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The Evidentiary Value of Bite Mark Analysis in Criminal Cases

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Abstract

For decades, the comparison between a bite mark injury and a suspect's teeth was considered evidence linking the suspect to the victim. However, in recent years, many convictions were re-assessed by a legal initiative in the United States called the "Innocence Project". The outcome of this project was the exoneration of many wrongfully convicted inmates. Some of those exonerations were of prisoners who had been convicted based on bite mark evidence.

Consequently, the admissibility and evidentiary value of bite mark evidence came under profound scrutiny. On the other hand, proponents of bite mark evidence advocate the use of bite mark evidence in courts as an evidence of approximation, rather than conclusion.

This paper will discuss the genesis and history of bite mark evidence, as well as the modern analysis of bite marks that is based on metric and non-metric digital assessment. The evidentiary value of bite

marks and the weight they should carry in today's courts will be discussed.

القيمة الاستدلالية لتحليل الإصابات العضية في الحالات الجنائية

المستخلص

اعتبرت المقارنة بين الإصابات الناتجة عن العضات وأسنان المشتبه به على مدى عقود أدلة تربط المتهم بالضحية وقت حدوث الجريمة. إلا أن هذا النوع من الإصابات بات يخضع في السنوات الأخيرة لإعادة تقييم، وذلك بعد التقارير التي أعدتها مبادرة قانونية في الولايات المتحدة تسمى -مشروع البراءة-، والتي كان من نتائجها تبرئة العديد من السجناء الذين كانوا قد أدينوا بجنايات بالاستناد إلى تحليل سيئ للدليل المبني على العضات. ونتيجة لذلك، وضعت القيمة الإثباتية لهذا الدليل تحت البحث والتدقيق.

وبالمقابل، يؤكد خبراء طب الأسنان الجنائي على أهمية هذا الدليل بالمحاكم، إذا تم استخدامه كدليل تقريبي يمهد للمزيد من التحقيقات والاستنتاجات، وتعد سجلات المحاكم في العديد من الدول خير دليل على الفوائد القضائية لدليل العضات.

ستناقش هذه الورقة نشأة وتاريخ الدليل المبني على الإصابات العضية، والتي كثيراً ما تصاحب الجرائم الجنائية، والطرق العلمية الحديثة لتحليل هذه الإصابات، والتي تقوم على التقييم الرقمي المتري وغير المتري. وسوف تناقش كذلك القيمة الاستدلالية الناتجة من العضات، والوزن الذي يجب أن يحمله هذا الدليل في المحاكم اليوم.

الكلمات المفتاحية: تحليل الإصابات العضية، القيمة الاستدلالية، الإدانات الخاطئة

Keywords: Bite mark analysis, Evidentiary value, Wrongful convictions

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1. Introduction

Court hearings represent a dispute between two or more versions of an event which occurred in the past. In almost all criminal cases, courts are faced with questions of a specialized nature. In order to know the answers, both the prosecution and the defense summon experts to present their findings and opinions in specific fields of science. The contribution of science to legal proceedings is unlimited and includes many fields, such as forensic chemistry, forensic biology, tool-mark analysis, etc.

Despite the widespread use of forensic science in courts, the evidentiary weight of many of the forensic science disciplines has never been established. The strength of evidence and its limitations are usually determined by the court based on the wordings used by expert witnesses. The impact the expert witness testimony has on the course of a trial and its verdict often changes based on the meticulousness of the cross-examination [1].

The quality of the scientific evidence presented to courts is not the only problem observed. The absence of an accreditation system for expert witnesses that would precisely determine who qualifies to act as an expert witness means that prosecution and defense can influence the court's decision by inviting experts who have an opinion that is favorable to one side versus the other.

For many years, bite marks have been viewed as injuries that can link the perpetrator to the victim at the time of assault. Historically, bite marks were seen as a key element in solving several notorious cases (see below). However, this evidence has recently been under serious revision after reports of several cases in which bite mark analysis led to wrongful convictions. This review will discuss the pros and cons of bite marks as evidence and how the evidentiary weight of this criminal evidence is witnessing a decline in its value.

2. History of bite mark evidence

Literature shows that bite mark injury was used as evidence in many notorious homicide cases. Perhaps the first historical report in which bite marks were comprehensively employed in a court was the infamous Salem Witch Trial in the United States in 1692. During the course of this trial, the dentition of George Burroughs was compared to teeth marks on the victims' flesh. Interestingly, additional comparisons were made between those bite marks and teeth of other people who were present in the courtroom in order to prove that there was a unique similarity between

Burroughs' dentition and the bite marks on the victims. The judges were convinced, and Burroughs was sentenced to death by hanging. Burroughs was hanged, despite being reportedly in prison at the time the alleged biting occurred [2].

Around 200 years later, in 1870, a person named Ansil Robinson was accused of murdering his mistress. There were five bite marks on her arm, which the examining forensic odontologist compared to Robinson's teeth and found a match. The odontologist described it by saying that it was a "surprisingly good fit". A counter-testimony by the defense questioned the reliability of linking the suspect's teeth with their imprints on human skin. One of the defense expert witnesses questioned the uniqueness of dental imprints by biting the victim with his own teeth, and then asking the suspect (Robinson) to bite the expert's arm. He concluded that Robinson's teeth and the bite marks did not compare at all.

Robinson's wife testified to the court by describing blood on his shirt when he had returned home on the day of the murder. She also described how he washed his blood-stained shirt and later burned it. Despite her testimony, the jury found Robinson not guilty, and he was acquitted after a 3-week trial. The perpetrator was never found [3].

The case of Robinson can be considered the first bite mark case in which deliberations between expert witnesses from both the prosecution and the defense took place. Although the suspect was acquitted, the concept of comparing someone's teeth with a bite mark was formally introduced into the judicial system for the first time in the United States. The same argument over the accuracy of bite mark analysis, which in 1870 led the jury to refute it as conclusive evidence, continues until this day.

Several notorious cases of bite mark evidence were reported in Australia [4], the UK, Scandinavia, and North America [2]. Perhaps the case with the greatest impact was that of a serial killer, Theodore Bundy. Bundy was convicted in 1979 of at least 36 murders, one of which involved two bite marks. The examining forensic odontologist saw a distinctive pattern in both and concluded that the biter had poorly-aligned teeth. His finding was sufficient to issue a search warrant based on the element of probable cause, which resulted in arresting Bundy and subjecting him to a dental examination. The final conclusion was that the distinctive pattern (the poorly-aligned teeth) was similar to the suspect's dentition and the bite mark injury.

Although bite mark evidence was admitted to US courts



in previous cases (Doyle v. State in 1954, and People v. Milone in 1976), the Bundy case had a significant impact by being a landmark evidence which brought a dangerous serial killer to justice [2].

3. The judicial value of bite mark evidence

Bite mark injury is a pattern injury which typically consists of two opposing arches and a central area of ecchymosis. If an examiner observes a pattern with some form of distinctiveness in the bite mark injury, and the same pattern is seen in the suspect's dentition, then approximation between the two is possible, taking into consideration the known limitations associated with this approximation. As a general rule, searching for inconsistencies (i.e., excluding potential suspects) is a safer and a stronger application of bite mark analysis than searching for consistency (i.e. linking potential suspects to bite marks).

In addition to the physical comparison between patterns, bite marks provide a valuable biological evidence represented by DNA. The perpetrator's leftover oral epithelial cells are considered to be a rich source of DNA. Accordingly, it is imperative for all bite mark cases to undergo two lines of investigations: a physical one and a biological one.

Even when a bite mark injury does not lead to meaningful conclusions about who caused it, or who could not have caused it, interpreting this form of injury is important for the following reasons: Firstly, among all traumatic injuries, the bite mark is the only one which cannot be accidental and always indicates an act of violence. Secondly, crude behavioral criminalistics profiling is often attempted when a bite mark injury is found on a victim, which is based on epidemiological studies. For example, sex differences have been seen in relation to bite mark injuries. Pretty and Sweet found that female victims of violence manifest bite marks four times more commonly as males [5], and Freeman et al found that males are more often bitten on the arms, while female victims were more often bitten on the breasts [6]. Diversity in anatomical location was also observed by Vale and Noguchi, who found that females suffered bite marks on the breasts, arms and legs, while males suffered bite marks on the arms and shoulders [7].

Behavioral profiling of the perpetrator that is based on his/her biting behavior has been suggested. Walter

examined various possible personality characteristics of the biter and found that bite marks can be a manifestation of an anger attack, sadism or cannibalism [8].

4. Methods of bite mark analysis

The basic method in bite mark analysis is not dissimilar from that used in tool mark analysis, in which two images are overlaid and concordance is assessed. In bite mark analysis, one of those images is a bite mark and the other represents the cutting surfaces of the suspect's teeth. The process of generating both images must be as accurate as possible, and there are guidelines to help examiners perform this analysis [9].

For the comparison to take place, both images need to be of the same dimensional configuration (i.e. 2-D or 3-D format). The transformation of a 3-D object (the bite mark) into a 2-D image results in compromising the third dimension (i.e., the depth). This causes distortion of the bite mark image, which is known as perspective distortion. This distortion must be corrected digitally, as described by Johansen and Bowers [9].

Despite this correction, perspective distortion has always been a limitation to the accuracy of bite mark analysis. To overcome this limitation, attempts were made to compare suspect's dentition and bite mark injuries in their original 3-D configuration. There are two ways to do this. The first method is to simply take an impression of the bite mark injury using a suitable dental impression material and then to pour the impression into a cast. The second method is to laser-scan the bite mark and transfer it into a 3-D digital image. In one study, more than 90% of comparisons were accurately attributed to the true biter when comparison was based on a laser-generated 3-D image [10]. In order for those two methods to work, indentations should be present in the bite mark; therefore, not all bite marks can be assessed using this method.

Several methods have been used to record the suspect's dentition. Traditionally, transferring the suspect's model (a 3-D object) into its 2-D image was performed by hand-tracing the cutting edges of teeth directly from the suspect's cast or the suspect's bite replica on wax. Other methods include xerographic imagery, radio-opaque wax impression method, and computer-based method, which



utilizes the multi-layer functions of Adobe® Photoshop®. Sweet and Bowers assessed the reproduction accuracy of those methods and found the computer-based method to be the most accurate [11].

Swabs for DNA retrieval and analysis must be performed in all bite mark injuries. In 1997, Sweet et al. found that swabbing the bite mark injury twice, first with a wet cotton swab and then with a dry cotton swab for collection, yields a greater number of epithelial cells, and hence greater DNA quantity, by comparison to other methods [12].

5. Accuracy of bite mark analysis

The accuracy of conclusions based on bite mark evidence depends on whether the unique pattern of the anterior human dentition has been accurately transferred onto the victim's skin and retained there until the time of examination.

Few studies have shown a uniqueness of the human dentition between different individuals, even if they were identical twins [13-15]. However, other studies found this uniqueness not to be an absolute one [16].

Despite the considerable attention that is given to the process of replicating the suspect's dentition, there is always the legitimate concern over the accuracy of assessing the dentition's imprint on the skin. The dynamic nature of the biting, the flexibility of the skin and the human body's anatomical curvatures result in poor replication of the perpetrator's dentition onto the skin.

Bush et al investigated the ability of the skin to accurately record the dentition's measurement. They found poor replication of the suspect's teeth in the bite mark [17]. Miller et al. found difficulty in discriminating individuals based on their bites on cadaver's skin [18]. Sheet and Bush found that some measurement errors due to image skin distortion could not be corrected, even when a single set of teeth is imprinted on cadaver's skin [19]. Blackwell et al performed laser scanning of dental casts and their corresponding bites on wax sheets in order to document their finest details and to generate a distortion-free 3-D configuration of both comparable objects. They found that a bite mark could be attributed to a wrong cast in 15% of cases [20].

Despite putting considerable efforts into accurately lifting off measurements from the suspect's dentition and

the bite marks, skepticism remains regarding the overall strength of conclusions based on bite mark analysis.

6. The Innocence Project

In 1992, Barry Scheck and Peter Neufeld founded the Innocence Project as an internal project belonging to the Cardozo School of Law of Yeshiva University in New York City. The project's mandate was to review cases of possible wrongful convictions and to apply DNA technology (if DNA material was available for testing or retesting), in order to exonerate those who are proven to have been wrongfully convicted.

Until the time of writing this article, 336 wrongfully convicted persons have been exonerated based on DNA evidence [21]. The majority of wrongful convictions were caused by eyewitness misidentifications (72%) followed by unvalidated/improper forensic evidences (47%). Figure-1 shows the different fields of forensic science in which unvalidated/improper forensic evidence led to wrongful convictions. Among those, bite mark analysis represented 2.3%. This was less than serology, hair analysis, and DNA analysis [21].

Although the majority of improper science-based exoneration cases were related to serology and hair analysis, the evidentiary value of bite marks was called into question. Several innocent persons were imprisoned for many years based on bad bite mark analysis. Garrett and Neufeld reviewed cases involving invalid forensic evidences, which included cases of bite mark testimonies that led to wrongful convictions [22]. Table-1 lists seven of those cases, in which defendants were wrongfully

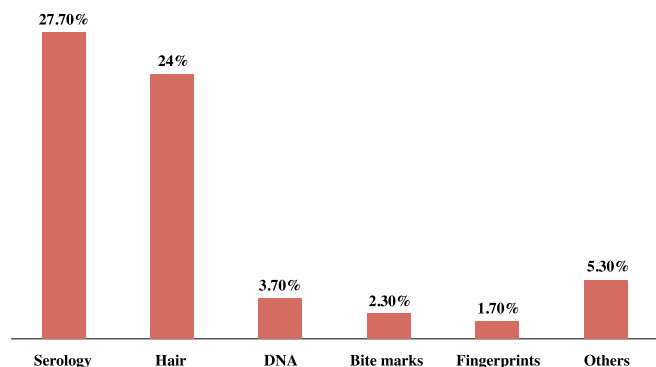


Figure 1 - Categories of unvalidated/improper forensic evidences that were associated with wrongful convictions. (Adopted from *The Innocence Project, report on cause of wrongful conviction*) [21].



Table 1- Cases of wrongful convictions based on bite mark testimonies

Name of the convict	Years spent in prison	The forensic odontologist's testimonies during trial
Kennedy Brewer [23]	7	An analyst used the term "reasonable medical certainty" that Brewer's top two teeth caused the bite marks found on the victim. When asked about what is meant by this statement, the odontologist said that Brewer was the person who "did" inflict the bite marks.
Roy Brown [22]	15	An analyst testified that the bite marks on the victim's body showed "a reasonable degree of dental certainty", and that the inconsistencies were explainable. The odontology testimony was not the only mishap in Brown's trial. The prosecution failed to disclose a testimony from another odontologist who excluded Brown from causing the bite mark.
Willie Jackson [23]	17	An analyst said: "My conclusion is that Mr. Jackson is the person who bit this lady."
Ray Krone [22]	10	Two odontologists testified in this case. One said there was an "excellent match" and that "the tooth caused that injury". While the other odontologist said that "there's a definite match". Similar to Brown's case, the police concealed the fact that they had an earlier testimony from the FBI's forensic odontologist who was definite in ruling out Krone as the biter.
James O'Donnell [23]	2	An analyst stated that O'Donnell's teeth were "consistent" with bite marks found on the victim.
Calvine Washington [23]	13	An analyst testified that a bite mark found on the victim was "consistent" with Washington's co-defendant, which led to linking Washington to the crime scene.
Levon Brooks [24]	16	The forensic odontologist examined the dentition of 12 suspects, and said that two of Brooks' teeth "matched" the marks on victim's body, excluding all other suspects. Interestingly, subsequent DNA testing, which exonerated Brooks, matched one of the 12 suspects whom the odontologist had excluded as the biter.

convicted based on poor bite mark testimonies and were later exonerated using DNA evidence.

A quick review of the wordings used by forensic odontologists in their testimonies clearly shows conclusive statements, such as 'definite match', 'excellent match', 'reasonable certainty', etc. The strength of some of those terms is inappropriate given the limitations of the bite mark evidence. Moreover, in the cases of Roy Brown and Ray Krone [22], the prosecution deliberately concealed earlier odontology opinions which were not in the prosecution's favour. The misconduct in justice was not, therefore,

entirely attributed to testimonies given by odontologists. The disagreement between two or more odontologists over the same bite mark injury is in itself a serious concern which undermines the validity of the evidence. But should this disagreement have been revealed in the Brown and Krone cases, the jury might have dismissed, or at least undervalued, the bite mark testimonies which were relied upon in the verdict.

The bite mark exoneration cases reveal the need for urgent corrective actions in the field of forensic odontology. Those should include subjecting odontologists to robust



accreditation standards that would qualify them to act as expert witnesses in courts. Short-term training programs in forensic odontology, which happen to be common in certain countries, should be discontinued and replaced with academically recognized programs which would lead to a formal qualification in this field.

7. Conclusion

Bite mark injuries have an important value in criminal investigations by retaining physical and biological evidences that can be traced back to the perpetrator. Recent reports of wrongful convictions have raised serious skepticism over the accuracy of several forensic evidences, including bite mark analysis.

Analysis of bite marks should be performed by professionally competent forensic odontologists who are highly qualified and trained, not only on the technical aspects, but also on the proper use of terms in the legal context. Comparison between a bite mark pattern with a suspect's dentition should only be used when highly visible distinctive features are observed in both images, such as grossly mal-aligned teeth. Even when such an approximation is observed, the terms used to describe it should be conservative. The limitations of bite mark analysis must clearly and fully be disclosed to courts at all times.

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