

Review Article

Limitations of Bitemarks as a Conclusive Evidence

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ABSTRACT

Bite marks identification can be used for comparison of a known person's dentition to a patterned injury, which appears consistent with Bite marks and Forensic odontologists examine, interpret, analyze, and prepare reports on Bite marks. Bite marks identification is facing lots of challenges nowadays because of many wrongful convictions and The National Academy of Sciences' Committee on Identifying the Needs of the Forensic Science Community 2009 report concluded that "The bottom line is simple: In a number of forensic science disciplines, forensic science professionals have yet to establish either the validity of their approach or the accuracy of their conclusions." Bite marks evidence is under scrutiny because of lack the scientific foundation, assertions on the uniqueness of Bite marks and lack of reliability and accuracy in Bite marks identification methods. Expert testimony based upon false claims lead to many wrongful convictions and courts also permitted the entry of potentially unsafe testimony. There is a failure on behalf of the courts to undertake any gatekeeping functions. This article explains many irregularities and limitations in Bite marks identification and it also explains the role of the court and expert testimony in many wrongful convictions.

KEY WORDS: *Bitemarks, expert testimony, wrongful convictions*

INTRODUCTION

Bitemarks are defined as marks made by teeth alone or in combination with other mouthparts.^[1] Bite marks look like the circular or ovoid area of abrasion, contusion, and occasionally associated with indentations.^[2] Bitemarks are a form of pattern injury, which means that it is caused by a particular object.^[3] Bite marks are mostly involved in crimes like sexual assault, child abuse, violent fights and sometimes recovered from the crime scene of the theft. Bite marks can be found on skin of living or deceased, adult or child, victim or suspect. Bite marks usually found on the skin of the victim but sometimes found on food stuffs like Cheese, chewing gum, chocolates, vegetables.

The identification of Bitemarks is used in an attempt to scientifically link the dentition of the potential biter with Bite marks recovered from crime scene. Before Bite marks analysis, Forensic dentists used human dentition for the identification of persons in mass disasters such as aviation accidents, earthquakes, tsunamis, ethnic studies and in the identification of decomposed and disfigured bodies like drowned persons, fire victims, victims of vehicle accidents. For the identification of this victims dental records were compared to their dentition, which include full mouth X-rays but after that Forensic dentists started identifying the source from the Bite marks left on the skin. The problem with identifying the source from the Bitemarks is that during disasters situation, there is limited number of people to identify and full dentition of the victims is also available as well as dental charts but in Bite Marks

identification cases limited Portion of the dentition available and flesh is far less clear medium than having the teeth.^[4]

First-time Bite marks analysis was used in United States court in the case of State versus Doyle in 1954. Doyle charged with burglary and Bite marks recovered from the piece of cheese at the crime scene. After that, a nondentist examined the Bite marks and concluded that marks made by Doyle dentition and at trial testifying dentist made the same conclusion.^[5] After Doyle case, Bite marks evidence admitted in The California case of people versus Marx (1975) and people versus Milone (1976). Bite marks evidence had a significant impact in the case of serial killer Ted Bundy. A study showed that around 42% of Bite marks cases examined by forensic dentists resulted in court appearance.^[6] In most cases, Bite marks identification and expert testimony admitted in court without examining the assertions of forensic dentists and without testing the reliability and validity of the methodology.

In recent times, some research and review on Bite marks evidence suggests that Bite marks identification is based on baseless assumption such as each human dentition is unique and also questions the reliability and accuracy of methods used in Bite marks identification. Another questionable

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assumption is that Dental details can be accurately transferred and recorded by skin but a study on skin mechanical factors concluded that skin is a poor material to record patterned injuries and is highly variable in its response to trauma.^[7] A committee of The National Academy of Science (NAS) given a report in 2009, which suggests that in number of forensic science disciplines (including Bite Marks) professionals have yet to establish either the validity of their approach or the accuracy of their conclusions.^[8] This review will discuss the limitations of Bite marks evidence and expert testimony of forensic dentists which led to wrongful conviction.

FACTORS AFFECTING TO BITE MARKS EVIDENTIARY VALUE

Bite marks as evidence affected by many factors Such as distortion of skin, degrading of DNA, time interval, movement, overlapping, etc.

The human dentition consists of 32 teeth, each with five anatomical surfaces. Therefore, there are 160 dental surfaces that contain identifying individual characteristics. Also, restoration, decay, malposition, injuries adds more features into individuality but during Bite marks analysis amount of the information recovered from the Bite marks is very less because often only four to eight or less number of teeth found in Bite marks evidence. Furthermore, five anatomical surfaces are not involved in biting, only edges of front teeth registered on skin. According to a study three dimensions models of dentition drawn from two different people from a sample of 500, whose six front teeth are found indistinguishably alike.^[9] The amount of information recovered from a Bite marks evidence is far less in comparison to fingerprints, DNA or any other forensic identification technique.

Bite marks evidence is also affected by the substrate on to which Bite marks pattern is transferred. Bite marks are mostly found skin of victims and sometimes found on food stuff. Skin is a poor material for recording the pattern of teeth. It is far less clear medium to record a human dentition in comparison to modern dental materials. Skin is a highly viscoelastic material that means indentations left by teeth during biting will rebound, so that affects to the recording ability of skin by leaving no potentially record of the three-dimensional structure of the biting edges of teeth.^[10] This is because of elastic fibers in the dermis, distorting under pressure and then recoiling back original position.^[11] This depends on the factors including age and Anatomical location.^[12] Bite marks are essentially bruising because it consists blood from crushed capillaries and bruising affects the precise measurements during Bite marks comparison.^[13] According to the NAS report "The pliability, elasticity, and reactivity of skin and flash these features may severely limit the validity of forensic odontology."^[8] A study conducted in 1971 involved the stamping of two individuals using ink stamp and photographs of stamps on arms taken before and after movement and distortion measured and after marks are analyzed it was discovered that there was an expansion or shrinkage of the inked mark, with a maximum linear expansion of 60% at one location.^[14]

Bite marks distortion on the skin depends upon the position and movement of bitten person or biter at the time of injury.

Biting in violent crimes occurs during struggles when skin is stretched at that time Bite marks is formed but when the skin returns in normal shape, Bite marks transferred on the skin is distorted to unknown extent.^[10] Bite marks distortion is also caused during photography and post mortem because of movement of body into different Positions. The study conducted by De vore on Bite marks distortion concluded that photographic images of Bite marks should be used in comparison only if the exact position of the body replicated.^[14] Research study done by bioengineering unit of the University of Strathclyde upon the appearance of Bite marks on human skin described about the differing characteristics of skin form a variety of anatomical locations such as Langer's line. Langer's lines or tension lines are linear clefts in the skin that indicate the direction of orientation of the underlying collagen fibers. Tension lines across the body alter with the movements and changes in body position. Hence, study described that skin tends to much stiffer along these lines rather than across them and bites crossing that lines are more prone to distortion. Study also described about distortion occurring during the biting process and the oedematous response of the skin to trauma is likely to stiffen the area but subsequent resorption of this will cause more distortion.^[7]

Bite marks evidence consists of valuable biological evidence which is DNA. Source for the DNA in Bite marks evidence is leftover oral epithelial cells. However, it is possible that the presence of nucleic acid degrades enzymes within saliva can quickly degrade DNA in living victims as the skin's temperature Speed up the process.^[15] DNA is also affected by environmental assaults. Bite marks evidence is also affected by photographic distortion. If the Bite marks are not recorded with the American Board of Forensic Odontology (ABFO) scale at 90° then the photographic distortion is possible.^[11] A study involved the review of 119 cases described that 101 case recorded in the colored photograph and only 51 (around 50%) out of 102 cases had an ABFO scale included in photographs. In some conditions, skin can Mimic Bite marks such as pityriasis rosea.^[16] Sometimes It is difficult to distinguish the pattern of Bite marks from animal or insect predation. Bite marks overlapping each other could be problematic during comparison. Factors such as intervening of clothing, force of the bite, movements of victim can affect the appearance of Bite marks.

Bite marks shape and clarity changes in a relatively short time in living and dead. Time interval for examining and recovery of evidence could cause distortion because of contraction and healing artifacts in case of laceration and abrasion injury and that affects the dimensions and appearance of Bite marks. It is possible injuries contract 50% or more in the absence of treatment.^[17] A study conducted on pig skin using human dentition to demonstrate the validity of Matching marks. In the first study, the percentage of incorrect identifications is 24% under Ideal laboratory conditions but after 24 h the percentage of Incorrect identifications is 91%.^[18] After death skin and flesh changes with time because of decomposition, animal predation, insect activity, other environmental factors. Because of the inevitability of distortions comparison of Bite marks on skins with dentition is very questionable.

INCONSISTENCIES IN METHODS OF ANALYSIS AND IDENTIFICATION

Bite marks identification methods include direct or indirect comparison. In direct comparison dental model from the suspect can be directly placed over the photographs of Bite marks to demonstrate concordant points and in Indirect comparison involves transparent overlay which is then placed over the scaled 1:1 photographs of Bite marks for comparison. Other methods such as odontometric triangle method and image perception software also used for the Analysis of Bitemark.^[19]

One of the fundamental problems in Bite marks analysis is the wide variety of techniques and techniques using complex computer systems, special light sources, reflex and scanning electron microscope and overlay have all been described. Recent survey on 72 odontologists found that 90% of them used some form of overlay method for pattern analysis but problem arise when the survey described 30% of the overlay used in the analysis are not computer generated and even 10% of them are hand-drawn. It is worrying because study clearly demonstrated that the superiority of computer-generated overlay over all other methods.^[20]

The guidelines of the ABFO for the analysis of Bite marks include a large number of methods for Bite marks analysis such as transillumination of tissue, computer enhancement, stereomicroscopy, scanning electron microscopy, video superimposition, and histology. Although there has been some research comparing techniques, finding some to be better than others at simplifying the visualization of Bite marks to dentition similarities and differences,^[21] but the guidelines do not specify criteria under which one method might be preferred over another. The guidelines do not indicate the necessary criteria for using each method to determine whether the Bite mark can be related to a person's dentition and with what degree of probability.

The NAS committee report described when odontologists work with doubtful information, the observer's mind tends to see what the observer expects to see, during the evaluation of specific Bite marks. Usually, in these cases, police agencies provide the suspects for comparison and limited numbers of models from which odontologists need to choose for comparing the evidence. There can be a great deal of pressure on examining experts to match a Bite mark to suspect. There is no science on the reproducibility of the different methods of analysis that lead to conclusions about the probability of a match. These include reproducibility between experts and with the same expert over time. Even when using the guidelines, different experts provide widely differing results and a high percentage of false-positive matches of Bite marks using controlled comparison studies.^[8]

In comparing the images of the questioned and the known, if examiners are left to their own subjective judgment of how similar two images need to be to declare them as a match then inconsistencies will occur when different examiners look at the same evidence.^[22] The methodology used by forensic odontologists in Bite marks identification is entirely subjective

and there are no minimal criteria for declaring match in Bite marks comparison. Absence of precise and objective criteria for declaring matches compromise the reliability of Bite marks Analysis. When computerized complex image analysis used for Bite marks analysis to make the process more objective and tested in the real legal case, a different biter was identified instead of the defendant who is already convicted on the basis of expert testimony.^[23]

In 2001, a study conducted by Iain pretty and David sweet using digital overlays for comparing known and questions Bite marks and evaluation done by board-certified dentists. Study described that "while the overall effectiveness of the overlay has been established, the variation in the individual performance of odontologists is concern." Because the study found that intraexaminer agreement as low as 65% and false-positive responses averaged 15.9% and false-negative responses averaged 25%.^[24]

Apart from experts' errors or subjective methodology, it is possible that Bite marks analysis is affected by other factors such as distortion. It is stated that rotation of incisors in suspect's dentition is unique features, but it can be possible that a five-degree rotation of the incisors can produce resulting the mark of the tooth that has a rotation up to 20° because of distortion.^[25] The difficulty arises when three-dimensional objects are replicated as two-dimensional photographs which can create distortion and color Change.^[2] Study done by sheet and bush found that some measurement errors due to image skin distortion could not be corrected, even when single teeth are imprinted on cadaver.^[26]

Errors in comparison, analysis and interpretation or misleading conclusions cause catastrophic consequences.

RELIABILITY AND ACCURACY OF BITE MARKS

Reliability is extent to which a measuring instrument including human examiners produces the same results again and again, when it measures the same thing repeatedly. Reliability study measures the consensus not the validity or accuracy of the examination. Intraexaminer unreliability means the same examiners giving different conclusions on different times when examining the very same evidence. Interexaminer unreliability means different examiners examining the same evidence and reaching different conclusions about it. The ABFO sponsored and conducted a reliability study of the judgment of experienced board-certified dentists making very basic decisions about Bite marks. The researchers selected 100 suspect Bite marks injuries from actual cases. These were examined by 39 ABFO certified forensic odontologists having experience of 20 years or more than that in Bite marks identification. The study included three questions in the form of a decision tree (basically a flow chart).

1. Is there sufficient evidence in the presented materials to render an opinion on whether the patterned injury is a human bite mark?
2. Is it a human bite mark, not a human bite mark, or suggestive of a human bite mark?
3. Does the bite mark have distinct, identifiable arches and individual tooth marks?

That last question is asking if, once the analyst has find out that the mark is a human bite, the mark contains enough individual characteristics to be of value as evidence.

Even within these basic and limited parameters, this study shows that bite mark analysis fails. The first question “whether the test provided sufficient evidence to determine whether or not the photographed mark was a human bite” it is the most basic question any bite mark analyst needs to answer before performing an analysis. Yet the 39 analysts came to unanimous agreement on just four of the 100 case studies. In only 20 of the 100 was there agreement of 90% or more on this question. By the time, the analysts finished question two “whether the photographed mark is indeed a human bite” there remained only 16 of 100 cases, in which 90% or more of the analysts were still in agreement and there were only 38 cases in which at least 75% were still in agreement. By the time the analysts finished question three, they were significantly divided on nearly all the cases. From the initial 100, there remained just eight case studies, in which at least 90% of the analysts were still in agreement.^[27]

Validity or accuracy related with the question of whether a measuring instrument including the judgments, decisions, and opinions of humans is generally correct answers. Many forensic dentists might all agree on whether or not a suspect's dentition made a Bite mark but it suggests more reliability not validity. They might all be incorrect.

The ABFO conducted several workshops, in which forensic dentists could test their identification skill. Only the 1999 workshop results have been made public. In that test 95 board-certified diplomates of ABFO were eligible to participate in the study and 60 diplomates who requested and were sent the study material, 26 returned the necessary data by the deadline and were included in the data results. All four of the “questioned” bites were made by biters whose identity was known. Three consisted of materials from actual cases (in which the biter's identity was established by independent means) and the fourth Bite mark on the cheese. Each of those marks compared to the lineup of seven bites. In general outcome examiners were in error on nearly half of their responses, more of those being false-positive errors (identifying a nonbiter as being the biter) than false negatives (failing to identify the actual biter).^[10]

Bite marks identification remains always questionable because of Bite marks analysis is based upon two assumptions the first that the human dentition is unique and second that uniqueness of dentition can be accurately transferred and recorded on skin.

A review undertook examining all empirical research based on determining whether all human dentition is unique or not. After reviewing 13 studies concluded that the uniqueness of human dentition was not detected and based on the performed systematic review, the uniqueness of human dentition was not scientifically proven.^[28] A study done by Rawson in 1984 attempted to prove the uniqueness of the anterior segment of human teeth by examining 397 bites and applying statistical probability theory to the results.^[29] The results of this study are

doubtful because the number of reasons, one is that selection of bites samples is based on clarity but without randomization and another is that study's conclusion is based on false assumption that the position of each tooth was independent compare to the position of the other teeth.^[13] The NAS report stated that “no thorough study has been conducted of large populations to establish the uniqueness of Bite marks.”^[8] The second assumption is that the uniqueness of human dentition can be accurately transferred on the skin is unreliable because of distortion, viscoelastic properties of skin, and movement of body.

NAS report published in 2009 finds that many Forensic evidence including Bite marks is introduced in criminal trials without any meaningful scientific validation, determination of error rates, or reliability testing to explain the limits of discipline.^[8]

EXPERTS TESTIMONY AND COURT ADMISSIBILITY

Some types of forensic science expert testimony, particularly some of the pattern matching subfields including Bite marks have in recent years come to be recognized as standing on foundations so weak and making claims so exaggerated without any empirical evidence and any populations study that the jurisdiction for admitting them as evidence in court has been called into serious doubt. Some of those types of forensic testimony had been used for decades without any judicial concerns being raised.

Doyle versus State is the first case in which Bite marks used as evidence in the modern US but it did not examine the scientific basis for the admissibility of the evidence.^[6] The California case of people versus Marx (1975) is one of the landmark cases in which Bite marks used as evidence and in that case testified dentists said that The Marx case was exception to identifying the source from Bite Marks because of Bite marks were highly unusual and well defined and three dimensional. In The Marx case defense challenge the admissibility of expert testimony based on the ground of novelty but the court turned away the appeal by referring to the technique's novelty without referring to the novelty of identification theory being employed. In The Marx case court opined that the experts applied scientifically and professionally established techniques Such as X-rays, models, microscopy, photography. Instead of being an exception, The Marx case becomes the precedent for decisions about the admissibility of Bite marks expert testimony.^[30]

Most cases involving Bite marks expert testimony is admissible in courts because courts do not examine the claims of experts on Bite marks identification and the scientific foundation for those claims. Courts admitted the Bite marks expert testimony by focusing on experts' credentials and citing legal precedent. Courts admitted the Bite marks testimony without any analysis because other courts have previously admitted the testimony. In rare instances, judges raise questions about the trustworthiness of evidence, even after errors in Bite marks identification came to light.

The rules on admissibility of expert testimony in the USA include the Daubert decision, Federal rules of evidence, and

some states prefer Fyre standard. Daubert standard requires published evidence of reliable of forensic procedure and there are limited with regard to Bite marks evidence. Daubert states that proposed scientific testimony should be based on scientific method and comprise of more than subjective belief or unsupported speculation.^[6] A partial application of these standards might give a judge the impression that Bite marks testimony meets the standards but some factors clearly demonstrate the lack of science behind Bite marks testimony. Bite marks testimony fails to meet each of these standards. Expert testimony in most cases of Bite marks evidence based on unsupportable assumptions lacking empirical research and methodology lacks standards and guidelines and it's entirely subjective.

Forensic odontologists support their conclusions of the match with impressive-sounding statistical assumptions, but these statistical assumptions based on a deeply flawed study published in 1984 by Rawson.^[29] The guidelines given by ABFO suggest forensic odontologists to render conclusions expressing near certainty, using words like “high degree of certainty” or “reasonable medical certainty” but these statements depend entirely upon the subjective methodology because there is no scientific criteria exist for reaching each type of conclusion.^[31]

The Bite marks expert testimony has no empirical basis and also failed to meet required admissibility standards so admitting Bite marks testimony could violate the defendant's right to fair trial.

WRONGFUL CONVICTIONS AND THE INNOCENCE PROJECT

The misapplication of forensic science includes misleading testimony, insufficient validation of a method, unreliable or invalid forensic discipline is a primary contributing factor to wrongful convictions and indictments later overturned through DNA testing. Bite mark comparisons pose threat to the fairness of the criminal justice system. The misapplication of forensic science contributed to 45% of wrongful convictions in the United States proven through DNA evidence. A total of 26 forensic dentists were involved in the 31 known wrongful convictions and indictments secured through the use of bite mark comparison evidence. Approximately 81% of those dentists were Diplomates of the ABFO and 90% of the wrongful convictions and indictment cases involved at least one board-certified dentist [Figure 1].

The innocence project is Founded by Barry Scheck and Peter Neufeld. It is a nonprofit legal organization that is committed to exonerating individuals who it claims have been wrongly convicted through the use of DNA testing. The innocence project reviewed cases involving Bite marks found that 26 people wrongfully convicted because of Bite marks evidence. Many wrongful convictions because of Bite marks evidence including Ray Krone, Kennedy Brewer, Ray brown, Willie Jackson exonerated using DNA testing with the help of the innocence project.^[32]

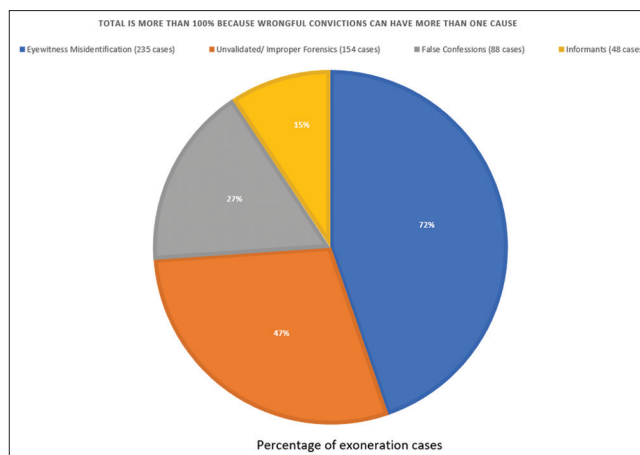


Figure 1: Contributing causes of wrongful convictions (first 325 DNA exonerations)

RAY KRONE

In 1991, the body of the 36-year-old victim was found, in the men's restroom of the Phoenix, Arizona bar where she worked. She had been stabbed, and the perpetrator left behind little physical evidence. Blood and Saliva recovered from the crime scene. Investigators relied on bite marks on the victim's breast and neck. Police collected Krone's tooth marks impression on Styrofoam and on December 31, 1991, Krone was arrested and charged with murder, kidnapping, and sexual assault. At his trial, two experts concluded “definite match” and said that defendant made the bite mark on victim. Krone was sentenced to death and 21 years term of imprisonment. Krone was found not guilty of the sexual assault. In a trial in 1996, Krone was convicted again using Bite marks testimony and judge sentenced him to life in prison, citing doubts about whether or not Krone was the true killer. In 2002 after serving 10 years in prison, DNA testing was conducted on the blood and Saliva samples found on crime scene and exonerated Krone from all charges.

KENNEDY BREWER

In 1992, Christine Jackson, the 3-year-old daughter of Kennedy Brewer's girlfriend was abducted from her home, raped, and murdered. Police suspected Brewer because he had been at home that night. Kennedy Brewer was arrested and accused of killing his girlfriend's daughter. After waiting in jail for 3 years the trial began in March 1995, the medical examiner who conducted the autopsy, Dr. Steven Hayne, testified that he had found several marks on the victim's body that he believed to be bite marks. After that testifying odontologist, Dr. Michael West concluded that 19 marks found on the victim's body were “indeed and without a doubt” inflicted by Brewer. Brewer was convicted of capital murder and sexual battery in 1995 and sentenced to death. In 2001, advanced DNA testing was conducted on semen recovered from the victim's body. The test results excluded Brewer as a possible perpetrator. On February 15, 2008, charges against Kennedy Brewer were dropped and he was exonerated.^[33]

CONCLUSION

Bite marks evidence have significant value in the investigation because of physical and biological evidence recovered from Bite marks but because of errors in recording, identification and less reliability and validity of methods led to many wrongful convictions. Bite marks evidence lacks standards for analysis methods. The NAS report suggests more research into the reliability and validity of methods. Judges should be more willing to correctly examine any forensic evidence before admitting into court. Currently, conviction mainly based on Bite marks evidence could be led to wrongful conviction because the field lacks proper research and standardization but biological evidence recovered from Bite marks could be used as evidence.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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