caliber of the chapters in the book before you. This project would not have been possible without his hard work and vigorous encouragement to our contributors. Thanks also to our publishers for their help and cooperation. Our joint wish to you all is happy forensics!

Paul Stimson

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Preface

Since the publication of the first edition of *Forensic Dentistry* in 1997 the discipline of forensic odontology has experienced considerable growth. Like all forensic specialties, forensic dentistry or forensic odontology has enjoyed (some may say suffered) a great increase in public interest during this period.

Forensic dentists assist medical examiners, coroners, police, other law enforcement agencies, and judicial officials to understand the significance of dental evidence in a variety of criminal and civil case types. Prosecution, plaintiff, and defense attorneys rely on forensic odontologists to analyze, report, and explain dental findings that impact their cases.

The growth and evolution of forensic odontology has not taken place without significant growing pains. The editors and contributors have chosen not to attempt to rationalize those problems but to report them, analyze the causes, and offer alternate courses to minimize the probability of similar difficulties in the future.

The editors did not intend for this book to include comprehensive, step-by-step instructions on how to practice each phase of forensic odontology. Instead, the editors and contributors have endeavored to look objectively and philosophically at the development, current state, and future of forensic dentistry and other closely associated forensic disciplines. We are of the mind that if sound scientific principles are applied from the beginning, and continued throughout, then the specific steps taken will follow that same model and will have the best opportunity to meet success.

The editors are confident that the assembled contributors are outstanding. They have produced thoughtful and sometimes provocative chapters that offer substance, fact, and ideas suitable for experienced forensic investigators or those who are just embarking on forensic careers.

The editors want to offer particular thanks to our families and especially to our wives, who not only gave us gracious support, but endured, mostly graciously, our extended physical, emotional, and mental absence. We owe them much in retribution.

Finally, we thank the publishers for their patience and support.

David R. Senn, D.D.S.
San Antonio, Texas

Paul G. Stimson, D.D.S., M. S.
Sugar Land, Texas

The Editors

David R. Senn, D.D.S., attended the University of Texas in Austin and received his dental degree from the University of Texas Dental Branch at Houston. He practiced general dentistry from 1969 until 1992 and has practiced and taught forensic odontology exclusively since 1992. He is board certified by the American Board of Forensic Odontology.

Dr. Senn is clinical assistant professor in the Department of Dental Diagnostic Science at the University of Texas Health Science Center at San Antonio (UTHSCSA) Dental School. He is director, Center for Education and Research in Forensics; director, Fellowship in Forensic Odontology; and director, Southwest Symposium on Forensic Dentistry. He has authored book chapters and articles in refereed journals on forensic odontology topics.

As a forensic odontologist for DMORT (Disaster Mortuary Operational Response Team), he worked in victim recovery and identification in New York following the World Trade Center attacks, in East Texas after the Shuttle *Columbia* crash, and in Louisiana following Hurricanes Katrina and Rita. He is a forensic odontology consultant and chief forensic odontologist for the Bexar County (Texas) Medical Examiner's Office.

He serves on the board of editors for the *American Journal of Forensic Medicine and Pathology* and is an editorial consultant for *Forensic Science International*. He has served on the board of governors for the American Society of Forensic Odontology, currently serves on the board of directors of the Forensic Specialties Accreditation Board, and is the president (2009–2010) of the American Board of Forensic Odontology.

Paul G. Stimson, D.D.S., M.S., is a graduate of Loyola University Dental School and has an M.S. degree in general pathology from the University of Chicago. He is an emeritus professor in the Department of Oral and Maxillofacial Pathology at the University of Texas Dental Branch in Houston. He began his teaching career there after completing graduate school in 1965, retiring in 1997. He taught oral and general pathology and forensic odontology and was an oral pathologist affiliated with M. D. Anderson Cancer Hospital and the Veterans Hospital Dental Department. In 1968, he became the forensic odontologist for the Harris County Medical Examiner. He is presently the chief consultant in forensic odontology for the medical examiner. He has taught forensic odontology for over forty years, and has written refereed journal articles, book chapters, and edited books on this subject. He

taught in the forensic odontology course at the Armed Forces Institute of Pathology from 1968 until 1998. He has lectured on this topic in Mexico, Europe, Canada, and the United States. He was one of the founding fathers of the American Society of Forensic Odontology and has held every office in that organization in the earlier years of the society. He is one of the thirteen original members that represented the founding of the American Board of Forensic Odontology (ABFO). He has held every office in that organization and has served on various study groups and committees. He is a registered emeritus diplomate of the American Board of Oral and Maxillofacial Pathology and an active diplomate of the American Board of Forensic Odontology.

The Contributors

Kenneth M. Anderson
Division of Oral and Maxillofacial Pathology
College of Dentistry
University of Tennessee
Memphis, Tennessee

Robert E. Barsley
Professor and Director
Dental Health Resources
LSUHSC School of Dentistry
Chief Forensic Odontologist
New Orleans Forensic Center
Orleans Parish Coroner
New Orleans, Louisiana

Paula C. Brumit
Forensic Odontology Consultant
Dallas County Medical Examiner
Dallas, Texas
and
Bexar County Medical Examiner's Office
San Antonio, Texas
and
Clinical Instructor-Fellowship in Forensic Odontology
University of Texas Health Science Center at San Antonio
San Antonio, Texas

Bryan Chrz
Consultant to the Office of the Chief Medical Examiner
State of Oklahoma
Perry, Oklahoma

Thomas J. David
Forensic Odontology Consultant
Georgia Bureau of Investigation
Division of Forensic Sciences
Atlanta, Georgia

Randall E. Frost
Chief Medical Examiner
Bexar County Medical Examiner's Office
San Antonio, Texas

Harrell Gill-King
Center for Human Identification
University of North Texas Health Science Center
Graduate School of Biomedical Sciences
Fort Worth, Texas

Gregory S. Golden
Deputy Coroner
Chief Forensic Odontologist
County of San Bernardino
San Bernardino, California

Scott Hahn
Special Agent
Federal Bureau of Investigation
Coordinator
Evidence Response Team
CAPT, DC, USNR
Miami, Florida

Edward F. Harris
Professor
Department of Orthodontics and Department of Pediatric Dentistry
College of Dentistry
University of Tennessee
Memphis, Tennessee

John D. McDowell
Professor
Department of Diagnostic and Biological Sciences
Director Oral Medicine and Forensic Sciences
University of Colorado School of Dental Medicine
Aurora, Colorado

Harry H. Mincer
Professor
Department of Biologic and Diagnostic Sciences
College of Dentistry
University of Tennessee
and
Odontology Consultant to the Shelby County Medical Examiner
Memphis, Tennessee

D. Kimberley Molina
Deputy Chief Medical Examiner
Bexar County Medical Examiner's Office
San Antonio, Texas

Haskell M. Pitluck
Circuit Court Judge, Retired
19th Judicial Circuit
State of Illinois
Crystal Lake, Illinois

Christopher J. Plourd
Certified Criminal Law Specialist
Forensic Evidence Consultant
San Diego, California

Bruce A. Schrader
Forensic Odontology Consultant
Travis County Medical Examiner
Austin, Texas
and
Bexar County Medical Examiner's Office
San Antonio, Texas
and
Clinical Instructor-Fellowship in Forensic Odontology
University of Texas Health Science Center at San Antonio
San Antonio, Texas

David R. Senn
Director
Center for Education and Research in Forensics
University of Texas Health Science Center at San Antonio
San Antonio, Texas
and
Chief Forensic Odontologist
Bexar County Medical Examiner's Office
San Antonio, Texas

Brion C. Smith
Deputy Director for Forensic Services
American Registry of Pathology
Armed Forces DNA Identification Laboratory
Rockville, Maryland

Richard R. Souviron
Chief Forensic Odontologist
Miami-Dade Medical Examiner Department
Miami, Florida

Paul G. Stimson
Professor Emeritus
University of Texas Dental Branch
Houston, Texas
and
Forensic Dental Consultant, Chief Odontologist
Harris County Medical Examiner
Houston, Texas

David Sweet O.C.
Director
BOLD Forensic Laboratory
Professor
Faculty of Dentistry
University of British Columbia
Vancouver, British Columbia, Canada

Michael P. Tabor
Chief Forensic Odontologist
Davidson County
State of Tennessee
Nashville, Tennessee

Aaron J. Uhle
Major Incident Program Manager
Latent Print Support Unit
Federal Bureau of Investigation Laboratory
Quantico, Virginia

Richard A. Weems
University of Alabama School of Dentistry
Forensic Odontologist Consultant
Alabama Department of Forensic Sciences
and
Jefferson County Chief Medical Examiner
Birmingham, Alabama

Franklin D. Wright
Forensic Odontology Consultant
Hamilton County Coroner's Office
Cincinnati, Ohio

Science, the Law, and Forensic Identification

1

CHRISTOPHER J. PLOURD

Contents

1.1 Introduction

Forensic science is simply defined as the application of science to the law or legal matters. In today's *CSI* and *Forensic Files* world, this area of science is much more widely known to the general public. However, it is also misunderstood due to Hollywood's resolve to complete every case within the context of a one-hour, commercials included, pseudo-real-life crime drama. When the actual real-life judicial system needs science to resolve a question, the person who is called upon to bring science into the courtroom is often a forensic scientist. The law and science are strange bedfellows. Science is an empirical method of learning, anchored to the principles of observation and discovery as to how the natural world works. Scientific knowledge increases human understanding by developing experiments that provide the scientist with an objective answer to the question presented. Through the scientific method of study, a scientist systematically observes physical evidence and methodically records the data that support the scientific process. The law, on the other hand, starts out with at least two competing parties with markedly different views who use the courthouse as a battleground to resolve factual issues within the context of constitutional, statutory, and decisional law.

1.2 Science

The essence of any scientific study involves developing an alternative hypothesis, devising an experiment or series of experiments to test the accuracy of the hypothesis (question presented), and finally, carrying out the scientific experiment so as to yield an unbiased result. Science meets the law only to the extent that the legal system must look to science to help resolve a legal dispute. Scientists in today's world no longer maintain the fiction that all science is equal. This inequality is often played out in courtrooms throughout the United States. The fundamental paradigm of the judicial system in America is that science is an open process, collegial in nature, unlike the legal system, which is adversarial in nature and legal strategies are developed in secret. The overriding objective of the parties in a legal dispute is to win. With a scientist, the objective of the scientific endeavor is to reach a correct result that will withstand scrutiny from fellow scientists who can review the methodology and examine the data. Science is premised upon observable phenomena, logical deductions, and inferences that are transparent and open to scrutiny. The inherently conflicting underpinnings between science and the law frequently make forensic science controversial and the courthouse an open arena in which forensic scientists are used as pawns in the resolution of legal disputes. To complicate the legal process, each of the nonscientist parties has an interest in the outcome, be it significant sums of money, personal freedom, or even life itself in cases involving the death penalty. At the center of legal cases there sits a person who wears a long black robe to whom we refer as a judge. The judge's job, usually with the help of a jury, is to keep the adversarial parties at bay long enough to accomplish the orderly resolution of the factual questions raised by the warring litigants using applicable law. The logic of the legal system is further complicated for the forensic scientist because often conflicting forensic scientific evidence that is generated by the opposing parties is ultimately submitted to the review and decision of twelve citizens, known as a trial jury. Those jurors are selected on the basis of each juror not having any knowledge or understanding of forensic or real-world science other than that occasional episode of *CSI* or *Forensic Files*.

The most common question asked by the legal system of a forensic scientist is a request to provide proof of identity of an item or person, which is a component of criminalistics. This area of forensic science involves the association of an evidentiary item that is typically related to a crime. A forensic identification has two essential steps: The first step is a comparison between an unknown evidentiary item and a known item and having the forensic scientist render a judgment as to whether there is a sufficient concordance to say there is a "match." Examples of these comparative sciences include latent prints located at a crime scene thereafter compared to the known prints of

a person, and bullet(s) collected from a body at autopsy compared to test bullets fired from suspected weapons. The second part to the identification analysis should give some meaning to the concordance (match) by providing a scientific statement that would allow the trier of fact, a judge or jury, to weigh the significance of the matching association and answer a simple question for the benefit of the trier of fact: What does "match" mean?

A forensic investigation requires a skillful blend of science using both proven techniques and common sense. The ultimate effectiveness of the scientific investigation depends upon the ability of the forensic scientist to apply the scientific method to reach a valid, reliable, and supportable conclusion about a question in controversy. Overall, science and the law must coexist within the framework of our judicial system, although each discipline may and often does have conflicting and competing interests. Any expert who is interested in the practice of a forensic science specialty must have a clear understanding not only of the fundamental principles of science, and presumably his or her chosen field, but also of the applicable legal standards relating to that area of forensic science; they must know quite a lot about that area of the law.

1.3 The Law

Expert testimony is a common and essential component in both civil and criminal trials. Every forensic scientist who is called into court to give the results of his or her study must first be qualified as an expert witness. Courts allow expert testimony out of necessity to assist the fact finder. A witness qualifies as an expert by reason of "knowledge, skill, experience, training, or education."[1] The trial judge determines if a witness is qualified as an expert and in what field of areas of science the expert may testify.[2] The forensic scientist may qualify as an expert on the basis of education, background, or study.[3] Evidence being offered by a qualified forensic expert is subject to admissibility standards for the specific scientific evidence being presented. A judge must determine admissibility of that scientific evidence. Before a judge can make that determination, the proffered scientific evidence must first pass a simple test of relevancy. Relevant evidence is defined by the Federal Rules of Evidence and most state court jurisdictions as "evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence."[4] Once a court determines that the proffered scientific evidence is relevant, there are two different legal standards that courts apply in determining the admissibility of evidence: the *Frye*[5] general acceptance standard and the *Daubert*[6] scientific reliability standard. The original scientific admissibility test developed in the case of *Frye v. United States*[7] held that, to be admissible, scientific evidence must be "sufficiently established to have gained general

acceptance in the particular field in which it belongs."[8] After the development of the *Frye* general acceptance standard, federal and state courts attempted to apply the rule to a wide variety of scientific evidentiary issues with mixed results. Courts often struggled with the *Frye* standard because the inquiry did not focus on the reliability of the particular scientific evidence; instead, the *Frye* test focused upon the general reliability of the scientific testing as a whole and its acceptance by others in the field. Another problem was that it was difficult to identify the appropriate expert community to answer the question of general acceptance. Some courts became concerned with the correctness of the *Frye* standard because the standard unfairly discredited new tests and accepted scientific principles. In 1993, the Supreme Court developed a new standard for scientific evidence in *Daubert v. Merrell Dow Pharmaceuticals*.[9] In *Daubert*, the Supreme Court concluded that in order for scientific evidence to be admissible, it must be shown to be scientifically valid and relevant to at least one issue in the case.[10] The Supreme Court offered numerous factors to aid federal judges in making the determination of scientific admissibility. These factors included whether the technique has been or can be tested, whether the technique has been subjected to peer review or publication, the known or potential rate of error, whether the technique is generally accepted in the community, and whether the technique was created outside of the litigation process. The *Daubert* test still allows courts to consider the issues addressed in the *Frye* standard because the "generally accepted" prong is one of many factors—instead of the sole factor in the analysis. By replacing *Frye* with *Daubert*, the U.S. Supreme Court made the trial judge a "gatekeeper" for the admissibility of any scientific evidence[11] (see Chapter 16).

1.4 Forensic Identification and Forensic Dentistry

The field of forensic dentistry or the more professional term, forensic odontology, is the application of dentistry to the law. Forensic dentistry now has been an integral part of the American judicial system for well over three decades. Overall, forensic dentistry includes multiple areas of scientific study, where the legal system and dentistry coincide. This specialized area of dentistry includes the gathering and interpretation of dental and related evidence within the overall field of criminalistics. Forensic dental evidence ranges from the identification of persons using dental records (Chapter 9) to the identification and analysis of bitemarks on an object such as a food item, or a bitemark on a victim compared to a suspect, or on a suspect compared to a victim (Chapter 14), to the estimation of a person's age based upon dental development or other characteristics (Chapter 13).

The forensic dentist is often an expert witness in civil disputes where dental injuries are at issue or there is a question of dental malpractice. Legal

liability cases relating to injuries to the teeth, mouth, or jaw may involve the expertise of a forensic dentist (odontologist). A qualified dental expert can provide opinion testimony on issues relating to the loss or damage to teeth and the effect of the loss or damage to an injured individual. For example, if a person was involved in an automobile accident or an altercation where legal liability is in question, the forensic dentist may explain to the jury how the accident or assault caused the dental injury to occur. In criminal cases, the forensic dentist will assist the judge or jury by relating expert testimony concerning a dental identification examination or by identifying bitemarks and giving an opinion as to who may have made the bitemark (Chapter 16).

Dental identification of a person from dental records by a qualified forensic dentist has long been established and accepted by courts as a means to prove the identity of an individual (Chapter 9). A question as to the identification of a person may arise from a mass disaster, such as an airplane crash, natural disaster, or a situation where multiple people died in a fire and the bodies are not otherwise recognizable (Chapter 12). Dental identifications relying on x-rays and dental records universally have been considered to be a reliable identification method and rarely has a legal challenge been raised in court. Age estimation using dental evidence is necessary when a question arises as to a person's correct age as it relates to court proceedings. Typically, if a person is accused of a crime, it may be significant to determine if the individual is a minor and therefore subject to the juvenile court jurisdiction or whether the person has reached adulthood, where he or she would be prosecuted as an adult (Chapter 13). Each of these subdisciplines of forensic dentistry is discussed in one or more of the chapters of this book.

One area of forensic dentistry merits additional discussion. Forensic bitemark evidence to determine identity has become controversial over the last decade and has undergone a fundamental challenge by the greater scientific community. The catalyst for this change was the development and acceptance of DNA identification genetic testing, which is now considered to be the gold standard of biological human identification (Chapter 7). Genetic DNA identification began to be used in the late 1980s and, in cases where the traditional fingerprint or dental identification cannot be done, has dominated the field of human identification.

DNA profiling over the past decade is the most significant advance in forensic science since the development of fingerprinting in the 1900s. DNA analysis has now set a high standard against which other forensic sciences are being judged. A working knowledge and understanding of the development and use of forensic DNA identification sciences is therefore essential to all scientists who practice in other areas of the forensic sciences. Not only has DNA identity testing redefined the standard of acceptability of other scientific evidence, but it has also fostered an awareness among juries that non-DNA-based identification techniques are less supported scientifically

and, in some cases, should be less accepted than DNA profiling as a method of scientific investigation.

Understanding all of the identification sciences, including DNA typing, how each developed, and how they are applied to specific casework, is essential to the forensic dentist. They are discussed in the following chapters.

Forensic DNA typing evolved from medical diagnostic techniques. Medical diagnostic DNA typing involves clean samples from known sources. In contrast, forensic DNA typing involves samples that are often degraded, contaminated, and may originate from multiple, unknown sources. Forensic DNA analysis also involves matching of samples from a wide range of alternatives present in the population. Except in cases where the DNA evidence excludes a suspected donor, assessing the significance of an apparent match requires a statistical analysis of population frequencies using a scientifically reliable database.

There are different types of DNA that are of interest to forensic scientists. They include nuclear DNA, mitochondrial DNA, and Y chromosome DNA. The DNA sequence, or order, of the base pairs is the same for every cell in a person's body that has a nucleus, with the exception of reproductive cells (ova and sperm), each of which contains only one-half of that person's DNA.[12] Approximately 99.9% of the sequence of the 3.3 billion bases is identical for all humans and performs the same function. However, approximately 1/1,000 of the sequence of the DNA molecule is different among all individuals, with the exception of identical multiple birth siblings (twins, triplets, etc.). The fact that people vary to this extent allows forensic scientists to determine whether DNA from a particular evidence sample could or could not have originated from a known person. DNA profiling is a catchall term for a wide range of methods for studying genetic variations. DNA technology for human identity purposes was designed for detection of variation (polymorphism) in specific DNA sequences. Forensic scientists have identified multiple small segments, or loci, where the DNA strand varies among groups of people. Highly variable loci are called polymorphic and are useful to identify biological material as unique (discussed further in Chapter 7).

Mitochondrial DNA (mtDNA) is a small genome that is found multiple times in the cytoplasm of each cell surrounding the nucleus. Mitochondrial DNA is passed from a mother to each of her children. A man's mtDNA is inherited from his mother, but he does not pass it on to his children. This maternal inheritance pattern has two important implications in forensic testing. The first implication is advantageous; the mtDNA of only a single maternal relative, even distantly related, can be compared to the mtDNA of another individual, for instance, the skeletal remains of an unidentified body, and help to solve both a missing person case and an unidentified body case. The second implication is disadvantageous; mtDNA is not a unique identifier.

Because maternal relatives share the same mtDNA type, the individual source of a biological sample can never be conclusively identified with mtDNA.

In a similar manner to how mtDNA is inherited from the maternal parent, the Y chromosome is inherited (only by males) from the male parent. All members from the same paternal lineage will therefore have the same Y-STR (short tandem repeat) profile. The STR genetic markers present on the Y chromosome may be used to obtain the genetic profile of the male donor(s) in mixtures of body fluids from males and females. Y-STR analysis will only target the Y chromosome; the DNA from the female contributor will be ignored.

Other mixture cases in which Y-STR analysis may be useful include sexual assaults involving saliva/saliva and saliva/vaginal secretion mixtures and instances in which the postcoital interval between the incident and the collection of intimate samples from the victim is greater than two days. DNA and DNA profiling are discussed in detail in Chapter 7.

In order to understand the present status of forensic dentistry as a forensic identification science within the overall forensic science community, it is helpful to understand and trace the history of the development of forensic dentistry. As with many changes in our American society, forensic dentistry emerged as the result of landmark events (cases) that established and shaped forensic dentistry as a useful scientific tool within the greater forensic science legal community. The issue of the scientific admissibility of bitemark evidence was established in 1976 in a landmark case in California. The use of bitemark evidence after that case grew dramatically and bitemark evidence became a sought-after identification technique by law enforcement and prosecutorial agencies. Additional new bitemark identification methods were developed and used in thousands of cases throughout the United States and around the world (see Marx in Chapter 14).

In a noteworthy case from the state of Florida, a clean-cut serial killer, originally from Washington state, was convicted and eventually sentenced to death based upon bitemark evidence. The bitemarks identified at autopsy were ultimately pivotal evidence against him. The significance of this case sent a clear message to law enforcement in the United States and elsewhere that bitemark evidence could be a critical link in establishing proof of identity and obtaining a conviction. The case received widespread media attention, which resulted in public acknowledgment and acceptance of bitemark evidence (see Bundy in Chapter 14).

Beginning in the later half of the 1990s, the forensic science community was shaken by numerous instances where errors occurred in cases and individuals were exonerated after a determination was made that they were wrongfully convicted. The problem of innocent people being convicted and unjustly imprisoned for crimes they did not commit became a growing national concern that received public acknowledgment by politicians and caught the

attention of the general public, with more cases arising in which DNA identity testing technology exonerated factually innocent people. A number of DNA exoneration cases involve forensic science errors relating to evaluation of trace and biological evidence such as hair comparison and serology evidence. DNA exonerations also occurred where the person was convicted by forensic dentistry using expert bitemark identification analysis.

In the discipline of forensic dentistry, a milestone case of a wrongful conviction was the case of Ray Krone, convicted and sentenced to death for a capital murder. He was the hundredth person in the United States who had been sentenced to death to walk free from prison since the reinstatement of the death penalty in the United States in 1977. The bitemark evidence was evaluated independently for the prosecutors by two forensic dentists, one of which was an American Board of Forensic Odontology (ABFO) board-certified forensic dentist who said positively, "better than a fingerprint," the bitemark matched the suspect. "The bite marks on the victim were critical to the State's case. Without them, there likely would have been no Jury submissable case against Krone."[13] Again, this case and its unusual and provocative outcome will be examined in the bitemark chapter (see Krone in Chapter 14).

Another bitemark conviction followed by a DNA exoneration will also be discussed. The suspect was sentenced to death for the murder of his girlfriend's three-year-old daughter. Even though other forensic dentists concluded that the marks were not even bitemarks, the jury found him guilty. The case demonstrated again that DNA collected from a crime victim can prove actual innocence in cases even where seemingly reliable evidence persuaded a jury to convict a person and sentence that person to death (see Brewer in Chapter 14).

1.5 Conclusion

The investigation of bitemark cases by forensic dentists has necessarily evolved as the result of deficiencies uncovered after convictions that relied on bitemark evidence were overturned by DNA evidence. Improved technology and an increasing awareness of previously untested assumptions by forensic dentists have developed. This is the result of a concerted effort by some forensic dentists to build a solid scientific foundation and reliable protocols for bitemark comparisons. As a direct result of past mistakes there is now a better understanding by forensic dentists of the inherent variability and resulting distortion of marks left by human teeth in human skin. Although much work remains ahead, progress has been made. There is an increasing acceptance by forensic dentists that there is rarely, if ever, a scientific basis to justify an opinion that a specific person in an open population made a bitemark on human skin with scientific certainty, be it total or reasonable,

based solely on the analysis of the pattern information. Therefore, a "positive match" in these cases is not scientifically supportable.

Those forensic dentists who have accepted the lessons of DNA exoneration cases have promoted an emphasis on conducting objective empirically based scientific research that will support bitemark opinion evidence and hold that evidence to a higher, more reliable scientific standard. One suggested approach being discussed by some forensic dentists is to unify the bitemark pattern analysis to the DNA profile testing as part of a single scientific study rather than independent scientific investigations.[14] This proposed method would avoid situations were the DNA and bitemark analysis are not in agreement. Scientific studies being performed by forensic dentists are expected to demonstrate that there are reliable methods and approaches to comparing bitemark evidence that minimize the potential for subjective bias and other factors that have, in the past, led to errors. As these studies are examined and other studies are undertaken by the forensic dental community they are expected to improve this troubled area of forensic science.

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History of Forensic Dentistry

2

PAULA C. BRUMIT
PAUL G. STIMSON

Contents

2.1 The Garden of Eden

Vale wrote in 2005, "It is always tempting to suggest that the history of bitemark evidence [and hence forensic dentistry] began with the eating of forbidden fruit in the Garden of Eden."[1] Temptation now, as then, is genuine. However, forensic odontologists and court reporters were very rare at that time; there is no dependable record of the event, analysis, comparisons, or testimony. Moreover, there were a limited number of suspects in this closed-population case and the suspects reportedly confessed.

2.2 Aggripina the Younger—Lollia Paulina

A later, but still early, and better-documented reference to the use of teeth for identification occurred during the first century CE. Agrippina the Younger, fourth wife of Emperor Claudius I and the ambitious mother by a previous marriage of Nero, contracted for the death of Lollia Paulina. To ensure that the contract was accurately concluded, Agrippina had Paulina's head brought to her. The confirmation of identification was made based on dental misalignments and other peculiarities.[2]

2.3 Jai Chand, Last Raja of Kanauji

In 1193, a great Indian monarchy was destroyed when Muhammad's army established the seat of his empire at Delhi. A significant battle during the invasion of the sacred city of Kanauji involved the sacking of the holy shrines of Muttra, the birthplace of Krishna, an important site in the Hindu religion. During the siege, Jai Chand, the Raja of Kanauji, was murdered after being taken prisoner and was identified by his false teeth when he was found among those slain.[3]

2.4 The Earl of Shrewsbury

The Earl of Shrewsbury was killed in the battle of Castillon in 1453. His herald was able to identify him by his teeth.[4]

2.5 Charles the Bold, Duke of Burgundy

After inheriting additional lands, Charles the Bold, Duke of Burgundy, decided to create an independent state between France and Germany. He was killed in the battle of Nancy in 1477 while trying to accomplish the task. The duke's page was able to identify him according to his dentition, as he had lost some teeth in a fall years previously.[5]

2.6 Peter Halket

During the French and Indian Wars Peter Halket was killed in a battle near Fort Duquesne in 1758. The fort was later captured by British General Forbes, who arranged to have the dead buried prior to leaving for Philadelphia. Three years later, a Native American who had fought in the battle remembered Officer Halket and was able to lead Halket's son to the area where he was killed during the battle. The son was able to recognize his father's skeleton by an artificial tooth.[6]

2.7 Dr. Joseph Warren—Paul Revere

In Boston in 1776, at the battle for Breed's Hill (often misidentified as Bunker Hill), Dr. Joseph Warren was killed. His face was unrecognizable as he suffered a fatal head wound, a rifle ball to the left side of his face. Paul Revere, silversmith and dentist, identified the decaying body of Dr. Warren by the small denture that he had fabricated for him. The denture was carved in ivory and was held in place by silver wires. The identification made it possible to bury Dr. Warren with full military honors on April 8, 1776.[7,8]

2.8 Janet McAlister—Dr. Pattison

The earliest known use of a dentist as an expert witness in court occurred in 1814 in the case of a Janet McAlister in Scotland. In *His Majesty's Advocate vs. Pattison et al.*, the High Court in Edinburgh charged a lecturer of anatomy and two of his students for the violation of Mrs. McAlister's grave. Mrs. McAlister had died at the age of forty years. The night after her burial, the trio was alleged to have moved her body to the nearby College Street Medical School. Mrs. McAlister's husband gave artificial teeth worn by his wife to a dentist, Dr. James Alexander, who was able to fit the dentures into

the skull. The presence of a "pivot tooth" was helpful in defining his opinion. The defense testimony stated the dentures could be "fitted to any skull" and, therefore, did not fit just this skull. The jury returned a verdict of not guilty.[9]

2.9 Guerin

Three years after the disappearance in 1829 of a Mr. Guerin, a new tenant discovered a human skeleton buried in the basement. Guerin's identification was accomplished by the abrasions caused by clay pipes he had a habit of using when smoking. The abrasive marks in the dentition were unique and were similarly described by multiple witnesses.[10]

2.10 Caroline Walsh

An elderly Caroline Walsh moved in with a young Irish married couple in 1831. She was never seen again. Later, the son of the married couple accused them of murder, stating that he saw his mother leave the home with something heavy and large in a bag. A woman fitting the description of the missing woman was found on the streets in a "squalid" condition and stated her name was Caroline Walsh. She was hospitalized and subsequently died. It was pointed out in the trial that the missing Caroline Walsh had perfect teeth. This Caroline Walsh had lost her front teeth many years previously. The remains of the missing Mrs. Walsh were never found, but the accused were convicted.[11]

2.11 Louis XVII

Louis XVII died in prison in Paris in 1795 at the age of ten years two months from advanced tuberculosis of the lymph nodes (scrofula). In 1816, a plan to erect a monument to the young prince generated rumors that he was still alive, now thirty-one years of age, and that another child had been buried in his place. The story did not end there. In 1846, during the reconstruction of a church, a lead coffin containing the skeleton of a child was found near a side entrance. Dr. Milicent, a physician, examined the bones and concluded the child had died of bad health and neglect. Another physician, Dr. Recamier, examined the bones and said they were those of an individual, fifteen or sixteen years of age. All twenty-eight teeth were present and the third molars could be seen. Dr. Recamier's age assessment was accepted and the body was reinterred in an unmarked place. The quest for the Dauphin continued and in 1897, a relative of Louis XVII gained permission to again search for the coffin.

A coffin was found that contained the skeleton of a young male. Based on tooth development, three experts aged the remains at between sixteen years plus and eighteen years plus. It was concluded the remains were not those of the Dauphin. These cases represent, perhaps, the first cases of forensic dental age estimation.[12]

2.12 Dr. John Webster—Dr. George Parkman

Dr. George Parkman, a respected professor at Harvard University, failed to return from dinner on November 23, 1849. Dr. Parkman was a physician, but also a real estate speculator and moneylender. He was sixty-four years of age and a man of very regular habits. When he failed to appear as expected, suspicion of foul play fell on his colleague, John White Webster, a professor of chemistry at the same university. Dr. Webster had been behaving somewhat irregularly of late, and it was known that he owed Dr. Parkman a considerable sum of money. His laboratory was searched and, in a tea chest, human remains were found. In a nearby assay furnace fragments of a lower jawbone, three blocks of artificial teeth in porcelain, and melted gold were also found. At Webster's trial for murder, Dr. Nathan Cooley Keep, a dentist, identified the teeth as part of an upper and lower denture he had made for Dr. Parkman three years earlier. He recalled the circumstances of the denture's construction in exact detail, as Parkman had been anxious about having the dentures ready for the opening of a new medical college at which he was to give a speech. The day before the event, when some of the bottom teeth collapsed during the baking process, Dr. Keep and his assistant worked through the night and fitted the denture some thirty minutes before the ceremony. Dr. Parkman returned in a short time and complained that the lower cramped his tongue. An adjustment was made by grinding away portions of the inside of the lower denture. Dr. Keep fit portions of the lower denture to models he had retained in the production of it and showed the court where he had done the grinding adjustment of the lower denture. The dental evidence was overwhelming and Webster was found guilty and hanged. The Parkman–Webster case represents the first case of a dentist giving expert testimony in courts in the United States.[13]

2.13 William I, the Conqueror

Struck by a stray arrow in France in 1089, William the Conqueror fell from his horse and died at the age of forty-four. In 1868, his tomb was opened. All who were present stated the bones and teeth were in "good condition as if the King had died only yesterday, instead of 768 years ago."[14] The durability and

longevity of teeth enable forensic dentists to make identifications even when bodies are severely damaged or long buried.

2.14 Misidentification Corrected

In the United States, in 1869, two women victims of a boat fire on the Ohio River were subsequently returned to Philadelphia, where one of the bodies was misidentified. The family dentist later examined the bodies and was able to correctly identify them.[15]

2.15 A. I. Robinson—His Mistress

Although well respected within the community, in 1870, a Mr. A. I. Robinson was suspected of murdering his mistress. Five distinct bitemarks were found on her arm, which clearly showed individual tooth marks. An investigating dentist actually bit the arm of the deceased and later had Robinson bite his (the dentist's) arm to make comparisons. The bitemark on the body showed that five teeth in the maxillary arch caused the mark. One suspect had a full complement of teeth and was excluded. Mr. Robinson had five maxillary front teeth but at trial was found not guilty.[16]

2.16 Winfield Goss—Mr. Udderzook

In 1873 outside of Baltimore, Maryland, a body was found in the ashes of a burned cottage. The body was tentatively identified as Winfield S. Gross, who was known to have used the cottage for his chemistry experiments. His widow and ten witnesses were certain that the body was that of Gross. Mr. Gross had insured himself for $25,000 eight days prior to the fire. The insurance companies refused to pay the widow's claim. A dental consultation was then requested. Mrs. Gross stated that "there were no artificial teeth to her knowledge and he never complained of pain or decayed teeth. No dentist saw him during the time we lived together." The remains were examined at the Baltimore College of Dental Surgery, where Dr. F. J. S. Gorgas gave a full and detailed description of the jaws and the remaining teeth. There were two teeth in the upper jaw and some misalignment in the lower jaw. These statements were at variance from those of Mrs. Gross and other witnesses. The insurance company thus claimed at trial that the remains were not those of Mr. Gross. The verdict of the jury, however, was in favor of Mrs. Gross. The insurance companies appealed the verdict. Within a month, the body of a murdered man was discovered in Pennsylvania. Mrs. Gross's brother-in-law,

a Mr. Udderzook, had been seen traveling in Pennsylvania with an unnamed friend. When the body was examined, the height and other characteristics were similar to Mr. Gross's. The teeth were in good shape and were well preserved. Ultimately, Udderzook was charged and prosecuted for the murder of Gross. He was found guilty and executed in 1874.[6] We do not know the fate of Mrs. Gross.

2.17 John Wilkes Booth, 1865 and Again in 1893

After shooting President Lincoln on April 14, 1865, John Wilkes Booth escaped and took final refuge in a barn on a farm in Virginia. The U.S. Calvary located him there on April 26. They surrounded the barn and set it on fire. Booth exited, was shot, and died at the scene. In later years, it was rumored that he had somehow escaped, was alive, and living abroad. Because of this rumor, his body was disinterred and examined in 1893. The family could not visually identify the body, but the family's dentist was able to recognize his work as well as a peculiar "formation" of the jaw that he had noted in his records during a dental visit for the placement of a filling.[17]

2.18 Dr. Oscar Amoëdo—The Bazar de la Charite, 1898

Considered by many to be the father of forensic odontology, Dr. Oscar Amoedo was born in Matanzas, Cuba, in 1863. He began his studies at the University of Cuba, continued at New York Dental College, and then returned to Cuba in 1888. He was sent as a delegate to the International Dental Congress in Paris in 1889. Paris was very appealing to him and he decided to stay. He became a dental instructor and teacher at the Ecole Odontotechnique de Paris in 1890 and rose to the rank of professor, writing 120 scientific articles on many topics (Figure 2.1). A tragic fire at a charity event, the Bazar de la Charité, stimulated his interest in dental identification and the field of forensic odontology. Amoedo was not involved in the postfire identifications, but knew and interviewed many who were. His thesis to the faculty of medicine, entitled *L'Art Dentaire en Medicine Legale*, earned him a doctorate and served as the basis for his book by the same name, the first comprehensive text on forensic odontology (Figure 2.2).[12] He lectured and worked in the field until 1936, finally stopping at the age of seventy-three. His accounts of the identifications following the Bazar de la Charite were given in a paper at the Dental Section of the International Medical Congress of Moscow and published in English in 1897, one year before the book was published. In that paper he revealed that neither a dentist nor physician generated the idea of dental identification: "It was then that M. Albert Hans, the Paraguay Consul,

Figure 2.1 Dr. Oscar Amoedo.

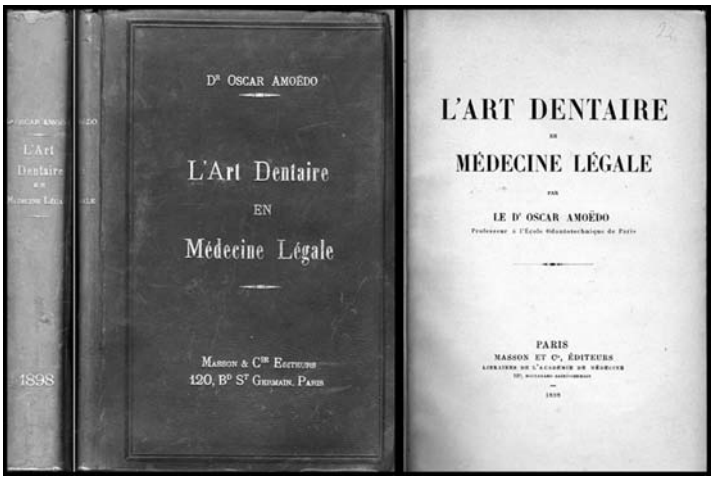

Figure 2.2 Amoedo textbook cover and title page. (Courtesy of Dr. Adam Freeman.)

conceived the idea of calling the dentists who had given their services to the victims. His counsel was followed, and with excellent results. In the face of the powerlessness of the legal doctors, since all ordinary signs of identification had disappeared, our *confreres* were appealed to … Drs. Burt, Brault, Davenport, Ducourneau, Godon, and some others."[18]

2.19 Strenuous Cross-Examination, 1898

In 1898, a girl was found dead. A local dentist described the state of her mouth and teeth. A missing girl's family dentist in another town was located.

The body was disinterred and the dentist was able to identify his work. The dentist complained about how strenuously and thoroughly the defense attorney grilled him while he was on the witness stand.[19] Many dentists still today dread having to go into courts of law and give sworn testimony.

2.20 Iroquois Theatre—Chicago, 1903

In 1903, the Iroquois Theatre in Chicago burned and 602 of the 1,842 patrons in the theatre died. The stairways had been closed and chained to prevent the "lower-class ticket holders" from coming downstairs. Also, the outside doors opened inward, a popular design of the day, but one that proved disastrous when frightened throngs pushed others against the doors, preventing their opening. Although no records of the identifications can be found today, Dr. Cigrand stated in his article that "hundreds" were "unmistakably identified" from their dental records.[20]

2.21 Bites in Cheese, 1905 and 1906

In 1905 and 1906, two cases were reported concerning tooth marks left in cheese. In the 1905 case in Germany, a robber bit into the cheese then left it on a windowsill. Plaster casts of the cheese were later interpreted to be from a pipe smoker. Just such a man was found among the suspects.[21] The 1906 British case involved a store break-in. The dentition of a store worker fit "exactly" a cast of the cheese. The store worker was arrested, but requested in court that his mouth be examined again, revealing that he had a broken tooth, the crown was missing, leaving only the root. In spite of this apparently attempted subterfuge, he was found guilty.[22]

2.22 Chilean-German Discord Averted, 1911

In the early 1900s, forensic odontology can be credited for the help of establishing a dental school in Chile. Residents of the small village of Caleu mistook a group of German tourists for bandits and, fearing an attack, fired upon them. In the ensuing disagreements with German officials, the German consulate in Valparaiso was set on fire. Shortly after this fire, the German litigation building in Santiago burned to the ground. A body was found in the rubble. It was first identified as the secretary to the litigation, a Mr. William Becker, according to clothing, a wedding ring (with his wife's initials in it), a watch, and glasses. An autopsy also identified the body as Becker's. The German minister, however, was not satisfied. Two German

physicians, members of the faculty of Santiago University, performed a second autopsy. The anterior teeth were severely burned, but the posterior portion of the remaining dentition was described and charted. A stab wound to the heart was discovered. During this time, news was given that a considerable amount of money was missing from the consulate. The immediate suspect was a servant, Mr. Ezekel Tapia. A Chilean dentist was then asked by a judge in the case to examine the body and any pertinent records. As a result, the body was found to be Tapia's, and it was believed that Mr. Becker may have murdered him, dressed him with his own clothes and personal effects, and burned the anterior portion of his face to hide the fact that the secretary had gold bridgework. A witness claimed to have seen Mr. Becker during the night after the fire in Santiago. The judge in the case asked a Chilean dentist, Dr. Guillermo Valenzuela Basterra, to review the dental facts of the case. Mr. Becker's dentist, Dr. Dennis Lay, had placed anterior gold and platinum fillings for Mr. Becker, and removed five posterior teeth. He shared these records with Dr. Valenzuela. The findings were inconsistent with those of the remains found in the fire. Law enforcement officials were alerted and the secretary was captured at a border crossing, trying to escape into Argentina. It is ironic that Mr. Becker was able to travel from Santiago into the mountains by wearing dark glasses and a handkerchief, hiding his identity by simulating a toothache. Mr. Becker was found guilty of multiple crimes and executed on July 5, 1910. This eased the problems between Chile and Germany, and the relationship between the two nations was repaired. To show its gratitude, the government of Chile asked Dr. Valenzuela what he most desired as a form of reward. Dr. Valenzuela asked to see the long-planned dental school building completed. The wish was granted and the school was built two years later.[23]

2.23 Tooth Numbering Systems and Denture Marking

Dr. Zsigmondy published a method of numbering teeth in 1861. He numbered permanent teeth from one to eight from the anterior midline and distinguished the quadrants by placing the numbers in segments of a cross.[24] Deciduous teeth were designated with Roman numerals. Palmer later made similar proposals in 1891.[25] In 1883, Dr. Cunningham proposed numbering all teeth from one to thirty-two. Numbering the teeth in this manner, starting with the upper-right third molar (1) and ending with the lower-right third molar (32), is commonly known as the universal system and is widely used in the United States. In this system the deciduous teeth are lettered from A to T in the same pattern. Most of the rest of the world uses the Federation Dentaire Internationale (FDI) numbering system, which is similar to the system proposed by Dr. Zsigmondy. Denture marking to assist in identification was first proposed by Cunningham.[26]

2.24 John Haig—Denture-Aided Identification, England

Dr. Keith Simpson describes a most interesting case in which dentures were useful for the identification of a body placed in an acid bath. A wealthy widow, living in a hotel in England, went out for an afternoon with a John Haig, who lived in the same hotel. She was never seen again. Investigation of Mr. Haig showed he had a police record and led to a two-story shed he used for what he called "experiments." Some interesting things were found: two carboys of sulfuric acid, papers relating to five other individuals who had disappeared, a pistol, and blood spatter on a wall from a possible shooting. During his interrogation, Haig admitted killing the widow and said he destroyed her body in acid. After a fourth sifting of a pile of black slush found behind the shed, a set of upper and lower dentures was found. The dentures were identified by the widow's dentist. It was fortunate in the case that Mr. Haig admitted to the murder, as the dentures were made totally of acrylic resin and would have dissolved completely, given enough time.[27]

2.25 Denture Tooth-Aided Identification—Australia

In the Carron murder case in Australia, the victim was thoroughly incinerated, but artificial denture teeth of a type known as diatoric were found. A dentist was able to identify the individual by the use of this particular type of denture teeth.[28]

2.26 Facial Reconstruction—Kollman and Buchley, Then Gatliff

Kollman and Buchley did the first scientific work in facial reconstruction. They proposed twenty-three points of skin thickness measurements, which they provided in the form of a table. Soft materials were then used to sculpt the face, a technique that has been widely used and is still used with modifications today.[29] Although computerized methods are becoming more common, Betty Pat Gatliff of Oklahoma has taught many forensic artists and a significant number of forensic dentists facial reconstruction techniques.[30] She also contributed chapters to the excellent and comprehensive text on forensic art published in 2001 by Karen Taylor.[31]

2.27 Adolf Hitler

After the end of World War II, rumors were rampant that Adolf Hitler had escaped with his wife, Eva Braun. They had in fact died together in 1945, but

their bodies had been burned and then buried in secret by Russian soldiers. Due to a lack of antemortem and postmortem records, it was a challenge to dispel the rumors. Finally, pieces of Hitler's jaw were found that showed remnants of a bridge, as well as unusual forms of reconstruction, and evidence of periodontal disease. Hitler's identity was confirmed when the dental work matched the records kept by Hitler's dentist, Hugo Blaschke.[32]

2.28 *Texas v. Doyle, Doyle v. Texas*, 1954

Although bitemark evidence had been used earlier, the *Doyle v. State* case in Texas in 1954 marked the first time that this type of dental evidence was used in court in the United States.[33] Like in some earlier cases, Doyle, in the process of committing a burglary, allegedly left the imprint of his dentition in a partially eaten piece of cheese. The analysis of the evidence was made by having the suspect bite into another piece of cheese for the comparison. Dr. William J. Kemp, a dentist and longtime dental examiner for the State of Texas, testified that the bites in both pieces of cheese matched.[34]

2.29 Lee Harvey Oswald, 1963 and Again in 1981

Several years after the assassination of John F. Kennedy, an English author named Michael Eddowes raised suspicion concerning the identification of Lee Harvey Oswald. It was his belief that the body buried in 1963 in Oswald's grave was really that of a Russian spy. To set the record straight, the body was exhumed and a positive identification of Oswald was made on October 4, 1981, with the aid of military antemortem dental records.[35]

2.30 Other Cases

Other significant dental identification cases in recent years include those concerning the Symbionese Liberation Army (1973–1975), the Los Angeles police shootout (1974), Jonestown in Guyana (1978), the terrorist attacks on the World Trade Center and the Pentagon (2001), and Hurricanes Katrina and Rita (2005).

2.31 Summary

There is a defining constant found in the historical cases discussed above: forensic odontologists were involved in helping to resolve difficult questions and bring closure to the families of the victims. Forensic odontologists

will continue to make these types of valuable contributions to society and forensic science.

There are several historical cases of interest in the area of bitemark analysis. That historical information will be discussed in more detail in Chapter 14.

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Scope of Forensic Odontology

3

BRUCE A. SCHRADER
DAVID R. SENN

Contents

3.1 Introduction

When the subject of forensic dentistry arises, the first reaction of many people tends to be toward one of two extremes: either very cool or decidedly gross. The public assumption seems to be that forensic dentistry deals with "the dead." This view is not totally inaccurate. Although the majority of dental identification cases do involve the dead, there is much more involved, including cases dealing with the living, in this interesting field of art and science. With training, ongoing continuing education, and experience, the forensic odontologist will find the application of this knowledge to be personally rewarding. If dentists are interested but do not wish to pursue the areas of forensic dentistry that are associated with "wet work," they will find that they can practice "dry fingered" forensic dentistry in their own offices by accurately recording their patient's oral information on an ongoing basis. Forensic dentistry or forensic odontology involves several areas that will be discussed generally in this chapter and explained in more detail in later chapters. The general definition of this discipline is that forensic odontology is the combination of the science and art of dentistry and the legal system, a crossroads of dental science and law. The general topics to be discussed

include the subdisciplines of forensic odontology, dental identification, multiple fatality incident management, bitemarks, abuse, age estimation, and expert testimony in criminal and civil litigation.

3.2 Dental Identification

When considering the many processes that are involved in forensic dentistry, most laypersons are familiar with identification of a deceased individual through the comparison of dental radiographs. Identification by dental means is a fast and reliable method. Dental identification is most often accomplished by comparing postmortem dental radiographs from the unidentified person with antemortem radiographs of a known individual. This process of dental forensics is often interpreted on currently popular forensic television series by the actor-dentist holding a dental radiograph backlit by the room lights with the film overhead while standing in the elevator lobby. This generally occurs following a brief evaluation of a body in the morgue. But, of course, the actor-dentist is certain that the radiographs he was just handed for evaluation are from the decedent. The positive identification is completed and without further discussion the district attorney's case theory is confirmed and the suspect is incarcerated.

In real forensic cases the process of using dental radiographs and dental charting can be an accurate and efficient method for making a positive identification or exclusion. But, the comparison must be completed in a controlled and methodical manner, with attention to the details of the dental structures and restorations that may be seen in the radiographic comparison. A comparison of an antemortem radiograph with a body in the morgue occurs only in the virtual reality of television and film world.

In a dental identification, the initial goal of the forensic dentist is to obtain a set of postmortem photographs, radiographs, and accurate dental charting on the unidentified person. This can be a straightforward or difficult process, depending on the condition of the postmortem specimen and the physical resources available to the dentist. The problems most often involve limited available resources in the morgue setting.

Procuring antemortem records can also be a challenge. Often, but not always, there will be some information on the unidentified person, a clue to his or her identity. Once a putative identity is known, the process of procuring antemortem dental records begins. Many dentists are concerned that their original records must remain in their possession and resist the release of their records. Although it is true that the dentist is expected to maintain the original record, this hurdle is easily cleared by discussion with the dentist concerning the necessity to use the record for comparison of a possible patient and the possible consequences of their interference in a medicolegal death

investigation. Also, with the current ability to digitize a paper record by using a flatbed scanner or to take digital photographs of a dental chart and analog radiographs by placing them on an x-ray view box, the problem of resistance from a dental office can be reduced or eliminated. Dental records are readily available from any number of dental facilities that could have previously collected dental information on a patient as part of their examination.

Any dental charting of the teeth, financial records for treatment rendered, insurance claim forms, photographs, and radiographs that would be part of a dental examination are important items to collect as part of the antemortem reconstruction. These items could be part of the dental record created during an examination in a dental or medical facility. These items could be found as part of a dental-medical record in a private dental practice, dental teaching facility, military in-processing facility, hospital-based dental program, dental in-processing examination as part of incarceration, or medical records of an emergency room. An emergency room could potentially have radiographs of the head/neck region that include dental structures that are found on dental radiographs. The dental radiographs that are most often seen in a dental comparison are dental bitewing x-rays, as these are generally taken during regular dental checkup visits and are the most recent radiographs available. After the postmortem charting and radiography is complete and the antemortem records are procured, the comparison process can begin. The detailed reconstruction of the dental records and the comparisons that result in positive identifications are rewarding parts of the work. The forensic odontologist is able to aid in the closure process for a grieving family (see Chapter 9).

3.3 Multiple Fatality Incident Management

A multiple fatality incident (MFI) develops when the number of fatalities in the incident exceeds the number the medical examiner or coroner's facilities were designed to handle. The process of collection of dental information on victims in a mass disaster is identical to the processes that are used in the identification of a single fatality. The major difference in this process is the potential magnitude of the event and the unique set of circumstances that can surround the event. These may include the location, climate, and coverage area of the event, for example, a plane crash in mountainous terrain, a tsunami in a tropical area, the collapse of multistory structures in a major city, or a hurricane in a coastal area. Each of these incidents has unique issues that must be addressed with regard to recovery, processing, and storage of remains. Each potential MFI will have its unique problems to overcome, but accurately collecting and comparing the data is the common process in all of these situations.

With each MFI, there will be the need for personnel with different levels of experience to work together to accomplish the common goal of identifying all of the victims of the disaster. Personnel in all areas of the operation should have the ability and desire to be detail oriented, as errors can lead to missed or misidentifications. A mass disaster team should be organized and trained in coordination with the local or state government to allow the most expeditious deployment of a dental team when its services are needed. These areas will be discussed fully in Chapter 12.

3.4 Bitemark Evidence Collection and Analysis

Bitemark analysis is the most complex and controversial area of forensic odontology. Consequently, some forensic dentists are reluctant to enter into this arena. Bitemarks can occur in a wide variety of substrates, although the most common of these is, unfortunately, human skin. The proper documentation of a bitemark is not overly complex, and the techniques for collecting evidence are manageable by most forensic dentists with practice and attention to detail. The bite site can be evaluated in the third dimension by using a very accurate dental impression material and dental stones or resins to create a solid model for viewing under magnification, light microscopy, or with scanning electron microscopy. This three-dimensional model of the bitten area can then be compared to suspects' dental casts. Technique shortcomings exist and include that solid models of bitemarks on skin are nonelastic. The problems associated with bitemark analysis will be discussed more fully in Chapter 14.

3.5 Abuse

Identification and reporting of abuse is a complex and emotional area. Healthcare practitioners are required by law in most jurisdictions to report suspected cases of abuse. The head and neck area is a common target in abuse. Extraoral injuries consistent in shape and appearance to a hand or object are identifiable. Intraoral trauma can occur as the result of strikes to the face, causing torn frena and fractured, mobile, or avulsed teeth. Intraoral soft tissue pathology may be noted following forced feeding or forced fellatio. Some cases may require the consideration of whether extensive or rampant caries are a result of the caregivers' lack of knowledge or stem from neglect or abuse. In areas where access to dental care is an issue there will likely be a higher caries incidence that could further exacerbate the determination of whether reporting of abuse may be necessary. Deciding to report suspected abuse requires sound judgment, especially considering that the parent or

guardian may be the perpetrator. If a report is initiated, the ensuing investigation will be difficult for all concerned (see Chapter 15).

3.6 Age Estimation

Researchers have studied the processes of human aging by many different methods. These include developmental, histological, biochemical, and anthropological techniques. Anthropologists analyze the fusion of the cranial sutures of the skull, the development of the long bones, features of the pelvic girdle, and along with forensic dentists, features of the teeth. These techniques can be valuable when creating a profile for an unidentified person, whether living or deceased. Estimating an individual's age can also be helpful in assisting law enforcement agencies in determining the attainment of the year of majority of a living individual that will ultimately affect the individual's treatment in the legal system as either a child or an adult.

The methods of age estimation using teeth include analyzing tooth development and eruption, studying tooth degradation, and measuring biochemical and trace element changes in dental structures. Each of these methods has its advantages and limitations in accuracy and in the ease of use. Some can be performed through the analysis of dental or other radiographs or with clinical examination; others require laboratory testing or tooth destruction. The individual jurisdiction's requirements and the odontologist's skill and knowledge will help to establish the appropriate techniques for each case (see Chapter 13).

3.7 Expert Testimony in Criminal and Civil Litigation

Forensic odontologists are frequently called to give sworn testimony in depositions and courtrooms. The testimony may involve the previously mentioned areas of dental identification, bitemark analysis, or age estimation. Dentists participating in forensic casework should expect that at some point they will be required to provide sworn testimony.

Forensic dentists also may be called to provide an opinion in standard of care, personal injury, dental fraud, or other civil cases. These cases, as with other forensic cases, require the evaluation of material and the development of an opinion concerning the case. Dental experts are *not* hired guns, or advocates for one point of view. Dental experts must be advocates for the truth and endeavor to find that truth by the application of their special knowledge and skills. The unwavering goal of the forensic dental expert must be impartiality, thoroughness, and accuracy (see Chapter 16).

3.8 Summary

Forensic dentistry is a multifaceted, interesting, and rewarding blend of dentistry and the law. For most who participate in the field of forensic odontology there is not great financial reward, but the satisfaction of performing difficult and challenging tasks well is immensely rewarding. A forensic odontologist's work can have great impact on the lives of individuals and families. Their opinions may influence judges and juries in cases that can and have involved exoneration, the loss of liberty, and even the loss of life. This is an awesome and sobering responsibility that should not be casually undertaken. "The majority of those who fail and come to grief do so through neglecting the apparently insignificant details."[1]

References

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Death Investigation Systems

4

RANDALL E. FROST

Contents

4.1 Introduction

Throughout human history, the inevitability of death has inspired not only a sense of fear, but also a paradoxical sense of fascination and curiosity. It is no surprise then that the investigation of death has a long and varied history, intimately involved with the rise and governance of human populations. The sociologist Stefan Timmermans[1] has noted that death is not an individual event, but a social one, and every developed society has had an interest in the phenomenon, be it from a legal or public health viewpoint in modern populations, or as part of a mythic or superstitious worldview in earlier societies. Beliefs about the phenomenon of death have also been inexorably linked to religious systems throughout history.[2–4]

4.2 Early Death Investigation

The most primitive societies likely had a well-developed sense of the causative relationship of trauma, old age, and illness to death, and early "investigations"