BITE MARKS IN FORENSIC DENTISTRY:
A REVIEW OF LEGAL, SCIENTIFIC ISSUES
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Although bites and biting have been around as long as animals with teeth have inhabited the earth, the science of bite mark identification is comparatively new and potentially valuable. Because of its origin, biting is a primitive type of assault. It is often used as the weapon of last resort. Consequently, bite injuries are frequently seen in circumstances of forcible rape, skirmishes between young children and hand-to-hand mortal combat. Since biting may be part of foreplay or other sexual activities, bite injuries are often seen in sex crimes, particularly among male homosexuals.¹

Identifying human remains by dental characteristics is a well-established component of forensic science with a definite scientific basis. However, the whole arena of bite marks is a recent and still controversial part of this discipline.

The history of the distinctive nature of tooth arrangement, and its legal implications, is extensive. William the Conqueror reportedly validated royal documents by biting into a wax seal with his characteristic dentition. Debtors coming from Britain or Europe to America to work as servants verified their agreements by biting the seal on the pact in lieu of a signature and became known as indentured servants. Although bite marks have only recently gained prominence, there have been cases and investigators for more than a hundred years. Various individuals have been recognized as being the first bite mark analyst. Several authors have mentioned Sorup as being the first such investigator; in 1924, he used transparent paper representations of a suspect's dentition to compare with life-size bite mark photographs.²

Possibly the earliest recorded bite mark case in the United States was Ohio vs. Robinson in 1870. Ansil Robinson was charged with the murder of his mistress, Mary Lunsford. In spite of evidence presented in court matching his teeth to bite marks on the victim's arm, Robinson was acquitted of the charge.³ As precedent-setting convictions involving bite marks were relatively uncommon in the legal literature, it is difficult to establish the nature of early cases. Presumably the...
first case involving a bite mark that led to a conviction sustained on appeal was a 1972 rape case, Illinois vs. Johnson.

Most early forensic investigators analyzed marks left by dental casts in wax, clear overlays and other mediums. Others attempted to simulate the consistency of human tissue by using articulated dental models to “bite” baker’s dough and sponge rubber. The problems of registering marks in the skin were studied, and there were descriptions of photographic techniques to preserve evidence.

With the advent of electron microscopy and computer enhancement, these new technologies were applied to bite mark analysis. Methods to determine the ABO blood groups from the saliva on the skin were developed, and investigators tried to link bacteria and other organisms found in the bite mark to the oral milieu of the perpetrator. In addition to the attempts to link marks left on human tissue to the dentition of the perpetrator, there were many instances of bites in food or other inanimate objects used as physical evidence to place the accused at the scene of the crime. Although there were several attempts to systematically investigate bite marks and their application to forensic science, there was no general agreement about national or international standards of comparison.

Several famous cases, notably Theodore “Ted” Bundy’s serial murder trial, made bite marks a high-profile item with excessive media attention. Because of the repellant nature of the biting of victims, bite mark evidence became highly sensationalized and prejudicial. Even popular fictional television series such as “L.A. Law” and “Quincy, M.E.” depicted bite mark evidence used to convict wrongdoers.

More recently, there have been highly publicized trials involving bite mark evidence in which several dental experts on each side have argued convincingly that the marks did or did not implicate the accused. These wide divergences of opinion have led some to question the value and scientific objectivity of bite mark evidence.

**LEGAL STATUS OF BITE MARK EVIDENCE**

**Admissibility.** New scientific procedures are not automatically admitted into evidence in judicial proceedings; they must first satisfy rigorous scrutiny and analysis. The goal of such inquiry is protecting defendants from improper conviction based on methods and techniques that have not been established and accepted by the scientific community. Judges and juries usually do not have enough background to assess the scientific merit of new methods and procedures and must rely on experts within approved judicial guidelines. Bite mark evidence has been challenged on this basis both because of its perceived lack of scientific merit and its potentially prejudicial aspects.

The relevance and admissibility of new forms of scientific evidence depend on their general acceptance in the scientific community. Identification by fingerprint comparison was accepted first in U.S. courts in 1911 only on the basis of its general and common use and acceptance. In 1923, the justification for admitting scientific evidence was established as a standard that would...
become known as the “Frye test.””¹ This requirement for admissibility has three components:

- the principle must be demonstrable;
- it must have been sufficiently established;
- it must have gained the general acceptance of experts working in the particular scientific field(s) to which the evidence belongs.

Of course, the criticism of such a test is that the judicial admissibility of new techniques is often delayed. But because of the importance and relative weight placed on scientific evidence in trials, most legal scholars conclude that the Frye test is an important restraint on dubious methods.

The first case involving the admissibility of bite mark evidence was a 1954 Texas case, Doyle vs. State. In this instance, a piece of cheese found at the crime scene had tooth marks. The defendant, Doyle, was asked to bite into another piece of cheese and a firearms examiner, not a dentist, compared the marks. At the trial, this examiner and a dentist testified that the marks were made by the same teeth. Although the dentist likely had no previous experience in evaluating bite marks, and the firearms expert presumably had no dental knowledge, the evidence was admitted. The court allowed the evidence because it appeared similar to fingerprint cases.

Most other cases involving bite mark evidence sidestepped the issue of scientific reliability even though there was often testimony to indicate a lack of plausibility in analysis. In a landmark 1975 case, People vs. Marx, the California Court of Appeals concluded that bite mark analysis was generally acceptable in the proper scientific community and thus admissible, in spite of the court’s acknowledgment that “there is no established science of identifying a person from bite marks.”¹⁸ In a 1976 Illinois case

There continue to be substantial questions about the validity of bite mark evidence and its scientific principles, but those questions must be considered by judges and juries listening to opposing witnesses, rather than by prior exclusion of evidence.

(People vs. Milone), a major disagreement between authorities arose when the prosecution’s experts asserted that the defendant’s dentition was responsible for the marks in question, and four witnesses testifying for the defense maintained that the defendant’s dentition was positively not responsible for the bite.¹⁷ In this case, the court decided that the discrepancy in the opinions of the experts would not affect the admissibility of the evidence, but would rather influence the relative weight of the testimony.

After the Milone decision, the admissibility of bite mark evidence was explicitly established, and material of this nature has been routinely accepted in several legal venues. Although some legal scholars argue that bite mark techniques have never been critically examined and legitimately passed the Frye test, the admissibility of this type of evidence is generally no longer at issue.¹⁸ There continue to be substantial questions about the validity of bite mark evidence and its scientific principles, but those questions must be considered by judges and juries listening to opposing witnesses, rather than by prior exclusion of evidence.

Impartiality. In legal circles, particularly in criminal defense, some have questioned the impartial, objective attitude of bite mark investigators. Most members of the forensic dental community are associated with law enforcement agencies. As
representatives of police, coroners or medical examiners, they could tend to identify with the prosecution in a trial. Of course, that partiality does not necessarily exist, and many investigators go to great lengths to avoid any partisanship.

The process of bite mark evaluation, even without considering the techniques and methods, can reinforce prejudice. In most cases, forensic dentists rely on police agencies to provide them with suspects for evaluation and comparison with the bite marks, and this process produces a limited number of models. There is seldom an equivalent to an identification “lineup.” Rarely, if ever, are investigating dentists offered models from individuals undoubtedly not involved in the crime.

Summary of legal considerations. Although there continue to be objections as to the relevance and appropriateness of bite mark evidence and its ability to pass the Frye test, the admissibility of such evidence is rarely questioned. It is up to the judge or jury to weigh the evidence presented by both sides and assess its relative value. The steps necessary to obtain bite mark evidence are reasonably well-established, and an investigator would be criticized for not following the appropriate steps. Presumably, an expert becomes defined by his or her knowledge of the correct manner in which a bite mark is processed.

Using bite marks: methodology

Obtaining evidence from the victim. For bites on human skin, a potential bite injury must be recognized early, as the clarity and shape of the mark may change in a relatively short time in both living and dead victims. Bite marks appear most often as elliptical or round areas of contusion or abrasion, occasionally with associated indentations. There may be avulsion of tissue, or even pieces of tissue bitten off. There may be considerable bruising and wounds that have penetrated the skin.

Once the mark is initially evaluated, it should be examined by a forensic odontologist to determine if the dimensions and configuration are within human ranges. Since a large proportion of individuals (80 to 90 percent) secrete the ABO blood groups in their saliva, swabbing the area and a control area elsewhere on the body should be completed before the body is washed. The swabs, moistened with sterile distilled water, should be allowed to air-dry before their submission to a serological laboratory.

Although there have been descriptions of using fingerprint “dusting” methods, photography is the primary means of recording and preserving the bite mark and is critically important in documenting the evidence. Since the skin marks are apt to change over time, photographs provide the most reliable means of preserving the information. However great their value, photographs have considerable inherent limitations, and there are stringent requirements regarding the accuracy of reproduction. The basic difficulties involve replicating a three-dimensional object in a two-dimensional film and producing an image with true colors and spatial relations. Attention to procedure can help minimize these restric-
tions and create a reasonably reliable, consistent image for comparison.

Photographs should be made by experienced photographers using both color transparency and black-and-white film with a negative size of 35 mm or larger. Lighting, camera orientation, close-up capability and stability are extremely critical. A camera support such as a tripod should position the camera perpendicularly to the long axis of the region. Photographs should be produced with and without a scale, and possibly other circular reference devices such as small metal washers. There has been substantial discussion of the nature of the scale for bite mark photographs, including the inherent inaccuracy of small plastic rulers, the value of curved vs. rigid scales, and the need for placing other objects in the picture. Many bite mark photographs are taken with substantial references. A scale developed by members of the American Board of Forensic Odontology has evolved as a standard, designated as the ABFO scale no. 2.

In addition to the customary color and black-and-white films, some authors have recommended ultraviolet photography at the initial encounter and for a few days after. The technique involves irradiating the bite mark with a UV light source and exposing black-and-white film through a UVA filter. With increased contrast printing, an image with additional details can be produced. In one article on the subject, two authors subjected themselves to being bitten under intravenous sedation for extended periods. The resulting marks were then photographed at various intervals with conventional films and UV techniques to demonstrate that images could be produced several days after the injury.

When there are indentations in the skin, or to preserve the three-dimensional nature of the bitten area, impressions should be taken to fabricate stone models. This is done by fabricating custom impression trays and taking an impression of the mark and surrounding skin with a standard dental impression material. These impressions are then poured in dental stone to produce models. After the initial analysis is complete, there may be a need to preserve the actual skin bearing the mark. A ring of custom tray material can be made to fit like a hoop, closely approximating the skin, which can then be attached to the skin with cyanoacrylate adhesive and stabilized with sutures. When the pathologist completes the autopsy, the bite mark can be excised with the supporting framework in place.

Obtaining information from the suspect(s). When suspects are identified, impressions and other dental data can be obtained by a qualified dental practitioner. There has been extensive debate in legal circles about the risk of potential self-incrimination by defendants in the process of furnishing dental information. Most jurisdictions, however, have allowed the procedures as

Figure 4. Dental models from a suspect in a child abuse/murder case.
similar to procuring fingerprints or facial photographs. Some police agencies obtain a search warrant from the court to permit dental impressions.

In addition to impressions for dental models, intraoral photographs and bite impressions can be secured from any potential suspects or from the victim in the situations where the perpetrator was bitten. In some special situations, dental radiographs, microbiologic cultures or salivary samples are indicated. These data should be procured as soon as possible to prevent alterations.

**Analysis and evaluation.** The standards for the collection of evidence from the victim and suspects have generally evolved into reasonably well-accepted protocols. There is still continuing controversy about the appraisal of bite mark evidence and the efforts to link it with a high degree of certainty to particular individuals. Even if all of the bite information is collected meticulously, the dental examiner’s objectivity and methods are critical to the ultimate outcome. There are several cases in which forensic dental experts have arrived at opposite conclusions regarding the perpetrator of a particular mark. These extreme divergences of judgment can make the reliability of bite mark investigation questionable.

An effort to standardize the analysis of bite marks has resulted in guidelines by the American Board of Forensic Odontology. As mentioned, the fundamental validity of bite mark inquiry has been challenged in court, generally because of the lack of standards and the widely differing results from separate investigators. Although there has been some negative commentary on the principles proposed in the publication, they are a commendable endeavor in the pursuit of scientific order.

The scoring system for evaluating bite mark evidence uses a relatively simple weighted compilation of points based on points of concordance between the mark and the dentition in question. The authors do not specify the confidence levels for making an indisputable match, but rather seek to “improve communication and impart meaning to the loosely used term, matching point.” There was no attempt to indicate levels of confidence where certain scores indicated relative degrees of certainty. Although we can, with some diminished degree of bias, evolve a score for a particular bite mark and dentition, it has no established relevance to the degree of scientific certainty.

**Problems in Bite Mark Analysis**

**Accuracy of the bite imprint.** Although the accuracy of various dental impression materials is definitely established, there is considerable variability in the precision of the representation of marks on human skin or other objects. Not only is skin a poor medium for accurate impressions, but human tissues often contain curves and other irregularities that produce intrinsic distortion. Additionally, any stretching of the skin produces large amounts of distortion in the shape of the tooth marks and the size of the dental arches. Some degree of distortion is found in all bite marks, and inattention to detail or photographic standards can increase this analytical deformation. Some inanimate
objects may initially produce reasonably good representations of tooth marks, but gross distortion can occur relatively rapidly in changing temperature or humidity. The accuracy of tooth marks in skin can depend on the amplitude and direction of the biting forces, sucking action, whether the skin was penetrated and any movements by the assailant or victim during the biting episode. In addition, pre- and postmortem changes such as edema, hemorrhage and lividity can result in radical modifications. Complicating the issue further is the lack of suggestion to the investigator as to the extent and nature of the distortion. Thus bite mark registrations are often assumed accurate, although it is clear that it is rarely, if ever, true. Because of the inherent distortions of bite marks in skin, some investigators have even used human skin as a template to analyze and compare bite marks.

Permanence. Unlike fingerprints, which are reasonably stable over the course of an individual’s life, the dentition is capable of major changes in configuration, with and without professional intervention. Teeth can be lost by extraction, trauma or exfoliation. The size and relationship of the arches can be altered by growth or orthodontic or surgical procedures. Various restorative materials can change the character of the biting surfaces or actual position of the individual teeth. Disease processes such as caries or periodontal disease can change the configuration or position of the teeth.

Uniqueness. The singular nature of an individual dentition is often assumed, but it has not been definitely established. We can argue that because of the endless variations in tooth position, size, shape and other characteristics, each dentition is unique. But there is no study of large populations to establish this argument firmly. There is no conclusive demonstration of the distinctive nature of a single bite pattern. Most forensic odontologists assume that bite patterns are characteristic and original, but this is not scientifically documented.

Many bite marks are incomplete registrations of the involved dentition. The theoretical studies promoting the concept of uniqueness generally include multiple teeth in both arches, which may have little relevance to actual cases in which only small portions of the dentition or only parts of the incisal edges are recorded. Possibly the most notable area of controversy in bite mark analysis is the minimum constitution and composition of a bite mark required for effective evaluation. Studies involving correspondence between 100 bite registrations made in ideal conditions and plastic overlays of the dentitions showed that several bite marks could be superimposed exactly with regard to one or more teeth, but none of the samples could be superimposed precisely unless all of the teeth were represented in the arch. It was concluded that no positive identification could be made unless there were at least four or five teeth marks present.

Each bite mark circumstance has been generally treated as an individual entity. Although there have been published inquiries involving more than one bite mark, and descriptions of the distributions of bite marks in certain populations, there is no central repository or inventory of bite marks and patterns, unlike fingerprints and ballistic information.

Analysis and comparison. In spite of a reasonably well-established approach to the acquisition of bite mark evidence, there is continuing dispute about the methods and emphasis of analytical procedures. Although the ABFO recommends a scoring system, it clearly states that “it is not the intent of these guidelines to mandate specific methods of analysis.” As a result, many methods of comparing bite marks in skin with dental models have been proposed.

Most commonly, the forensic investigator compares life-size (1:1) representations (photographs or tracings) of the bite mark on skin and models of a suspect’s dentition. This has been accomplished by a variety of means, from plastic overlays to imprints in wax or Styrofoam to templates of human skin. One author recommends using...
a photocopy machine to produce 1:1 paper reproductions of dental models to facilitate the tracing of tooth edges onto clear overlays.43 In even the most careful process, each stage introduces errors. There is considerable interpolation and extrapolation required to take these inherent errors into account.

The few controlled studies of the accuracy of comparisons by bite mark examiners reported a fairly high rate of inaccuracy. In one 1975 study, experienced examiners could match bites in wax to the corresponding dentitions with a high degree of accuracy (99 percent), but 24 percent of the time, they were unable to correctly match bite marks in skin (porcine) with the appropriate dentitions.44 It was further suggested that the accuracy rate could fall to as low as 9 to 20 percent if impressions were not taken or photographs were substandard.

There has been considerable interest in scanning electron microscopy, computerized image enhancement and other similar “high-tech” procedures to analyze bite marks.45,46 Some advocate transillumination of the excised skin with a radiographic “hot light” to illustrate subcutaneous hemorrhages not otherwise visible.47 Although these techniques enhance the apparent detail and visualization of marks in skin, we do not understand whether these augmentations represent artifacts or improvements.

Bite mark analysis is generally limited to comparisons of one or two sets of dental models with representations of the mark. There is rarely, if ever, any attempt to try to match the bite mark with a large number of dental models. As a result, it is impossible to determine if anyone else could likely have made the bite. In spite of the general lack of comparisons in a broader population, there are instances of bites in which two sets of teeth have matched identically with bite marks. In 1976, Sopher indicated that in one case, two suspects were “quite consistent” with the bite mark found on the deceased.48 In the 1976 Milone murder trial, the defendant was convicted of a murder, largely on the basis of bite mark testimony. Later, another individual was found to have a dentition that exactly matched the bite mark. He subsequently confessed to the murder.49 Although bite mark evidence usually connects perpetrators with victims, there are instances where such data have been instrumental in the acquittal of defendants. In one case, a man was acquitted, primarily on the basis of bite mark testimony, of a murder charge for which he had already served seven years in prison.50

A rational approach to bite mark evidence. These problems and limitations associated with bite marks do not necessarily relegate the whole field to question and subjectivity. But if bite marks, particularly those involving human skin, are approached in a rational, systematic way with full understanding of the innate limitations, they can be worthwhile forensic evidence.

Any mark suggesting a bite injury should have a preliminary evaluation and data collection including standardized photographs, drawings, qualitative description and

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**TABLE 2**

**SYNOPSIS OF ABFO BITE MARK SCORING SHEET.**

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>NO. OF POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross</td>
<td></td>
</tr>
<tr>
<td>All teeth present</td>
<td>One/arc</td>
</tr>
<tr>
<td>Size of arch consistent</td>
<td>One/arc</td>
</tr>
<tr>
<td>Shape of arch consistent</td>
<td>One/arc</td>
</tr>
<tr>
<td>Tooth position</td>
<td></td>
</tr>
<tr>
<td>Same labiolingual position</td>
<td>One/tooth</td>
</tr>
<tr>
<td>Same rotational position</td>
<td>One/tooth</td>
</tr>
<tr>
<td>Vertical position</td>
<td>One/tooth</td>
</tr>
<tr>
<td>Spacing</td>
<td>One/spine</td>
</tr>
<tr>
<td>Intradental features</td>
<td></td>
</tr>
<tr>
<td>Mesiodistal width</td>
<td>One/tooth</td>
</tr>
<tr>
<td>Labiolingual width</td>
<td>Three/tooth</td>
</tr>
<tr>
<td>Incisal edge curvature</td>
<td>Three/tooth</td>
</tr>
<tr>
<td>Other distinctive features</td>
<td>Three/tooth</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Edentulous arch</td>
<td>Three</td>
</tr>
</tbody>
</table>
salivary swabbing. This should be part of the regular protocol of the medical examiner or pathologist when preparing for a postmortem examination. At this time, the pathologist and forensic odontologist can decide whether to proceed with a more complete workup. Certain elements, if present, make a particular bite mark case more amenable to extensive investigation and deduction. The preliminary analysis should allow a staged appraisal, ending when it is clear that the evidence does not warrant further investigation. There is considerable jeopardy in pursuing inadequate bite marks too far.

The bite mark's location is of prime importance because of the distortions and deformations that can occur on curved surfaces. The nature and volume of distortion have not been quantified, so that the analyst cannot accurately interpolate the dimensions. The preliminary inquiry should indicate an estimated degree of distortion in a particular bite mark. Suspected extreme deformation precludes more extensive analysis.

Photographs and other recordings of the bite mark should be produced in accordance with the ABFO guidelines and special techniques considered. The goal should be producing accurate illustrations that faithfully represent the bite mark. Life-size enlargements should be produced precisely and reliably.

Records from suspects should be taken by a qualified dentist familiar with the techniques of bite mark analysis. These should minimally include dental models and intraoral photographs. The dentist may choose to include models from other individuals with similar demographic variables as controls. It is best to perform this analysis in a blind fashion, with the investigator unaware of the identities.

There is no consensus on the appropriate technical methods for evaluating the bite mark and potentially associated dental composition. Clear plastic overlays produced from the skin mark can be superimposed on the dental models for a preparatory appraisal. It is prudent to produce some sort of bite mark in wax or Styrofoam with the dental models either hand-held or in an articulated setup. These can then be compared with the photographs and drawings. The ABFO scoring system is a credible method of staged evaluation to produce a numerical tally. Although there is no information on the relative value of such a tally, it provides a logical format for moving from general to specific and produces objective estimations of the potential for agreement.

Often techniques such as electron microscopy and various image enhancers are used when there is minimal or clearly distorted information present in the bite mark—situations that may not warrant extraordinary means to produce matches. Unadorned methods can avoid extensive investigation of bite marks with minimal information.

Above all, the investigator should recognize the innate problems in bite mark examination and avoid expanding the analysis beyond rational boundaries. While it is important to extend and improve the methods used, it should be done scientifically and realistically. The forensic odontologist should make the difficulties and imprecision clear to police and other law enforcement agencies and encourage meticulous gathering of evidence. In addition, courtroom testimony should honestly depict the restrictions involved in bite mark analysis and candidly admit the areas where deficiencies exist.

CONCLUSION

Although there are questions about the scientific merit of some aspects of the evaluation process of bite mark evidence, numerous legal precedents allow for the admissibility of such evidence. The conflicts will now occur in the courtroom, with prosecution and defense witnesses arguing the relative merit and reliability of this material.

Likewise, the methods and techniques for gathering evidence in bite mark situations are becoming more established. The ABFO guidelines have gone a long way toward instituting standards for procedures such as photography, impressions and swabbing. There appears to be little question as to the rational precision involved in impression procedures and the production of dental models from suspects.

Forensic dentists need to
approach bite marks with a certain degree of skepticism and continually acknowledge their limitations. Bite marks with only minimal information should not be pursued beyond initial evaluation and evidence gathering. Bite marks with definite details should be evaluated along conventional lines, with allowances made for distortions and errors. When reporting on bite mark evidence, dentists should freely admit the inherent obstacles to accurate analysis and apply the bite mark evidence in a manner consistent with scientific principles. With the slow but rational enhancement of techniques along scientific lines, bite mark evidence can reinforce and expand its sound and logical basis.

The opinions expressed are those of the author and do not necessarily reflect the opinions or policies of the American Dental Association.