

HUMAN BITEMARK ANALYSIS - A REVIEW

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ABSTRACT

BACKGROUND: Bite marks can play a vital role in personal identification of the assailants in the field of forensic odontology. In cases of rape, murder and violence physical evidences such as bite marks are considered variable. Bite marks are unique due to specific characteristics and teeth arrangement. While collecting bite marks the vital information like demographics, location of bite marks, shape of the mark, size of the mark, colour of the mark and the type of injury can be inferred which can be potential legal aid in personal identification and criminal prosecution .

REASON: Bite mark evidence can assist the justice system to answer critical questions about the crime.

KEYWORDS: Bite-marks, impressions, evidence, photographs, abuse.

INTRODUCTION:

Identification of an individual or an animal by teeth is not a new technique; it dates back as far as 66A.D. It was used during the US revolutionary war by Paul revere (dentist) who identified casualties by his bridgework. It was also used on Adolf Hitler at the end of world war –II, world trade centre bombing –New York, numerous air crashes and natural disasters. Rawson investigated the uniqueness of human dentition using a precise method mathematically. The uniqueness of bite mark is not such a clear cut issue. Human skin is not a good bite registration material. The individuality of a bite mark rises to a high level due to the state of dentition, repair of the teeth and /or the degree of breakdown. It consists of abrasions superficially or bruising of the skin or sub-surface haemorrhage. Depending upon the part and constitution of the skin bite marks can be distorted which is the common problem during bite mark analysis. Crimes featuring bite marks include homicide, assault, and rape, abuse (spousal, elder and children). [1] Many techniques to analyse bite mark patterns have been used in the past. They involve the use of “overlay.” The tooth exemplar, independent of the method used to produce it when biting surface data are transferred to a clear acetate sheet, is called an “overlay.” These are physically compared to the injury on skin or a patterned mark. “Hollow volume overlay” records the perimeter of biting surface of each tooth and leaves the inner aspect of the tooth image transparent.

Based on the site and type of bite marks, overlays are generated using hand tracing, xerographic images, or through X-ray films. These life-sized overlays can be compared with the overlays from suspect's teeth. The present study focused to assess the most accurate bite mark overlay fabrication technique by direct similarities between bite marks and models of cases with indirect similarities in the form of conventional traced overlays of subjects. It also aimed to determine the relative accuracy of the technique and its possibility in forensic science. [2]

Bite marks 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. In cases of sexual assault, face, lips, breasts, shoulder, neck, thigh, genitals and testicles are mostly involved. Bite mark impression can be left on skin, chewing gum, pencils, pens and may also be

found on musical instruments, cigarettes, cigar, food material like cheese, fruit, potato, and chocolate etc. These are encountered in a number of crimes especially in homicides, quarrels, abduction, child abuse cases, sexual assaults, during sports events and sometimes intentionally inflicted to falsely frame someone. While bite marks on the body are caused intentionally, those found on food articles are usually unnoticeably left by the culprit at the scene of crime. In order to identify the culprit, the dental casts of suspected persons are prepared using dental material and matched. Bite marks if investigated properly can prove the involvement of a particular person or persons in a particular crime.

The anatomical location of the bite mark is always important in correlating crime. It is also important to analyse the difference between attack injuries and defensive wounds. Bite marks are presented in the semi-circular injury with two distinct arches. The bite mark will always be seen with a bruise at the centre. The diameter of the bite mark injury ranges from 25-40mm typically. Bite mark identification have been enhanced by some new techniques that includes the application of electron microscopy, determination of ABO blood groups from the saliva of the bite mark, computer enhancement technique etc. Alteration of shape and clarity in a relatively short duration of approximately 10-20 minutes in both dead and living necessitates their recording at the earliest possible time. The bite marks are taken into consideration only when 4-5 teeth are present for analysis. The accuracy of these bite mark overlay production methods were studied by Sweet and Bower and came to a conclusion that the computer generated overlays provided the most accurate and reproducible models. This article gives an overview of human bite mark analysis. [3]

GUIDELINES OF BITE MARK ANALYSIS:

American Board of Forensic Odontostomatology (ABFO) established the guidelines to standardize the bite mark analysis in 1986.

- 1) **HISTORY:** History of any dental treatment in proximity to the date of the bite mark should be obtained.
- 2) **PHOTOGRAPHY:** Intra-oral photograph should include two lateral views, frontal views and occlusal views of each arch. Extra-oral photograph including profile views and full face. Always it's useful to include a maximal mouth opening photograph. If inanimate materials, such as chewing gums, Styrofoam cups are used for test bites the results should be preserved photographically. UV light photos can capture deeper information such as spacing, size, and shape of teeth. Blood group verification is possible on account left in bite mark.
- 3) **EXTRA-ORAL EXAMINATION:** The factors that influence biting dynamics include observation and recording soft and hard tissues. Measurement of maximum opening and any deviation on opening and closing should be made. The evidence of surgery, presence of facial scars and presence of facial hair should be noted.
- 4) **INTRA-ORAL EXAMINATION:** Saliva swabs should be taken. The size and function of the tongue should be noted. Dental chart should be prepared if possible.
- 5) **IMPRESSION:** Take two impressions of each arch using the material that meet ADA (American Dental Association) specification. The occlusal relationship should be recorded.
- 6) **SAMPLE BITES:** Sample bites should be made into an appropriate material whenever possible, simulating type of bite under study
- 7) **STUDY CAST:** Cast should be prepared using type –II stone according to manufacturer's specification. Additional casts should be made by duplicating the master cast. [4]

COLLECTION OF BITE MARKS EVIDENCE:

The anatomical location and the severity are the two aspects of forensic significance. Bite mark should be collected from both the bite victim and suspect, sometimes it should be remembered that the victim could be the suspect. Techniques such as impression taking are used to collected evidence from the bite suspect. Those techniques are undertaken by trained clinician. [5]

CLASSIFICATION OF BITE MARKS:

A. Mac Donald's classification:

- a) **Tooth pressure marks:** Marks produced on account of direct application of pressure by teeth. They are generally produced by the occlusal surface or incisal surface of the teeth.
- b) **Tongue pressure marks:** when adequate amount of tissue is taken into mouth, tongue gives force against rigid areas.
- c) **Tooth scrape marks:** The scrape marks are caused due to svaping of teeth across the bitten material. They are usually caused by anterior teeth and present as superficial abrasions and as scratches.

B. Cameron And SIMS classification:

This is based on the type of agent producing the bite mark and materials exhibiting it.

1) Agents:

- a) Animals
- b) Humans

2) Materials:

- a) Food stuffs
- b) Skin, body tissue
- c) Other materials

C. According to the degree of impression:

- a) Clearly defined
- b) Obviously defined

- c) Quite noticeable
- d) Lacerated

The severity of the bite mark or an injury gives indications of the mental state of the offender. [6]

Characteristics of Bite Marks

Class Characteristics

According to the Manual of American Board of Forensic Odontology, a class characteristic is a feature, characteristic, or pattern that distinguishes a bite mark from other patterned injuries. It helps to determine the group from which the bite mark commences. While evaluating the bite marks, the first step is to confirm the presence of class characteristics. The 'tooth class characteristics' and the 'bite mark characteristics' are the two types of class characteristics. In a bite mark, the front teeth which include the maxillary central incisors, lateral incisors and the canines are the primary biting teeth according to tooth class characteristics. Each type of tooth in the human dentition has class characteristics (tooth class characteristics) that differentiate one tooth type from the others. Thus, the two mandibular central incisors and the two mandibular lateral incisors are almost similar in width, while the mandibular canines are cone shaped. The bite mark features help in diagnosing if the marks were from maxillary teeth or the mandibular teeth. According to the bite mark features, the maxillary central incisors and lateral incisors make rectangular marks of which the centrals are wider than the laterals and the maxillary canines produce round or oval marks. The mandibular central incisors and lateral incisors also produce rectangular marks but these are almost equal in width, whereas the mandibular canines produce round or oval marks. [7]

Individual Characteristics

Individual characteristics are variations from the standard class characteristics. They are the specific features found within the class characteristics which can be a feature, a trait or a pattern that represents an individual variation rather than an expected finding. Dental patterns, features, or traits may be seen in some individuals and not in others such as rotation, buccal or lingual version, and mesial or distal drifting of teeth etc. Dental characteristic is specific to an individual tooth and makes one tooth different from the other. The teeth of different individuals differ from one another with respect to their size, their position in the dental arches and in their shape. Individual differences may be formed by various physical and chemical injuries affecting the teeth over the years like attrition, abrasion, erosion, the teeth may be affected by caries due to poor oral hygiene, and there may be restorations of the carious teeth. The teeth are subjected to various insults such as sports injuries, chemical injuries, biologic attacks, motor vehicle accidents, workplace accidents, and caries. After such damages have taken place, the teeth often need a restoration. These restorations or the injury itself produces distinctive and unique features within a tooth. Individual characteristics of bite marks may be affected by the type, number and peculiarities of the teeth, occlusion, muscle function, individual tooth movement and temporomandibular joint dysfunction in the perpetrator. [8]

Controversies Regarding Bite Mark Evidence

There are number of factors which can alter the bite mark evidence. Hence there is controversy regarding the legal status of bite mark evidence. Errors in recording, comparison, analysis and interpretations of bite marks may lead to serious consequences. So many attempts have been made to establish —standardsl for gathering evidence and interpretation of evidence. [7] The American Board of Forensic Odontology and The British Association of Forensic Odontology has published guidelines which describe that evidence should be collected from both victim and suspect and represent a sound basis for such collection. Deviations from these recommendations may be questioned. [6, 8]

LOCATION OF THE BITE MARK:

The anatomical location of the bite mark is crucial in determining its potential to be analysed. Breast is the commonly bitten location which presents as a considerable problem as it is highly mobile and easily deformed and so it can be difficult to determine the position of breast during biting on the effect of force on the deformity of the tissue and results in injury. [9] A study conducted in order to evaluate the anatomical locations of bite marks in 101 cases from United States courts of appeal, found that human bite marks can be found at almost all anatomical location, with a bias towards certain areas. The results revealed that females are four times more likely to be bitten than males and breasts, arm and legs are concentrated. In case of female children bites are seen on the legs, face and arms. Males are most frequently bitten on the arms, hands and back. [10]

Appearance and Factors Affecting Bite Mark Injuries

An ideal human bite mark is doughnut shaped which consists of two 'U' shaped arches representing the mandibular and the maxillary arches separated from one another at their base. The individual arches are produced by the anterior six teeth. In practical scenario, human bite mark is mostly circular to oval in shape as compared to an animal bite which is usually 'U' shaped. When teeth of only one of the two arches come in contact with the skin during biting, then instead of the two 'U' shaped marks, only one 'C' shaped mark is produced by biting. Such types of bite mark patterns provide very less information to the investigator. The diameter of the bite mark injury varies and is usually between 25-40 mm in diameter. The size of an injury allegedly caused by human bite must fall within the known parameters of the human dentition. Due to the pressure created by the biting teeth and the negative pressure created by the tongue and suction effects, there is an extra-vascular bleeding which causes bruising in the centre of the bite mark injury. These bruising show colour changes over a period of time as the injury undergoes a healing process in the skin of a living individual. [11] Factors such as strength and force of the bite, intervening clothing, and relative movements or struggle posed by the victim have a bearing on the depth of penetration and can alter the appearance of the bite marks. Rarely atypical human bite presentations are reported that need careful analysis and explanations regarding its production. The dermal

properties, anatomical site of the bite, age of the victim and weight are responsible for the distortion produced by bite marks. Body parts with loose skin bruises easily due to excess subcutaneous fat, lesser fibrous tissue and muscular tone. More bruising is observed in children, females and elderly persons. More bruising in children is attributed to delicate, loosely attached skin and presence of subcutaneous fat. In an old person, more bruising is due to lesser elasticity and subcutaneous fat whereas easy bruising in females is due to delicate skin with more subcutaneous fat. [12]

BITE MARK ANALYSIS:

The first stage of bite mark analysis is to determine whether the injury is a bite mark and then to provide a statement on the forensic significance.

- 1) Shape, size and arrangement of teeth: The cross-section of human incisors and canine produce rectangular and triangular marks respectively whereas the cross-section of animals' bites produce small and circular marks. The distance between individual teeth may be greater in animal bites.
- 2) Size of dental arch: The average width of adult arches from canine to canine is 2.5-4cm. Paediatric arches are smaller than adult arches.
- 3) Evaluation of the bite mark photographs: The bite marks should be thoroughly analysed in both in vivo and in vitro rather mere superimposition of marks in the photographs with the models.
- 4) Evaluation of arches: Shape of the arch should be considered. Central lines of lower and upper arches should be established.
- 5) Suction marks: A suction mark in the centre of the arch is the sign of bite marks of human origin. Now it is considered that suction marks are due to the compression of blood vessels between the jaws of the biter.
- 6) Characteristics of the mark: Areas of injuries may be at the occlusal level of particular tooth or sharp cusp. Tooth numbers, placement of tooth marks and missing teeth should be noted. [13]

METHODS OF ANALYSIS:

There are two broad classifications of comparison techniques for bite marks, they are: direct and indirect methods which use 1:1 life-size photographs and models of the teeth.

In direct method, the suspect's model will be directly placed on the photograph of the bite mark and the concordant points will be demonstrated,

In indirect method, transparent overlay of occlusal or incisal surface of teeth is prepared and then it will be placed over the scaled 1:1 photograph of the bite marks followed by comparison.

There are five methods of bite mark overlay production.

1. Two types of radiographs
2. Hand traced
3. Xerographic and
4. Computer based.

Odontometric triangle method: In this method, a triangle is made on the teeth models and the tracing of bite marks by marking three points one in the centre of the maxillary central incisors and two on the outermost convex points of canine. Three angles of the triangles are measured and compared. [14]

Other methods in bite marks analysis are:

Vectron: used to measure distance between fixed points and angles.

Stereometric graphic analysis: this can be used to produce the contour map of the suspect's dentition.

Experimental Marks: may be produced on pig skin, baker's dough or rubber for analysis.

Scanning electron microscope: can also be used for analysis of bite mark wounds.

Image perception technology: analysis of bite mark with a use software where one can add colour to different grey scale areas of image. [15]

MECHANISM OF BITE MARKS

Three predominant mechanisms associated with production of bite marks are; tooth pressure, tongue pressure and tooth scrape. Tooth pressure marks are caused by direct pressure applied by incisal edges of front teeth or occlusal edges of back teeth. Severity of bite mark depends upon duration, degree of force applied and degree of movement between tooth and tissue. Clinical characterisation of tooth shows pale areas representing incise edges and bruising that represent incisal margins. Tongue pressure is caused when the material taken into mouth is pressed by tongue against teeth/ palatal rugae and distinctive marks are present due to tongue sucking/ thrusting. Tooth scrape is caused by teeth abrading against tooth surface commonly involving the front teeth. Clinical representation can be in the form of scratches and abrasions. Scratches and abrasions that indicate irregularity and peculiarity of incisal edges are useful in identification. [16]

EVALUATION AND COMPARISON TECHNIQUES:

The American Board of Forensic Odontology provides a wide range of conclusions such as exclusion, possible bite mark, and definite bite mark. Again a range of conclusions is available to odontologists to describe the results of a bite mark comparison, they are:

- a) Excluded- There are discrepancies between the suspects' dentition and the bite mark that exclude the individual from making the mark.
- b) Inconclusive- There is sufficient forensic detail or evidence to draw any conclusion or the link between the bite mark injury and the suspects' dentition.

- c) Possible biter- Teeth like the suspects' could be expected to create a mark like the one examined but so could other dentitions.
 d) Probable biter- Suspect most likely made the bite; most people in the population would not leave such a bite.
 e) Reasonable medical conviction- Suspect is determined for all practical and reasonable purposes by the bite mark. [17]

LIMITATIONS OF BITE MARK ANALYSIS:

Human bite mark analysis is highly time dependant and investigator should collect and examine the evidence as early as possible from the victim. Time lapse can significantly impair the quality of evidence and forensic identification may be deemed questionable. Photographic evaluation and comparison also present inherent errors in surface reproduction and magnification in mild to moderate bite injuries. Capturing the impression from the bite-marks is extremely technique sensitive and possible distortion can occur due to the compression of impression materials against movable soft tissues. Incomplete or partial capture of bite marks in the impression and subsequent working casts can also limit the sensitivity of forensic identification. [18]

DISCUSSION

Human bite mark investigation is by far the most demanding and complex part of forensic dentistry. There is no dependable way of stating that one or more tooth marks seen in a wound are irrefutably unique to just one person in the population. Bite mark contortion through skin elasticity, anatomical location and body positioning is a recurring issue. With the recent developments regarding expert testimony, the need for accurate, reliable, reproducible and above all objective methods for bite mark analysis and comparison has never been greater. Although more groundwork is needed to identify the feasibilities of image perception technology, its possibilities to visualise more details in a bite mark photograph are promising. The availability of additional colouring of selected areas with similar intensity values as well as rendering 2-D photographs as pseudo 3-D images may enable the researcher to analyse the image more broadly and come to a more exact conclusion regarding the source of the bite. However, bite mark analysis alone should not be allowed to lead to a guilty verdict, but it will offer the opportunity to exclude a suspect from a crime when the data do not correspond. [19]

The investigators dealing with analysis of bite marks should also have the knowledge of any mark or bruise which have characteristics which closely resemble the injuries produced by teeth as determination of an injury being produced by human teeth requires substantial information. Tooth markings may also be found on items such as chocolates, vegetables, chewing gums, Styrofoam cups, cigarette and even on steering wheel of a car, it is reported a case of a murder in which the bite marks in a piece of cheese was reported. Bite marks left in substances which are malleable like cheese have a more potential for accurate identification. A characteristics in a human bite mark is a distinguish feature, trial or pattern within the bite mark and is delivered as a class or an individual characteristic. Once teeth impressions are taken from a suspect these can be compared against the bite mark data and matched for up to seventy-six comparison factors. These include whorls, indentations, chips, abrasions, striations, distances between cuspids, tooth width and thickness, alignment and mouth arch. [20]

Although more groundwork is required to identify the possibilities of image perception technology, its possibilities to visualize more details in a bite mark photograph are promising. The availability of additional colouring of selected areas with similar intensity values as well as rendering 2-D photographs as pseudo 3-D images may enable the researcher to analyse the image more extensively and come to a more outcome regarding the source of the bite. However, bite mark analysis alone should not be allowed to lead to a guilty verdict, but it will offer the opportunity to exclude a suspect from a crime when the data do not correspond. More groundwork is needed since bite mark evidence on its own does not always produce conclusive results.

CONCLUSION:

The field of bite mark science is expanding and the need for newer objective techniques to pinpoint the suspect are increasing with recent advances in research, objective methods of bite mark analysis like salivary DNA recovery and bacterial genotyping, have become the main stay of investigations. Bite Mark analysis have served to pinpoint suspects in many unsolved criminal cases of the past and will have its own say in criminal investigations, what with the newer objective techniques coming to the fore.

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