REVIEW

Bite Mark Analysis- A Crucial Forensic Evidence

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Abstract

Background: Bite mark analysis has a critical role in forensic cases. Bite marks have been recorded has played an important role in the criminal justice system.

Aims: Based on the fact that no two mouths are alike, this review article draws a perfect association between dentistry and law. The present review describes the history of bite mark analysis along with its classification, characteristics, mechanism of production, collection of evidence from both the suspect and the victim, comparison techniques and technical aids.

Materials and Methods: Data was collected and analyzed from the literature already published in books and electronic database searches of PubMed and Google Scholar.

Results: Forensic odontologists should be familiar with all methods of bitemark comparisons and appropriately use those methods that are indicated for the case at hand.

Conclusion: Bite mark being a valuable alternative to fingerprinting and DNA identification, the analysis of bite mark evidence does have place in the courtroom aiding the legal system in answering crucial questions about potential suspects and victims.

Keywords: Bite mark analysis, Classification, Collection of evidence, Forensic dentistry, Methods of comparisons.

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Introduction

The field of forensic dentistry or the more professional term, forensic odontology, is the application of dentistry to the law. The science of Forensic odontology involves the correct collection, management, interpretation, evaluation, and presentation of dental evidence for criminal or civil legal proceedings: a combination of various aspects of the dental, scientific, and legal professions. These include human identification, dental identification, age estimation, sex determination, cheiloscopy and palatoscopy, molecular biomarkers, bite mark analysis, identifying human abuse and neglect, dental malpractice and negligence, and dental anthropology and archaeology. The overall field of criminalistics ranging from the identification of persons using dental records to the identification and analysis of bitemarks on an object such as a food item, or a bitemark on a victim compared to a suspect, or on a suspect compared to a victim, to the estimation of a person's age based upon dental development leading to identification of the criminal.

The "sui generis" characteristics of human morphology is the human dentition withstanding the test of time and temperature. Thus, is considered as hard tissue analog to the fingerprint making it almost as distinctive to an individual as a fingerprint and DNA[1].

A bitemark is a patterned injury in skin or a pattern in an object caused by the biting surfaces of human or animal teeth.

The American Board of Forensic Odontology year manual (2013) defines a bitemark as

☐ a physical alteration in a medium caused by the contact of teeth

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☐ a representative pattern left in an object or tissue by the dental structures of an animal or human[2].

Hence, a bite mark is a blotch created by teeth either alone or in combination with the other oral structures. Bite mark analysis is built on the fundamental essence that "no two mouths are alike"[3].

Bite marks (Figure 1) may be found virtually on any part of the human body, common sites being the face, neck, arm, hand, finger, shoulder, nose, ear, breast, legs, buttocks, waist, and female genitals[4]. In cases of sexual assault, face, lips, breasts, shoulder, neck, thigh, genitals and testicles are mostly involved[5,6]. Bite mark imprint can be left on skin, chewing gum, bottle caps, pencils, pens, musical instruments, cigarettes, cigar, food material like cheese, fruit, potato, and chocolate etc.[7,8,9].

Review of Literature

The Garden of Eden

According to the Old Testament Book of Genesis, the evolution of forensic odontology started right back in the Garden of Eden where Adam put a bite mark on an apple in the Garden of Eden. But there was rarely any provision to record the events, compare or analyze the case[10].

The Kama Sutra, 2nd century CE

The ancient Sanskrit enumerates numerous types of bites and their roles in lovemaking and beyond in second century CE. Although certainly not forensic in nature, these descriptions can be considered the earliest known classification system for bitemarks. The types of bites listed are the hidden bite, the swollen bite, the point, the line of points, the coral and the jewel, the line of jewels, the broken cloud and the biting of a boar.[11]

William, the Conqueror, 11th century

It has been previously reported that William, the Norman conqueror of Britain who would seal official documents by biting his teeth into the wax seals affixed.[12]

Mayhem and the Ancient Law of England, 17th century

In the seventeenth century in England, according to the Lawes of England, the loss of the teeth at the hands of another was considered to be the crime of mayhem, depriving one of "a member proper for his defense in fight" and on that account it was punishable by death[13]. This interesting ancient law clearly illustrates a fact otherwise not widely known that people often bite other people, especially during violent interaction.

Indentured Servitude, 17th century

There was a well-established concept of indentured servants for the debtors and others desiring entry to the New World, where agreements were made with entrepreneurs to finance their passage, by biting into the document seals in lieu of or in addition to signatures for the borrowed money or joining the service[14]. An alternate explanation of the term refers to the practice of drawing up the agreement in duplicate, then cutting or tearing between them in a zigzag manner so that the two halves of the document could be fitted together to assure authenticity[15].

Ohio v. Robinson, United States, 1870

This case was a special one in itself for being the first one in North America that included the testimony of a dentist in a bitemark

Fig. 1: Bite mark on human body

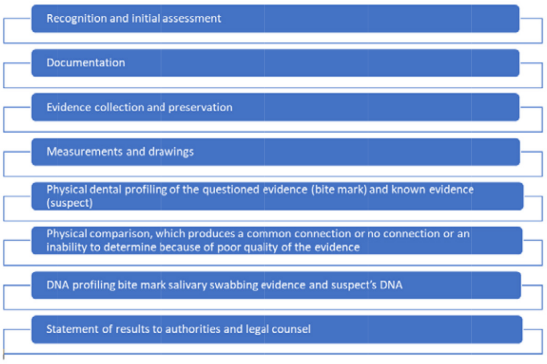

Fig. 2: Flow-chart for diagnosis of a bite mark case

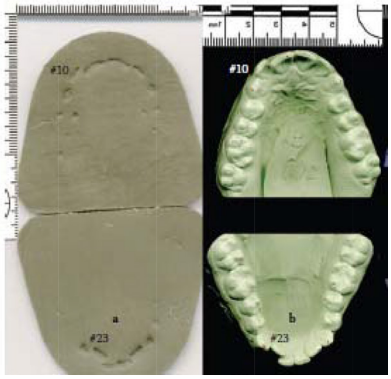

Fig. 3: Static test bites in Aluwax (a). The suspect's dental models(b)

Fig. 4: Dental models seen through a mirror- concept of sidedness

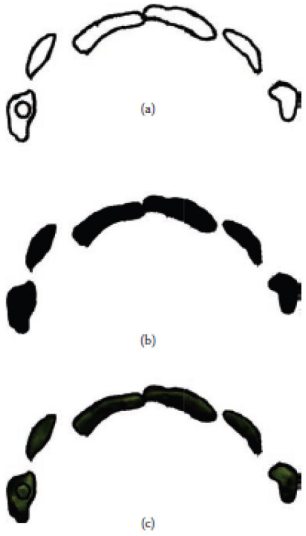

Fig. 5: Hollow volume overlay (a), filled volume overlay (b), and compound overlay (c).

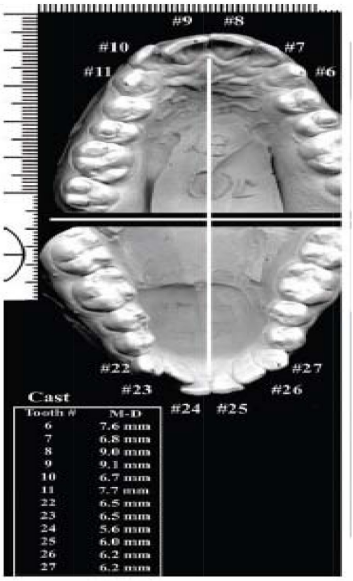

Fig. 6: The metric information for the anterior teeth from dental models

case. Records of the trial are sparse and most of the information about it comes from newspaper accounts[16]. Ansil L. Robinson was charged with the murder of his mistress, Mary Lunsford. Prosecutors introduced evidence that alleged Robinson had left bitemarks on the victim's arms. For the defense, a physician testified and described his unusual examination technique. The article reports that he later asked Robinson to bite his own arm, in order to compare the mark with those on the body of Lunsford. Three other physicians testified for the defense. The jury deliberated for 6 hours and found Robinson not guilty. The procedures used, testimony given, and legal points cited are all remarkably similar to those of many cases that followed[17].

Doyle v. State, Texas, 1954

The first time a type of dental evidence was used in court in the United States was the Doyle v. State case in Texas in 1954[18]. Doyle, in the process of committing a burglary, allegedly left the imprint of his dentition in a partially eaten piece of cheese. The analysis of the evidence was made by Dr. William J. Kemp, a dentist and longtime dental examiner for the State of Texas, by having the suspect bite into another piece of cheese for the comparison and testified that the bites in both pieces of cheese matched[19].

Forensic odontology is still a nascent field in India. With a significant history of forensic science, it is proving to be extremely valuable in criminal and civil cases. The application of science and technology for detection and investigation of crime and administration of justice is new to us.

Nirbhaya case: Delhi gang rape, 2013

On December 16, 2012 in Delhi, India, Nirbhaya, a 23-year-old female was the victim of multiple rape when she was a passenger on a private bus. Due to the severe injuries which she received in the brutal assault, she later died on December 29, 2012. The suspects were traced within 24 h. Six men were found guilty including a juvenile. The numerous bite marks on the victim's corpse were compared with the dental models of the accused. Dr. Ashit B. Acharya analyzed the bite marks with the aid of computer software and postulated that two of the bite marks were identical with two suspects. The submitted evidence was approved by the court and a verdict was placed where the juvenile was sentenced to 3 years imprisonment, one of the accused committed suicide and remaining four adults faced the death penalty[20].

In 2014, life imprisonment was served to a 34-year-old rapist-murderer, who had left bite marks on his 14-year-old victim's body[21].

In May 2015, Dr Hemalata Pandey has helped the Mumbai city police secure conviction for a rapist by matching bite marks found on a 28-year-old woman from Powai. After the incident, the victim was not able to recollect the episode and with no other evidence available, the police had to rely on the forensic expert. The victim was taken to BYL Nair Hospital's forensic department, where the expert successfully managed to get the impression of the accused's teeth and match it[22].

Numerous cases like The Paper Mill Colony Case: 2012, The Perumbavoor case: 2016 and many more had been recorded and are still under trail for the verdict.

Classification

There are seven types of bite marks (table 1)[23]:

These further can be classified into four degrees of impressions:

- 'Clearly defined' resulting from the application of significant pressure,
- 'Obviously defined' which is the effect of first-degree pressure,
- 'Quite noticeable' due to violent pressure,
- 'Lacerated' when the skin is violently torn from the body[24].

Characteristics

Class characteristics

According to the Manual of American Board of Forensic Odontology (ABFO)[25], a class characteristic is a feature, characteristic, or pattern that distinguishes a bite mark from other patterned injuries. It helps to identify the group from which the bite mark originates.

The 'tooth class characteristics' and the 'bite mark characteristics' are the two types of class characteristics[26].

The tooth class characteristics differentiate one tooth type from the others[27], whereas the bite mark characteristics help in determining if the marks were from maxillary teeth or the mandibular teeth[28].

The class characteristics associated with human bite marks are:

☐ A circular or ovoid-shaped injury comprising two opposing arches with each arch featuring patterns of smaller injuries representing individual teeth.

☐ Arches should be of an appropriate size.

☐ A central contusion (or bruise) may be present alongside a linear contusion or abrasion that is associated with the teeth dragged across the surface, details of the palatal surfaces of upper incisor teeth and the embrasures between the teeth.

☐ Multiple injuries may be present at different sites, and sometimes may be seen in the same site overlapping or superimposed on each other[29].

Individual characteristics

Individual characteristics are deviations from the standard class characteristics specific features found within the class characteristics which can be a feature, a trait or a pattern representing an individual variation rather than an expected finding[25].

They may include:

☐ The approximate sizes of the arches in the injury.

☐ The pattern resulting from the specific arrangement of teeth like gaps in an arch due to missing teeth or diastema, over-erupted or misplaced teeth, chips, notches, or surface features. Any other specific attribute of a dentition in an assailant's dental arches.

☐ Scrape marks across a tissue surface.

☐ The pattern produced by the bite favoring one or other side of the dentition indicative of the position of the biter and victim, or a habitual biting pattern[29].

Mechanism of Bite Marks

Three predominant mechanisms associated with production of bite marks are:

i. Tooth pressure marks- caused by direct pressure application by incisal edges of anterior teeth/occlusal edges of posterior teeth[30].
ii. Tongue pressure marks- caused when the material taken into mouth is pressed by tongue against teeth/ palatal rugae.
iii. Tooth scrape marks- caused by teeth scraping against tooth surface commonly involving the anterior teeth[25].

Collection of Evidence in Bite Mark Analysis

The flow of a bite mark case involves (figure 2)[31]

Collection of bitemark evidence from the bite victim

1. Documentation: A written record of the injury that clearly document the injury's location, appearance, colour, size and orienta-

tion[32]

2. Photograph: The most important kind of evidence from the bite victim is photography, including shots:

- ☐ With and without the ABFO No. 2 scale;
- ☐ In colour and black and white;
- ☐ On and off camera flash
- ☐ An overall body shot showing the location of the injury;
- ☐ Close-ups that can easily be scaled 1:1;
- ☐ UV photography;
- ☐ Several body positions should be adopted in order to assess the effect of movement, if the bite is on a moveable anatomical location.

Photographs should be taken with the camera at 90° (perpendicular) to the injury. It has been recommended that bitemarks are photographed at regular 24-hour intervals on both the deceased and living victim as their appearance can improve[33].

3. Salivary swab: deposition of saliva during the biting process is inevitable. A double-swab technique is recommended for its recovery[34]. The procedure is worthwhile even if the skin has been washed, first a cotton wool swab is moistened with distilled water and rubbed on the bitten surface using light, circular motions followed by a second, dry swab to collect the remaining moisture which are then allowed to dry at room temperature. A control swab should be taken from the victim. The stored swabs are handed over to the police as soon as possible[35].

4. Impression of the bite injury: permits the registration of any irregularities produced by the teeth such as cuts and abrasions on the bitten surface. Vinyl polysiloxane impression materials are most suited to this. These impressions can be subsequently casted in plaster providing an enduring record of the injury. The collection of evidence must take place with the victim's consent[36].

Evidence collection from the bite suspect:

The collection of dental evidence is supposed to be an invasive procedure, where suspects are usually uncooperative during the collection of physical exhibits[37].

1. History and Dental Records: obtained from the suspect's dentist, dental records are tremendously useful and play a very imperative role in establishing the identity of the suspect[38].

2. Photographs: photography of the suspect is vital and both intraoral and extraoral photographs should be taken. The extraoral photographs include both profile and full-face photographs. The intraoral photographs should include the frontal, lateral, and occlusal views of both arches. Photographs of the maximum interincisal opening with and without a scale in place should also be taken.

3. Impressions and Study Casts: impression taking and fabricating study casts of the dentition of the suspect are a very vital part of the examination of bite marks.

4. Test Bites: Test bites are very useful for investigating the position, shape, and alignment of the incisal edges of the biter's teeth. Materials of choice include baseplate wax, aluwax, and coprwax, silicone etc.

5. DNA Samples: a non-invasive procedure for extraction of DNA is saliva whereas the invasive procedure uses the suspect's whole blood. These samples collected from the suspect can then be used for comparison with any biological evidence at the crime scene[38].

Methods of Comparison

The preceding sections have described the impact of a variety of factors upon the forensic significance of bitemarks. Analysis of a bitemark should only be done if exhibits at least one class characteristics.

1. Test Bites: the goal is to visualize the pattern produced by the biting edges of teeth in a position that simulates the bitemark injury by the use of various materials like static test bites, aluwax, styrofoam, dental impression materials, identical substances pieces of cheese, soft cake, chocolate, chewing gum, a sandwich, soap, animal skin, human cadaver skin, dynamic test bites on a volunteer (figure 3)[39].

2. Direct Comparison: it may be possible to actually have the dental stone models of the suspected biters at the time a bitemark injury is examined (Figure 3). This additional examination is supplemental to the other testing done or to be done in the case. Investigators must use extreme caution when using this direct comparison technique because ideally, a biter's dental casts could be placed directly into tooth-created indentations in a replica of the patterned injury found on the victim's skin and an injudicious contact of dental casts with human skin could introduce artifact and/or skin injury[40].

3. Dental Nomenclature: records including documentation of tooth numbering, suspected biter's complete dental records etc should be routinely collected by the concerned authorities[39].

4. Inverted Cast: One of the most difficult concepts for the forensic dental neophyte, trier of fact, and the jury is the concept of "sidedness" (Figure 4) in relating teeth to bitemark as bitemark versus dentition may be confusing. The dental health professional think opposite sides when seeing through a dental mirror. However, the tendency for the forensic dental neophyte is to see the bitemark as a patient, thus reversing sides. If, instead, the investigator thinks of himself or herself as the biter, then bitemark sidedness does not become an issue. The concept, however, has to be related in a written report and to the trier of fact and the jury.

The use of a transparent overlay—a clear acetate sheet outlining the hand-drawn dental incisal edges— was a common comparison method with bitemark photographs. Overlay sidedness can be an issue. To avoid confusion, the overlay should be clearly marked with an "R" and/or "L," for right- and left-sided dental quadrants. If the acetate is flipped, the letters will be also. Other overlays are created using photocopiers, flatbed scanners, or digital cameras to capture the incisal/occlusal edges of the dentition or dental models. Regardless of the technique used to make dental overlays from dental models, an unwritten convention has developed among forensic dentists to place an ABFO no. 2 scale alongside the models. This automatically resolves sidedness issues (figure 5).

5. Overlays: The most common indirect methods utilized to compare a suspected biter's dentition to a bitemark injury involve some form of an overlay fabrication technique. An overlay is simply a representation of the incisal or biting edge pattern of the anterior teeth. Overlays can be prepared in a number of ways; however, the use of hand-drawing methods has recently been shown to be highly subjective, and their use should be discontinued (figure 5)[41].

6. Metric Analysis: performed independently on the bitemark and suspected dentition. The goal of the metric analysis is to ascertain as much quantitative information like the size of each tooth within both dental arches accomplished directly from the suspect's dental stone models or from sample bites. Additionally, measurements in the third plane can be recorded with great success by calipers, rulers, compasses, protractors and other instruments[42]. The manual methods of metric analysis are tried and true, and these old ways still work well (figure 6).

7. Digital Analysis: The digital tools available in Photoshop and other software programs allow for accurate measurement of width and angulation[43,44,45]. Additionally, images can easily be enhanced requiring little time and effort compared to darkroom techniques. A color image can now be screened by individual color channel, converted to gray scale, changed for brightness or contrast, and inverted—all with a few keystrokes. It is imperative that the untouched archival original images remain untouched (figure 6).

Conclusion

Forensic dentistry is a multifaceted, interesting, and rewarding blend of dentistry and the law. Bite mark analysis is an important aspect of forensic dentistry that is invaluable in solving crimes and in identification of persons involved in criminal activities The field of bitemark science is quite new and potentially valuable with an increase in need for trained individuals who are experienced in the recognition, collection and analysis of this type of evidence.

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