FORENSIC ODONTOLOGY
One of the most famous cases involving forensic dentistry occurred in 1776, after Joseph Warren, an American doctor and a key figure in the American Revolution, was killed by British troops during the Battle of Bunker Hill. His body was badly mutilated postmortem and buried in a shallow grave with another fallen volunteer soldier. Ten months after the battle, Warren’s family located and exhumed his body. He was positively identified by the now-famous Paul Revere, who recognized a false tooth—held in place by a wire—that he had built for Warren.
A closer look

Forensic dentistry, also known as forensic odontology, utilizes the art and science of dentistry as they pertain to matters of law. The task of the forensic odontologist is to assist in the identification of decedents who are not identifiable by the usual means. These individuals instead must be identified using dental, DNA or fingerprint comparison. Fingerprints are widely used because they are unique, but in many cases fire and decomposition make fingerprint retrieval difficult or impossible. Also, antemortem (before death) fingerprint cards may not be available for comparison. DNA-comparison analysis is, of course, scientific, but the expense and extended time requirement for test completion is problematic.

Odontology becomes necessary when bodies are charred, decomposed, skeletonized, mutilated or comingled. Antemortem dental records must be available for comparison before the dental identification is made. If records are obtained promptly, the identification can be quick, accurate and reliable. Positive identification is needed for families to have emotional closure, for proper burial of the decedent, and for legal proof of death for insurance claims and settlement of estates. Law-enforcement agencies also require positive identification before they can begin an investigation. The dentition is the most resilient structure in the human body, which allows identifications to be made even in cases of extreme degradation. The teeth are protected by the soft tissues of the lips, tongue and facial musculature, and can withstand very high temperatures, environmental factors and extensive trauma.

While forensic dentistry is not one of the nine recognized specialties of the American Dental Association, an oversight board does exist which certifies forensic odontologists. The American Board of Forensic Odontology (ABFO) was established in 1976 and has almost 100 members. Forensic odontology is one of 11 disciplines represented in the American Academy of Forensic Sciences, an internationally recognized forensic science organization.

The forensic dentist fulfills a very important professional obligation by performing identification of human remains, bite-mark analysis of victims and suspects in child and adult-abuse cases, and on alleged homicide victims. The identification of mass-disaster fatalities, such as those that occurred on 9/11, during Hurricane Katrina, and numerous plane crashes, has played a significant role in forensic dentistry. Expert testimony is a common outcome in the criminal arena, but some forensic dentists also give opinions and testify in cases of civil litigation.

A personal journey

My passion for and interest in forensic dentistry began when I served as a U.S. Army dentist stationed in Vietnam. While practicing general dentistry, I was called upon to aid in the identification of a deceased military serviceman. The need to identify this hero gave me the satisfaction of helping surviving family members move on with their lives after the tragic death of their loved one. Other identifications followed. This glimpse into the world of forensic dentistry stayed with me throughout the rest of dental school and into my private practice. I graduated from Georgetown Dental School, grateful that two years in the military gave me experience that became beneficial later in my practice.

I moved to Phoenix, where I frequently consulted with the Maricopa County Office of the Medical Examiner (MCOME) and many local law-enforcement agencies on a variety of cases involving forensic dentistry (including one for which I used dental casting techniques to preserve a footprint in sugar). After almost 38 years of private practice, I went to work for the medical examiner’s office as a forensic odontologist.

Maricopa County, with a population of more than 4 million, is one of the few county medical examiner’s offices in the nation that employs a full-time forensic anthropologist, and a forensic odontologist, in addition to 11 on-staff forensic pathologists/medical examiners.
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In 2014, the office investigated more than 8,600 cases. Of those, 222 cases required a dental consultation consisting of a clinical examination, a full-mouth series of dental radiographs, and charting.

Early in my career, dental radiographs were completed in the conventional manner using dental film, developer and fixer solutions. The radiographs had to be developed at my private office because there was no developing source for dental film at the medical examiner’s office.

Thankfully, we have advanced to the digital age and have become more environmentally friendly. In 2010, the medical examiner’s office implemented a new identification protocol in response to a high volume of decomposed or otherwise unrecognizable decedents. This led to a purchase of a digital dental X-ray system.

We have done away with film, chemicals and disposal issues. Our source of radiation is a handheld X-ray unit, and our developer is a software program that allows the images to be displayed on a computer screen. The images are clear, instant and can be exported or emailed in different formats.

The process
When it comes to identifying victims, police offices use three designations: identified, unidentified AKA (UNID AKA) when a decedent has a tentative

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ernsic dentists have an important role when it comes to solving crimes. We spoke with Dr. Adam J. Freeman, president-elect of the American Board of Forensic Odontology, to find out about how odontologists (also known as forensic dentists), play a vital role in identifying disaster victims.

What is DMORT, and how did you personally get involved with the team?

Working with the dental division of the Disaster Mortuary Operational Response Team (DMORT), I have seen emotions and reactions ranging from great loss to tremendous generosity, and always phenomenal teamwork in the face of unspeakable tragedy.

My experience after the 9/11 attacks, when my practice lost two patients, started me on a path leading to DMORT. My curiosity for helping families achieve closure after a disaster led me to take the Armed Forces Institute of Pathology’s forensic odontology and forensic pathology courses. I then entered a year-long fellowship in forensic odontology at the University of Texas San Antonio.

Afterward, I applied to DMORT region 1, which at the time was part of the National Disaster Medical Service within FEMA, an agency of the Department of Homeland Security. The National Disaster Medical Service and the DMORTs are currently within the Department of Health and Human Services. I am honored to be one of fewer than 100 board-certified forensic dentists. Since working with DMORT, I have realized that digital radiography is a valuable tool in identifying victims quickly and efficiently.

DMORT region 1 is responsible for the geographic area stretching from Connecticut to Maine. My first deployment was in the wake of Hurricane Katrina. For dental identification of bodies, we use digital sensors along with a handheld X-ray unit (DEXIS sensors and NOMAD). Digital radiography makes this difficult process faster and more efficient. In contrast, after the 9/11 attacks, the forensic dentists were using traditional film X-rays. After the X-rays were taken, they had to wait while the X-rays were processed. After that, the dentists needed to view the X-rays and determine which ones needed to be captured differently, and then more X-rays were taken and processed—a lengthy process.

The impact of digital radiography, specifically, the combination of DEXIS and the NOMAD, has literally changed protocols. The speed at which we can perform our assigned tasks and exchange information has become faster, more accurate and easier.

How has technology helped DMORT to evolve over the years?

At The World Trade Center site, in the dental area, each body potentially could take 80 minutes just in the dental identification section. At the time of Katrina, with digital X-rays and paperless protocols, that time in the dental section dropped to about 20 minutes. We were able to do about five times more work in the same amount of time just because of the portability of our equipment and the immediate feedback regarding image quality and whether we had captured the necessary dental structures. The portability of the sensor and the X-ray unit was particularly helpful in comparison with antemortem that was taken at a severe angle, because we could easily take several X-rays at different angles to reconstruct postmortem what we were seeing antemortem.

Is being a part of DMORT an emotionally draining experience?

Being a part of the DMORT team is an emotional process, but the team knows that our task is to provide closure to families who are waiting for any kind of news about their loved ones. While we are in the middle of a disaster scene, we are so focused on the task at hand that the impact does not set in until the work is done. As the dental section chief of Health and Human Services DMORT region 1, I feel responsible for my team, but we all must closely monitor our colleagues to see if the

Dental Forensics in the Field:

The DMORT Team reviews DEXIS X-rays in WinID software, an identification program used as a national database.
identification but may not be visually identifiable, and unidentified (UNID), when a decedent has no identification. The forensic investigator and the pathologist assigned to the case determine if a dental consult is needed. The forensic dentist is then required to complete a full dental examination.

Meanwhile, forensic investigators obtain antemortem dental records (radiographs and written dental records) when possible to help in the identification. Frequently, family members don’t know the name of the deceased’s dentist, making this a very difficult and frustrating task for the investigator. If the case comes in as unidentified, then the postmortem dental radiographs are stored in a database. The forensic dentist obtains a full-mouth series on these individuals because there is no way to anticipate what types of antemortem dental records will be available. There may be only one periapical, only written records or bitewings. Our hope is to find a full-mouth series of X-rays or a panograph available for comparison to help identify the individual. The postmortem full-mouth series allows the forensic

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Adam J. Freeman, DDS, D-ABFO, earned his dental degree from Columbia University’s College of Dental Medicine. He completed a fellowship in forensic odontology at the University of Texas Health Science Center at San Antonio and Center for Education and Research in Forensics (CERF) and is a diplomate and president-elect of the American Board of Forensic Odontology. He is the founder and director of Connecticut’s Disaster Identification Response Team (DIRT), and the deputy chair of Interpol’s Disaster Victim Identification Odontology Working Group. Dr. Freeman is a fellow of the American Academy of Forensic Sciences.
odontologist to adapt to the antemortem information, no matter what is obtained for comparison.

The positive dental identification is based on comparing the dental findings of the antemortem dental radiographs to the postmortem radiographs. Dental features for comparison consist of restoration morphology, missing teeth, root anatomy, trabecular bone patterns, pulp-chamber shapes and maxillary-sinus morphology. If the decedent is edentulous, there is a possibility that dentures may be found. The protocol is to examine the denture for some type of nomenclature, such as a number or name. In the state of Arizona, dentists are required to place nomenclature on all removable appliances, unless a patient objects. When a positive dental identification is made, the forensic investigator assigned to the case informs the family and law enforcement agents.

When tragedy goes big … and public

The MCOME is well prepared for the possibility of a mass-fatality incident. We have training exercises that involve pathologists, investigators, the anthropologist and the odontologist. Both the anthropologist and the odontologist have memoranda of understanding with additional board-certified individuals who will provide additional assistance, if necessary. We also have occasional call-down drills, which notify all staff of a possible incident and ensure our leaders are knowledgeable about the protocols in response to the mass fatality.

On June 30, 2013, an unpredictable wildfire 80 miles north of Phoenix killed 19 firefighters—the highest wildland firefighter death toll since 1933. The MCOME was called to assist in identifying the firefighters. On July 2, 2013, our pathologists completed all of the examinations, and digital full-mouth series of dental radiographs were obtained for all of the victims.

Due to the diligent teamwork by our entire staff and the preparedness of the office, the identifications were completed scientifically.

Another interesting case involving forensic odontology involved the identification of a woman in a multiple-fatality accident on a Maricopa County freeway. One of the women survived and was taken to the hospital in critical condition, but was unrecognizable due to trauma. Family members sat vigil at the hospital and did not question the identity of their daughter. The other woman died and was brought to the medical examiner's office. Due to protocol established just a few months before the accident, she was admitted as unidentified. Postmortem digital dental radiographs were completed on the deceased woman and were compared to the antemortem radiographs and written records of the purportedly deceased woman. Many inconsistencies were found, resulting in an exclusion of this individual’s identity as the decedent. Subsequently, antemortem radiographs of the second woman were obtained and a positive identification was established.

Mistaken identities have occurred in other states and received widespread media attention. The most publicized misidentification happened in Indiana, when two women with similar physical attributes were involved in a motor vehicle accident. One woman died and was buried, while the other woman's family sat vigil, supposedly with their daughter. After five weeks in a coma, the injured victim regained consciousness and wrote her name on a pad. Dental records were used to verify the misidentification. For readers interested in further details about this story, the book, "Mistaken Identity," written by the families of the two women, is an excellent resource and was on The New York Times bestseller list.
When the case goes cold

A forensic odontologist may be called upon to identify remains of a John Doe or Jane Doe buried years earlier. The advancement of technology gives promise to the idea that it is possible to identify all the deceased currently listed as unidentified. The MCOME received a federal grant through the National Institute of Justice (NIJ) to exhume unidentified decedents with the hope that these individuals could be identified. The main concentration of cases involving the grant is from the 1970s through the 1990s, when DNA technology was not as advanced as it is today. At that time, DNA samples were not collected and digital dental radiographs were not taken, as the technology simply didn’t exist.

An exhumation team was formed, composed of medico-legal death investigators, a forensic odontologist and a forensic anthropologist. The team traveled to indigent cemeteries to conduct graveside examinations. The bodies were exhumed at the scene and placed on portable exam tables. A dental examination was done, including a digital full-mouth series and dental charting, along with an anthropologic examination that determined age, ancestry, stature or any notable injuries or more specific identifiers.

DNA samples were also collected from the teeth, femur, clavicle or other remains that might be still available. The lead investigator documented the entire process, including the decedent’s demographic profile, and the body was reinterred with a new casket.

While these types of cases are challenging, they are solvable with the appropriate resources from these grants. Fifty unidentified cold cases were exhumed or reinvestigated, and as a result of that effort, 13 decedents were scientifically identified. The team was able to provide closure to the families. Of the 13 who have been identified, two were teenagers, one was 7 years old, and one was a World War II veteran who subsequently received a military burial. At least six of these cases were homicides, and the identification led to new avenues for law enforcement to follow.

When a bite can convict

Another aspect of forensic dentistry deals with bite-mark analysis. Bite marks are pattern injuries caused by the dentition, and in some cases these injuries may be helpful in comparing the pattern to a suspect’s dentition.

This comparison may include or exclude a suspect. Swabbing the bite mark may recover DNA that would be very helpful to law enforcement. Recently, the scientific validity of bite-mark analysis has been challenged due to questions about the uniqueness of the human dentition and the reliability of the skin as an impression medium to accurately record tooth data. Further scientific research is presently being conducted and will hopefully improve scientific reliability of this type of analysis.

Medical examiners, attorneys or immigration authorities may request a forensic odontology consultation to help establish an age estimate for an individual. The individual may be a child, adolescent or adult, and the estimation of age incorporates the use of different specific population studies in tooth formation for each category.

Age estimation may also be useful as a starting point in identifying unknown victims. Third-molar development is a reliable indicator for an adolescent or an early adult to establish whether the individual has reached the age of 18. In many societies, 18 is a very important age, establishing legal majority in issues involving immigration. Legally, individuals under the age of 18 are handled differently from those who have reached the age of legal majority.

Conclusion

Forensic odontology has been a very enjoyable part of my career as a dentist. While forensic odontology was not part of the curriculum when I was a student at Georgetown University Dental School, the subject is being added to some of the dental school programs around the country. Forensic odontology has become a critical piece of many forensic investigations and legal actions. I’m fortunate to be a forensic dentist and to play an active part in the growth of this fascinating field.