Forensic Odontology - Part II

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CE Credits: 1 hour
Intended Audience: Dentists, Dental Hygienists, Office Managers, Dental Students, Dental Hygiene Students

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Disclaimer: Participants must always be aware of the hazards of using limited knowledge in integrating new techniques or procedures into their practice. Only sound evidence-based dentistry should be used in patient therapy.

Warning: This course contains content that some may find disturbing.

Introduction
This course will discuss bitemark evidence, human abuse issues seen in the dental practice environment and dental age assessment. Course participants can expect to learn the basic concepts of the overall practice of forensic odontology.

Please note this is Part II of a two-part series. Forensic Odontology - Part I discusses dental identification, disaster victim dental identification and the dental-legal issues associated with personal injury cases and standard of care cases, sometimes referred to as dental malpractice, including the role of the dental record. Each of the two courses can be taken independently and in any order.

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Overview
This series is comprised of two separate courses, each of which will consist of three sections of forensic odontology. Part II discusses bitemark evidence, human abuse issues seen in the dental environment and dental age assessment. Part I discusses dental identification, disaster victim identification, dental-legal issues associated with personal injury cases and standard of care cases, sometimes referred to as dental malpractice, including the role of the dental record.

Learning Objectives
Upon completion of this course, the dental professional should be able to:
• List the six main sections of forensic dentistry.
• Understand the concepts and methodology involved in the examination, analysis and, when appropriate, the comparison of human bitemarks to suspect dentitions.
• Understand the concepts, limitations and complexities of bitemark evidence in criminal cases.
• Detect and report cases of child abuse seen in the dental practice environment.
• Collect all evidence and information necessary to report suspected cases of child abuse.
• Understand the prevalence of all forms of human abuse in society with special attention to the abuse of children.
• Appreciate the role dental age assessment can provide to the legal community in helping to establish the age of majority (age 18).

Introduction
Forensic odontology, or forensic dentistry as it is also known, encompasses a sub-specialty of dentistry that deals specifically with the relationship between dentistry and the law. This dynamic field of dentistry is one of the most interesting yet poorly understood of all the areas of the profession of dentistry. This series, divided into two separate independent courses, will provide an introduction to forensic odontology. Course content will be supplemented with actual forensic cases, where appropriate, to help participants understand the complexities and techniques utilized in its practice.

Forensic odontology is divided into six sections:
• Dental identification of unknown human remains
• Disaster Victim Identification of human remains (also known as mass disaster identification or mass fatality incidents)
• Dental legal issues in the practice of dentistry, including both personal injury matters involving dentistry as well as standard of care (dental malpractice) issues
• Bitemark evidence in violent crime
• Human abuse issues seen the dental practice environment
• Dental age assessment

Each of these sections will be presented with the general practice guidelines employed in their use. It is not the intention of these two courses
to bring course participants into the realm of forensic dental expertise. These courses serve only as an introduction to forensic dentistry.

There are other outstanding post-graduate courses on forensic odontology that are presented regionally throughout the United States each calendar year providing ample additional learning opportunities. Most of these courses are either one or two-day courses, or in some instances, week-long courses. Online searches on forensic odontology will provide the dates and locations of these courses.

Additionally, there are a number of outstanding textbooks available on forensic odontology. Simple internet searches will provide the most recent publications including textbooks on specific forensic odontology subject matters such as bitemark evidence.

**Forensic Odontology Professional Organizations**

Forensic organizations exist in several countries. Within the United States, there are three professional organizations dedicated to forensic odontology. All three organizations meet annually in February as part of a week-long meeting.

The introductory organization is the American Society of Forensic Odontology (ASFO). Enrollment is acquired through the website (Figure 1). Annual dues are nominal. Membership in the ASFO is open to anyone with an interest in forensic odontology; no experience or credentials are required. The ASFO publishes a newsletter periodically each year on their website that provides information on a wide spectrum of forensic odontology-related topics. Membership in the ASFO is an excellent way for those interested in forensic odontology to become involved and to network with other novices and experts in the field. No experience or credentials in forensic odontology are required for membership.

The second organization is the Odontology Section of the American Academy of Forensic Sciences (AAFS). The AAFS is comprised of eleven separate sections of forensic science. The Odontology Section is for forensic odontologists exclusively. The AAFS is a credentialing organization, therefore membership requires satisfying a list of educational, practice and experience levels in order to join. The website details those requirements.

The third U.S. organization is the American Board of Forensic Odontology (ABFO). Membership in the ABFO requires an individual to have significant experience in forensic odontology in order to first become eligible to challenge the certification examination. Once qualified, the candidate must successfully pass the certification examination. Information about the list of requirements necessary to become exam-eligible can be found on the ABFO website. These organizations and their URL's are listed in Figure 1.

**Bitemark Evidence**

By far, the most controversial subdivision of forensic odontology, if not the entire forensic science field, is that of the use of bitemark evidence. For reasons that are not at all understood, biting is involved in many cases of violent person on person crime. Sometimes it is the victim of the crime being bitten but there are also instances of the victim doing the biting. During these physical altercations, many patterned injuries may be discovered on the body of the victim. Occasionally one or more of the patterned bruises can be produced from teeth. These patterns can be analyzed to determine if they are bitemarks, and more specifically, if they were inflicted by an adult or a child. In rare circumstances, it may be possible
to do a comparison between suspect dentitions and a bitemark in order to establish linkage. However, in no instance should bitemark evidence be used as the only physical evidence linking a suspect to a criminal act.

Previous studies have shown that there is variation of opinion between experts when tasked with determining exactly what a bruise pattern must look like in order to qualify as a human bitemark. One such study published at the 2015 American Academy of Forensic Sciences (AAFS) annual meeting showed a wide range of disagreement among ABFO diplomates. When the results of the study were reviewed, it was the opinion of the participants that the terminology used to determine if an injury was a bitemark was ambiguous and contributed to the poor results. Additionally, many participants could not state with confidence nor agree upon what criteria was required for a patterned injury to be defined as a bitemark.

In an effort to improve the techniques and establish conformity among experts, the ABFO has revised the terminology but has yet to initiate a follow up study to see if the issue is the language or the inability of the diplomates to actually determine when a patterned injury can first be labeled a bitemark. For bitemarks to be useful as evidence, it is a critical first step that an investigator be able to demonstrate with validity and reliability the ability to properly identify a patterned injury as a bitemark.

Bitemark evidence presents with unique issues when compared to other kinds of forensic evidence. In many sub-specialties of forensic science investigations, there are laboratory procedures that can be reliably employed to test, examine and quantify an unknown sample of evidence. However, in bitemark investigation, there is no established database or testing equipment to establish nor quantify probabilities of teeth linking to a bitemark patterned injury. Further, because of the violent nature of biting, it is not possible to design laboratory experiments to study the infliction of the biting injuries in a way that reproduces real-world biting as it occurs in true life or death struggles.

There is also no data available for quantifying the mathematical probability linking a specific suspect's dentition to a bitemark in skin. Bitemark analysis differs from DNA and fingerprint analysis in that databases exist that are used to establish a numerical probability and error rate when linking a DNA sample or latent fingerprint to an individual. Other complicating factors affecting the interpretation of bitemarks include the subjective interpretation of the examiner, inter-examiner differences and investigator bias, all of which can be significant factors in the resultant opinion.

Another issue that can affect the investigation includes how to measure the distortion that occurs in the biting. The pinching of the skin by the teeth during biting is quite painful and induces a reactive movement away from the biter's teeth. Motion induced in the skin by both the biter's teeth and the person who is bitten add distortion to bitemark pattern injuries. At this time, it is not possible to measure and fully understand the distortion that occurs. Bites through clothing, partial bitemarks, double or multiple bites over the same area and avulsive bites can all affect the evidentiary value of bitemarks in legal proceedings.

Even with these limitations, there are bitemark injuries that can be useful for analysis and possible comparison to suspect dentitions. Depending on the individualizing characteristics of the suspect dentitions and the amount of information contained in the bitemark, it may be possible to differentiate between possible biters. Individualizing characteristics include differences in arch widths, tooth positional configurations and locations in the arch, missing or unerupted teeth, and other observable details the teeth transfer to the skin during biting. Beyond the actual bitemark pattern(s), the presence of severe bruising from having been bitten can demonstrate violent physical contact which may contribute supplementary evidence in a criminal act. Bitemarks sometimes also provide an excellent source for collection of salivary DNA which, when collected properly, is very useful as evidence.
The appearance of a bitemark injury can range from a high-quality pattern distinctly showing both easily identifiable arches and clear individual tooth markings, to diffused or healing bruise patterns that appear as fuzzy “smoke rings.” A high quality bitemark can be used to link to a suspect’s dentition as well as exclude other dentitions.

Terms relating or linking a dentition to a human bitemark are:
1. Excluded as having made the bitemark,
2. Not excluded as having made the bitemark, such that dentition or a similar dentition cannot be excluded as having created the bitemark, and
3. Inconclusive, when there is insufficient information to support any conclusion whether or not the bitemark could have been caused by dentition.

It may be possible to analyze high quality bitemarks for orientation of the upper and lower teeth, the individual tooth position and alignment as well as relative arch size. Analysis of high quality bitemarks can also help determine if the bitemark is from a child or adult dentition. It is only the very rare case in which a comparison to suspect dentitions is done.

**Bitemark Case Study 1**

**History:** A young child was the victim of repeated physical abuse as documented by Child Protective Services. When the child was taken to the hospital after a recent abusive episode, photographic images of the sustained injuries documented several bitemarks, two of which were located on the arm. The time and location of the abusive episode was known and occurred in the child’s home. The child’s mother and mother’s boyfriend were the only people home at the time of the attack. Both the child’s mother and her boyfriend gave law enforcement sworn statements that they were in fact present when the abusive episode occurred. In their statements, both said the other was responsible for the attack.

Additional evidence collected included DNA swabs from the bites, dental impressions of both adults’ teeth, from which dental stone models were created, and sample bites from both adults’ suspect dentitions in Aluwax® to record the arch shape and tooth positions.

The bitemarks were analyzed and then compared to the suspect dentitions. The results of the comparison showed that one of the dentitions could be excluded as the arrangement of the teeth could not have created the bitemark. The other biter could not be excluded as having done the biting. Additionally, the DNA test came back matching the DNA of this same the unexcluded biter (Figure 2).

**Bitemark Evidence Collection Guidelines**

Before investigative procedures commence some form of legal permission must be obtained from an appropriate authority. This may be in the form of written consent, search warrant, subpoena, or court order. Details of how the investigator was contacted, by whom, when, documentation of the case number and agency from where the case originates should be recorded.

“Opportunities to physically view the suspected bitemark are rarely presented other than during the initial examination due to a variety of reasons often beyond the odontologist's control. Collection of bitemark evidence should endeavor to obtain maximal information so as to enable meaningful analysis and comparison of the wound pattern with a potential source, with the assumption that further access to the material evidence will no longer be possible after the primary examination. Every effort must be made to capture the true nature of the evidence at the time of collection by recording as much detail about the injury as possible.”

There are two categories of evidence collection associated with patterned injury/bitemark case work. The first involves evidence collection of the patterned injury/bitemark. The second is the collection of evidence from the suspected biter(s).
Evidence Collection from the Patterned Injury/Bitemark

1. DNA Collection:
   DNA swabs of the injury should be properly collected as soon as the injury is discovered. Only persons with knowledge and experience in the correct protocols for DNA collection, handling and storage should be utilized for this process.

2. Photography:
   Photography is the best and most common method of collecting and documenting the appearance of any injury. High quality digital camera systems are recommended; however, technology and capabilities of digital photographic equipment are constantly improving. Thus, no suggestions for a specific type of digital imaging system will be recommended. The photographic techniques involved in the evidence collection should include the following:
   • Orientation color digital images showing the location of the injury on the body (or the pattern on an inanimate object).
   • Close up (macro) digital images of the patterned injury with and without a photographic scale. It is recommended that the ABFO #2 scale be used whenever possible. Placement of the scale should be on the same plane and adjacent to the injury so as not to overlap or cover it. The surface of the lens should be as parallel to the injury as possible to avoid parallax distortion.
   • If the injury is on a curved anatomical location, digital images from different orientations around the injury will be necessary to adequately document the pattern.
   • Specialized photographic techniques include alternate light source imaging (ALS), infrared (IR), reflective ultraviolet light (UVA) protocols and indirect lighting techniques for injuries that may contain three dimensional properties. It is beyond the scope of this course to give detailed explanations for these specialized photographic techniques.

Figure 2. Suspect A (left) could not be excluded. Suspect B2 (right) was excluded. DNA testing came back as a match for suspect A.
however, there are many textbooks and other references that describe how to employ these techniques.

- Repeated photographic sessions to observe changes occurring in the injury over time (days in the deceased or up to a month in living tissue) may be employed until all attempts to capture the details of the injury have been exhausted.  

3. **Impressions of the Injury:**
   If a patterned injury contains three-dimensional properties, an impression of the injury should be made. The impression material should be a polyvinylsiloxane (PVS) type dental impression material and should be rigid enough to reproduce and maintain the three-dimensional properties of the injury. A rigid backing material, such as dental stone, is frequently used as a stabilizing framework to minimize distortion of the impression material.

**Evidence Collection from the Suspect**

It is recommended that the same investigator who collects the bitemark evidence should NOT also collect evidence from the suspect to avoid the inadvertent introduction of bias. The evidence to be collected from the suspect includes dental impressions, buccal DNA swabs, photographs of the dentition and bite exemplars showing the upper and lower teeth.

1. **DNA Collection:**
   DNA swabs of the suspect should be collected by trained technicians who possess knowledge and experience in DNA collection, handling and storage proper protocols for the collection and storage of DNA should always be employed.

2. **Photography:**
   Photography is the best and most common method of the collection and preservation of the suspect dentition. The use of a quality digital camera system for the photographic documentation of this evidence is recommended. The quality and capabilities of the digital photographic equipment is constantly improving and changing; thus, no suggestions for a specific type of digital imaging system will be recommended. The photographic techniques involved in the evidence collection should include the following:
   - full face image
   - macro image of the anterior teeth closed together
   - macro image of the anterior teeth slightly open
   - right and left lateral canine images
   - upper and lower occlusal images

3. **Exemplar of Biting Edges of the Anterior Teeth:**
   The exemplar should ideally capture the biting edges of the upper and lower anterior teeth without biting through the exemplar. Commonly used exemplars include Aluwax® and Coprwax® (Figure 3).

**Bitemark Analysis and Comparison**

After the evidence is collected from a patterned injury, a process is available to assist in the analytical and procedural steps. The Bitemark Evidence Flow Chart provides a pathway to direct the patterned injury investigator through a structured series of decisions that help avoid unsupported methods and/or opinions (Figure 4). Using scientific methodology, the examination of bitemark evidence can be divided into four basic steps:

1. Examine the pattern to determine if it is a bitemark.
2. If the pattern is a bitemark, determine its evidentiary value.
3. If there is high evidentiary value, examine the suspect dentitions.
4. If the suspect dentitions are unique to each other, a comparison may be possible, after which an opinion may be reached.

The first step, the analysis phase, tests the injury against the known definition of what characteristics represent a bitemark. The investigator then compares the patterned injury to that definition. While certainly subjective, applying a restrictive definition can guide the forensic odontologist in the right direction. The definition for establishing a patterned injury as a bitemark which offers the most complete description follows:

**Human Bitemark** – human teeth created the pattern.

**Criteria:** The pattern demonstrates class characteristics of human teeth. A circular, or oval or curvilinear pattern or patterned injury consisting of two opposing arches, often, but not always, separated at their bases by space. Individual marks, abrasions, contusions, or lacerations may be found near the periphery of each arch. The marks present should reflect the size, shape, arrangement, and distribution of the contacting surfaces of human teeth. Either the maxillary or mandibular arch, or both

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**Figure 4. Bitemark Evidence Flow Chart.**

Used with permission from Dr. Robert Wood.
arches, can be identified and the midline of each arch should be visible or determinable. Some of the marks made by individual teeth can be recognized and identified based on their class characteristics and/or location relative to other features. The size and shape of each arch visible is consistent with the size and shape of the human dentition.⁴

Below are examples of patterned injuries with the bitemark definition inserted below the caption. The restrictive definition must be employed during the observer’s subjective interpretation while deciding whether or not the injury is a human bitemark. Compare the images to the definition, inserted directly below the image sets, and try to determine if the injury pairs meet the criteria of the definition. (NOTE: Each pair of injuries demonstrated is NOT from the same case nor are they linked to each other in any way.)

EXAMPLE 1

Human Bitemark – human teeth created the pattern.

Criteria: The pattern demonstrates class characteristics of human teeth. A circular, or oval or curvilinear pattern or patterned injury consisting of two opposing arches, often, but not always, separated at their bases by space. Individual marks, abrasions, contusions, or lacerations may be found near the periphery of each arch. The marks present should reflect the size, shape, arrangement, and distribution of the contacting surfaces of human teeth. Either the maxillary or mandibular arch, or both arches, can be identified and the midline of each arch should be visible or determinable. Some of the marks made by individual teeth can be recognized and identified based on their class characteristics and/or location relative to other features. The size and shape of each arch visible is consistent with the size and shape of the human dentition.

Do the two injury patterns above conform to the definition such that they can be described as human bitemarks?

These two injuries do appear to meet the definition of a human bitemark in skin.
EXAMPLE 2

Human Bitemark – human teeth created the pattern.

Criteria: The pattern demonstrates class characteristics of human teeth. A circular, or oval or curvilinear pattern or patterned injury consisting of two opposing arches, often, but not always, separated at their bases by space. Individual marks, abrasions, contusions, or lacerations may be found near the periphery of each arch. The marks present should reflect the size, shape, arrangement, and distribution of the contacting surfaces of human teeth. Either the maxillary or mandibular arch, or both arches, can be identified and the midline of each arch should be visible or determinable. Some of the marks made by individual teeth can be recognized and identified based on their class characteristics and/or location relative to other features. The size and shape of each arch visible is consistent with the size and shape of the human dentition.

Do the two injury patterns above conform to the definition such that they can be described as human bitemarks?

There are some characteristics present in these injuries as required by the definition but they are certainly less clear than those seen in example 1.
EXAMPLE 3

Human Bitemark – human teeth created the pattern.

Criteria: The pattern demonstrates class characteristics of human teeth. A circular, or oval or curvilinear pattern or patterned injury consisting of two opposing arches, often, but not always, separated at their bases by space. Individual marks, abrasions, contusions, or lacerations may be found near the periphery of each arch. The marks present should reflect the size, shape, arrangement, and distribution of the contacting surfaces of human teeth. Either the maxillary or mandibular arch, or both arches, can be identified and the midline of each arch should be visible or determinable. Some of the marks made by individual teeth can be recognized and identified based on their class characteristics and/or location relative to other features. The size and shape of each arch visible is consistent with the size and shape of the human dentition.

Do the two injury patterns above conform to the definition such that they can be described as human bitemarks?

These two cases contain some required characteristics but fall short of meeting the criteria of a bitemark.
Human Bitemark – human teeth created the pattern.

Criteria: The pattern demonstrates class characteristics of human teeth. A circular, or oval or curvilinear pattern or patterned injury consisting of two opposing arches, often, but not always, separated at their bases by space. Individual marks, abrasions, contusions, or lacerations may be found near the periphery of each arch. The marks present should reflect the size, shape, arrangement, and distribution of the contacting surfaces of human teeth. Either the maxillary or mandibular arch, or both arches, can be identified and the midline of each arch should be visible or determinable. Some of the marks made by individual teeth can be recognized and identified based on their class characteristics and/or location relative to other features. The size and shape of each arch visible is consistent with the size and shape of the human dentition.

Do the two injury patterns above conform to the definition such that they can be described as human bitemarks?

These two injuries lack the required criteria to be termed “human bitemarks.”
those cases, the forensic odontologist can proceed to the comparison, which is the fourth step. Each suspect dentition is compared to the bitemark and a separate opinion is given for each set of teeth.

The ABFO Bitemark Terminology Guidelines define possible results of a bitemark comparison as only three choices:

- **Excluded** – the suspect dentition could not have created the injury
- **Not excluded** – the suspect dentition or similar dentitions could have created the injury
- **Inconclusive** – insufficient information exists to form a conclusion either way

Further, the ABFO Standards state that biter identity is not sanctioned. As previously explained, the distortion that occurs during the act of biting human skin cannot be measured or quantified. Additionally, the lack of statistical databases for the determination of an error rate and the mathematical probability linking a suspect dentition to a bitemark are precisely the reasons the ABFO does not sanction that biter identity can be established. The bitemark evidence must only be used as a part of the total evidence presented in a case. In many bitemark cases, the only questions asked are: (1) is the patterned injury a human bitemark and, if so, (2) is it an adult or child bite? There is no attempt at comparing the bitemark to any suspect dentition. The analysis stops after the first step.

Using the methodology of the Bitemark Evidence Flow Chart, if a determination is made that there is a human bitemark of high evidentiary value AND the suspect dentitions are distinctly unique when compared to each other, a comparison may be possible.

There are several different methods that are used in a comparison step. The overlay method, (see Case 2: Figures 6-7) is the most frequently used comparison technique. The biting edges of the suspect dentition are outlined and transferred to an exemplar. The exemplar is then overlaid onto the bitemark image. Both the exemplar and bitemark image should be of life-sized dimension.

Other comparison techniques include:
- wax exemplars of suspect dentitions compared to the bitemark
- direct comparison of dental stone models to nearly life-sized images of the bitemark
- metric analyses

**Bitemark Case Study 2**

**History:** A victim was attacked in the parking lot of a shopping center during a robbery and car heist attempt. The victim, who died of multiple stab wounds, was bitten by the perpetrator during the altercation. The bitemark was used as part of the evidence in the case which ended in a conviction (Figures 6-7).

There are many physical and physiological factors that must be considered when...
When the primary investigator has completed the analysis and, when appropriate, the comparison in a given case, there are several more steps involved before preparing the final case report. These include seeking a blinded second opinion by another independent investigator such that the second investigator only has information directly related to the injury pattern. “Blinding” is done to avoid the examining bitemark evidence. These include, but are not limited to, biting dynamics, skin tension lines, all three planes of the suspect dentition (mesial-distal width, buccal – lingual width and incisal height), arch shape, missing or broken teeth and tooth rotations. It is beyond the scope of this course to attempt to teach the intricacies of bitemark case work, however it is possible to conceptually understand the overall process.

When the primary investigator has completed the analysis and, when appropriate, the comparison in a given case, there are several more steps involved before preparing the final case report. These include seeking a blinded second opinion by another independent investigator such that the second investigator only has information directly related to the injury pattern. “Blinding” is done to avoid the 

Figure 6. Adobe Photoshop® was used to digitally scan and outline the biting edges of the models of a suspect dentition which were transferred to the overlay. The overlay was then compared to the bitemark image.

Figure 7. A comparison showing a suspect dentition overlaid on a bitemark at the start of the biting (A) and at the end of the biting (B). Other evidence in this case included DNA evidence, a confession, surveillance video and witnesses.
introduction of investigator bias. Assuming the second investigator reaches the same conclusion as the primary investigator after both have completed their blind analyses, the case report will then be prepared. The ABFO has report writing guidelines that should be followed and which flow logically from the start of the case to the preparation of the final report. The final report, when submitted to the respective agency or attorney, becomes part of the chain of evidence in the overall case and may be used in a future legal proceeding.

**Methods of Analysis:** This section describes the analytic methods used for the patterned injuries determined to be bitemarks.

**Results of Analyses:** This section describes the results of the comparisons and analyses.

**Opinion:** This section states the author’s opinion of the relationship between one or more bitemarks and a suspected biter or biters using ABFO Bitemark Terminology. Only one comparative term is used for each opinion in this part of the report.

**Disclaimer:** Disclaimer statements may be included to convey that the opinion or opinions are based upon the evidence reviewed through the date of the report. The author may reserve the right to file amended reports should additional information become available.

**ABFO Guidelines for Investigative and Final Bitemark Reports**

The following ABFO Bitemark Report Writing Guidelines propose a format for written bitemark case reports. These guidelines are suggestions for the form and content of the report. Diplomates may be asked to provide preliminary or investigative reports. Those preliminary reports may follow the same general guidelines without being conclusive in nature. Reports may be structured into the following sections:

**Introduction:** This section provides the background information, the “who, what, when, where and why” data related to the case.

**Inventory of Evidence Received:** This section lists all evidence received by the Forensic Odontologist and details the source of the evidence.

**Inventory of Evidence Collected:** This section lists the nature, source, and authority for evidence collected by the Forensic Odontologist.

**Opinion Regarding the Nature of the Patterned Injury or Injuries:** This section states the author’s opinion as to whether the patterned injuries in question are bitemarks, using ABFO terminology. Only one comparative term is used for each opinion in this part of the report.

**Human Abuse Seen in the Dental Practice Environment**

Human abuse in the United States has been described by Donna Shalala, former Secretary of Health and Human Services under President Bill Clinton, as a national epidemic. Human abuse is generally described as physical harm against any person. Categories of the types of human abuse include child abuse, intimate partner abuse (also known as domestic violence), disabled abuse, geriatric abuse, sexual abuse as well as other forms of assault, battery and homicide (Figure 8). The most detailed reported information involves cases of child abuse.

Forensic dentistry’s role in detecting and reporting episodes of human abuse, specifically child abuse, is two-fold. First, health care providers are legally mandated to report suspected cases of child abuse in all 50 states. Secondly, clinical signs and symptoms of the abused are often discovered in the medical and dental office environment (Figures 9-10). Forensic odontologists are charged with the task of informing practicing dentists and other healthcare providers about the duties of reporting suspected abuse.
While child maltreatment is the most widely followed and reported, all categories of human abuse continue to experience significant increases in the number and frequency of the reported incidents of abuse year-over-year. This course will focus on child abuse.

Child abuse has four main elements: physical abuse, sexual abuse, emotional abuse and neglect. Overt signs and symptoms of sexual abuse are unlikely to be seen in the dental practice environment. However, the other three categories are regularly seen but severely under-reported by dental health care providers (Figures 11-12).

It is estimated that 43-75% of abused children present with signs and symptoms of injuries on the head, neck and mouth yet dentists report less than 1% of all cases. Many of the victims have experienced multiple abusive episodes that, if go unheeded, can increase in frequency and violence, up to child’s death. Often, child abuse victims will appear with multiple injuries...
in different stages of healing (Figure 13). These factors underscore the role of the forensic odontologist both as an educator to the profession as well as an expert witness in cases of suspected abuse (Figures 14-15).

**Signs and Symptoms of Child Abuse - The Caregiver**

Upon discovery of a suspected case of child abuse while at a dental appointment, the practitioner may find that the caregiver presents conflicting information not corresponding with the clinical appearance of the injuries, or they may give a history that is inconsistent with the explanation of how the injuries occurred. Often, the caregiver may refuse to cooperate when questioned or reject the recommended treatment for the child. Many times, caregivers seek treatment for the child elsewhere if they suspect someone believes the child has been abused. Unfortunately, statistics have shown that dental health care providers typically do not report suspected cases of abuse. As a result, caregivers typically have little to no fear of being reported after seeking treatment in a dental office.
Figure 13. Child abuse victim with bitemark on the right cheek. The child survived this abusive episode.

Figure 14. Child abuse homicide victim with bitemarks and other injuries in various stages of healing. The child did not survive this episode. A forensic dentist assisted with the documentation of the injuries.
Many times, the caregiver will delay seeking care hoping the injuries will heal regardless of how severe they are. This explains why an abused child often will have multiple injuries in different stages of healing. If the child is questioned about how the injuries occurred, frequently the caregiver will speak for the child including being highly critical of the child or even prevent them from speaking. All of these behaviors should alert the dental team to a possible case of child abuse that must be reported.

Contrary to popular belief, most caregivers who abuse children are not mentally ill. The abuse toward children transcends all socio-economic classes, educational levels, races, religions and personal lifestyle choices. In most instances, the abusers themselves were victims of abuse when they were children, thus making the abuse “learned behavior.” The goal of intervention is to break the chain of violence and learned behavior. Forensic odontology can provide one link in educating the dental profession about human abuse and work to stop the propagation of violence in the home for future generations.

**Intimate Partner Abuse Case**

History: Victim was beaten and raped in a multi-hours long attack in which she almost died. During the vicious attack, which she survived, more than 30 bitemarks were inflicted (Figure 16). The attacker was a former acquaintance.

**Signs and Symptoms of Child Abuse - The Abused Child**

In a clinical situation where child abuse is suspected, it is best to first separate the caregiver from the child. Often a caregiver will accompany the child to the operatory when the child is seated for the appointment. The dental team should ask the caregiver to return to the reception area while the child is being treated.

Once the caregiver has left the operatory, the child should be asked about their injuries, including how they occurred, when they
Figure 16. Color and black and white images of multiple bites on this victim of domestic violence.
occurred and if there is any untreated pain. During this conversation, close attention should be paid to the verbal responses and non-verbal physical behavior of the child.

The signs and symptoms of an abused child include such things as inappropriate responses to questions or sudden physical withdrawal when touched. Responses to questioning can range from total silence to dubious answers that either do not comport with the appearance of the injuries or seem carefully coached.

Perhaps the most obvious clinical sign of an abused child is a blank stare and unresponsiveness during attempted conversation. There is little-to-no eye contact nor any emotion; certainly not the typical behavior for a child who has presented for dental care. If the child exhibits multiple injuries in various stages of healing, coupled with unresponsive behavior in the absence of the caregiver, serious consideration should be given that the child may be an abuse victim.

On the other hand, if the child offers explanations for various visible injuries, the dental team should then go to the caregiver, in the absence of the child, ask about the same injuries. If the stories do not match, there is a good chance the child has been the victim of abuse.

**Child Abuse Homicide Case**

**History:** This two-year-old child died after a short life of continuous abuse. One episode involved the removal of his lower anterior teeth either from traumatic avulsion or by use of a tool. After the fatal episode, the child was observed to have multiple injuries in various stages of healing and a torn maxillary frenum (Figures 17-19). The ultimate question is simple: Was this needless death preventable had the abusive episodes been reported?

**Collection of Evidence in Case of Suspected Abuse**

All 50 states mandate that healthcare professionals report cases of suspected child abuse. Laws in each state provide protection to the healthcare professional in the event that a suspected case of abuse turns out not to be abuse (false positive). The laws grant the healthcare professional the latitude to collect any evidence necessary to document the suspected abusive episode without the consent of the parent or caregiver. Examples of evidence that may be collected would include the following:

- Labeling of injuries on an outline drawing of a human body.
- Photographic images of each injury that can be seen.
- Radiographs and any other item necessary to document the injuries.

If a healthcare professional believes that the child has been abused, Child Protective Services (CPS) must be contacted and the suspected abuse reported. The role of CPS and the reporting healthcare professional is not punitive toward the abusive aggressor; rather it is to remove the child from the abusive environment to stop the abuse and possibly prevent the child’s death from future abuse. After the case is processed through proper legal channels, the disposition and future care of the child is ultimately determined.

**Background and Statistics**

The US Department of Health and Human Services produces an annual report on child maltreatment. The Child Maltreatment report series is an important resource relied upon by thousands of researchers, practitioners, and advocates throughout the world, per the Internet. The latest report, Child Maltreatment 2015, outlines risk factors associated with the maltreatment of children. The principle risk factors fell into one of three categories:

- Alcohol abuse, where 10% of abuse victims were reported to have been related to caregiver alcohol abuse.
- Drug abuse, where 25% of the abuse victims were reported to have been related to caregiver drug abuse.
- Domestic violence, where 25% of the abuse victims were reported to have been related to caregiver domestic violence.

The American Society for the Positive Care of Children, in a January, 2017 release, offers these statistics regarding child abuse within the USA for the calendar year 2015:
Figure 17. Color image of injuries on the child's face (A). The same injuries viewed in 425nm monochromatic blue light (B). Note the greater extent of the injuries when viewed in the blue light.

Figure 18. Note the premature absence of some of the lower primary incisors (A) and the torn maxillary frenum (B).

Figure 19. Medical kit used to hide the avulsed lower primary incisors (A) and the recovered incisors (B). Attempts to find tool marks using ultraviolet photography on the avulsed teeth were not successful.
There continues to be an epidemic of human abuse in our society that does not show signs of slowing down. The dental practice environment can play an important role in starting to change that upward trend.

**Dental Age Assessment**

Dental age assessment is a valuable asset that forensic odontology can provide when issues arise regarding the legal age of an individual. For most of the United States, the legal age is 18 years. Determining whether an individual is equal to or greater than 18 years of age is important to law enforcement as well as the courts.

Over the years, there have been many attempts to design methods to accurately predict if an individual has or has not attained the legal age. One study from 1993 by Mincer, Harris and Berryman \(^1\) used data collected from eight defined stages of development of the mandibular third molars from persons of known age, which established a database for comparison to persons of unknown age. When the mandibular third molars were assigned to one of the eight developmental stages, an approximate age range could be established.

Other studies were designed to include more than just the developing human dentition. A 1990 study \(^2\) from Bogota, Colombia collected medical, dental and radiographic data from the third molars, hand and wrist bones, the cranium, as well as gender and pubertal development. In doing so an approximate age of majority in Colombia could be established with a 75% reliability. This landmark study was important because a significant part of the Colombian population is born with no documented birth certificate.

Age estimation expanded beyond the third molars to include information on ancestry, nationality and gender in a freeware computer-applied data driven program called UT-AGE \(^3\) developed by Lewis, Senn and Silvaggi (Figure 20). The use of the computer helps prevent inadvertent errors in the mathematical calculations used in the assessment of age. \(^4\)

Dental age assessment is most useful in matters involving proof of identity, and, by association, age in criminal cases, immigration matters, paternity and custodial issues among other possible applications. The UT Age program accurately predicts age with a 95% reliability within 2 standard deviations of the estimated age. The program is a huge asset to law enforcement.

**Conclusion**

In the criminal world, forensic odontology is able to assist law enforcement and the legal system utilizing bitemark injuries as a piece of the overall case evidence that may be useful in child abuse, domestic violence, sexual assault or homicide cases. Further, by providing a detection and reporting matrix for dental healthcare professionals, child abuse and other forms of human abuse seen in the dental practice environment can be properly recognized and appropriately reported to authorities to remove and protect the abused. Finally, using dental age assessment as one method of establishing if an individual has reached legal age can greatly aid law enforcement and the legal community in keeping those of legal age who violate the law out of society.
Figure 20. UT Age Data Collection Form.\textsuperscript{13}
Course Test Preview
To receive Continuing Education credit for this course, you must complete the online test. Please go to: www.dentalcare.com/en-us/professional-education/ce-courses/ce504/start-test

1. The most controversial section of forensic odontology is ____________.
   a. dental identification
   b. human abuse seen in the dental practice environment
   c. dental age assessment
   d. bitemark evidence analysis and comparison

2. Bitemark evidence opinions in the legal system ____________.
   a. cannot be used for absolute biter identity
   b. are supported by a numerical database linking suspect dentition to the bitemark
   c. are supported by laboratory methods that establish a verifiable error rate
   d. have been banned by the legal system

3. The Bitemark Evidence Flow Chart ____________.
   a. consists of four basic steps
   b. is used as a methodology to guide the bitemark examiner
   c. allows high evidentiary bitemarks to be compared to suspect dentitions
   d. directs the bitemark examiner to link a poor evidentiary bitemark to a suspect dentition

4. ABFO Bitemark Terminology and Guidelines which define the link between suspect dentitions and the bitemark include all of the following EXCEPT ____________.
   a. suspect dentition excluded as creating the bitemark
   b. suspect dentition not excluded as creating the bitemark
   c. insufficient information
   d. suspect dentition links to the bitemark such that the probable biter can be identified

5. Factors to consider when examining bitemark evidence include ____________.
   a. skin tension lines
   b. the incisal plane in all three dimensions
   c. biting dynamics
   d. All of the above.

6. When the primary investigator in a bitemark case has finished the analysis and comparison, ____________.
   a. the agency requesting the examination of the evidence is called
   b. the final report is written and sent to the authorities
   c. all of the case evidence is sent to a second forensic odontologist for an independent, blinded review
   d. the final report is written using the ABFO Bitemark Report Guidelines

7. Human abuse in today's society is ____________.
   a. an epidemic
   b. regularly and accurately reported by practicing dentists to law enforcement
   c. mandated to be reported in all its forms in all fifty states
   d. an emphasis area of law enforcement such that abusers can be jailed
8. **Abused children often present to the dental office __________.**
a. as happy go lucky children  
b. with many injuries in various stages of healing  
c. with stories about the injuries that always make sense for the injuries seen  
d. with nurturing and supportive caregivers  

9. **The abusers are __________.**
a. usually quite poor  
b. mentally ill  
c. over intellectually challenged  
d. None of the above.  

10. **Dental age assessment __________.**
a. is used to establish the age of majority (age 18) of an individual  
b. is capable of establishing an exact age based on the characteristics used in the assessment  
c. cannot be used in the legal system as it lacks reliability  
d. is only used to age immigrants
References
13. The University of Texas Health Science Center at San Antonio. Center for Education and Research in Forensics.

About the Author
Franklin D. Wright, DMD, D-ABFO
Dr. Wright has been practicing forensic odontology since 1985. He is a diplomate and past president of the American Board of Forensic Odontology (ABFO), one of only 167 board-certified diplomates since its inception in 1976. He is a Fellow in the Odontology Section of the American Academy of Forensic Science and a Member of the American Society of Forensic Odontology. He has served on the Disaster Committee at the Cincinnati-Northern Kentucky International Airport since 1985 and responded two different times to help identify the victims of the World Trade Center disaster. He has lectured throughout the United States as well as Europe, Central and South America on forensic odontology and has been published in numerous textbooks and journals. He maintains a full-time general dental practice in Cincinnati, Ohio.

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