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Analysis and Identification of Bite Marks in Forensic Odontology- A Review Article

¹Dr.Mohammad Abdurrahman Khan, Assistant Professor, Department of Forensic Medicine and Toxicology, Hind Institute of Medical Sciences, Barabanki.

²Dr. Manisha Verma, Senior Resident, Department of Periodontology, FODS, KGMU, Lucknow (U.P).

³Prof.Dr. Anoop Kumar Verma, Professor and Head, Department of Forensic Medicine and Toxicology, KGMU, Lucknow (U.P).

⁴Prof.Dr. Anjani Kumar Pathak, Additional Professor, Department of Periodontology, FODS, KGMU, Lucknow (U.P).

Corresponding Author: Dr. Mohammad Abdurrahman Khan, Assistant Professor, Department of Forensic Medicine and Toxicology, Hind Institute of Medical Sciences, Barabanki.

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Abstract

Analysis of bite marks plays an important role in personal identification in forensic odontology. Bite mark identification is based on the individuality of a dentition, which is used to match a bite mark to a suspect. Bite marks can be recorded in violent crimes such as sexual offences, homicides, child abuse cases, and during sports events. Teeth, acting as tools leave recognizable marks depending on tooth arrangement, malocclusion, habits, occupation, tooth fracture, and missing or extra teeth. Bite mark identification is based on the individuality of a dentition, which is used to match a bite mark to a suspect. Bite marks often considered as valuable alternative to fingerprinting and DNA identification in forensic examinations. The present review describes the classification, characteristics, mechanism of production, and appearance of bite mark injuries, collection of evidence, comparison techniques, and technical aids in the analysis of the bite marks.

Keywords: Bite Marks, Bite Severity index, Different characteristics of bite mark analysis

Introduction

Forensic dentistry is the branch of dentistry that deals with the legal aspects of professional dental practices and treatment with particular emphasis on the use of dental records to identify victims of crimes or accidents. One sector of forensic odontology is the analysis of bite marks. Bite mark analysis and comparison is a complicated matter¹ which may occurred as a result of either a physical alternation in a medium caused by the

contact of teeth, or a representative pattern left in an object or tissue by the dental structures of an animal or human ^{2,3}. The standard techniques for examining bite marks are based upon interpreting photographic evidence in which a bite is compared with the models of the teeth of suspects⁴. The quality and angle of the bite mark photographs and the precision of the impression of the suspect's dentition is of extreme importance to the forensic odontologist. Bite marks analysis is based on the principle that 'no two mouths are alike'.

Bite marks are thus, considered as valuable alternative to fingerprinting and DNA identification in forensic examinations. A bite mark is a mark created by teeth either alone or in the combination with other oral structures ^{5,6}. "The criminal may lie through his teeth though the teeth themselves cannot lie" Furness⁷.Bite mark are usually seen in cases involving sexual assault, murder, child abuse and can be a major factor in leading to a conviction. Bite marks are often located on breasts, inner thighs, arms buttocks and genitalia. Trube-Becker (1973) reported a case with 17 bite marks⁸. Vale and Noguchi .1983 also stated that bite marks are the most commonly found on the back side of the male and female victims. Many types of violent assaults consists of more than one bite, making some bites difficult to identify. Bite marks will appear as an oval or circular patterned injury consisting of two opposing symmetrical, U-shaped arches separated at their bases by open spaces. Injuries observed with bite marks include abrasions, lacerations, contusions/bruises, petechie, indentations, erythema and punctures (Jones, 1998; Bell, 2000; ABFO,2000, Webb et al.,2000; Bowers,2006). The forensic significance of bitemarks is dependent on a number of variables and these are discussed in this article.

Different characteristics of bite mark

The term 'bite mark' is used in this field knowing that the marks are the result of the tooth impression in different materials. So, in the literature bite mark is mostly used as description. The state of the dentition, the degree of breakdown and/or repair of the teeth may create a bite mark with a high level of individuality. In some cases, bite marks may allow an identification of the biter (Ligthelm and van Niekerk 1994, Saglam et al. 1998, Lessig and Benthaus 2003)⁹.

Generally, bite marks consist of superficial abrasion, and/or sub-surface haemorrhage, or bruising of the skin because of the bite (Endris 1979)¹⁰. Though the mechanism is not clearly understood, the pattern of the injury is affected by the force and length in time of the bite, in combination with other mechanical and physiologic factors. Barbenel and Evans (1977)¹¹ have discussed the influence of the lineages of the skin.

Occasionally bite marks are obtained in various types of food like chocolate, chewing gum, fruits, vegetables and similar (Endris 1979, Saglam et al. 1998, McKenna et al. $2000)^{10}$. Solid food has an advantage in such cases. Aboshi et al. $(1994)^{12}$ reported the identification of a suspect arsonist by means of bite marks in cakes which were found at the scene of the crime. A missing upper right central incisor was proved to be in the patterned injury. Bernitz et al. (2000)¹³ reported a case of murder with a bite mark in a piece of cheese which was recorded. The pattern-associated comparison between the impression and a study model of the suspect was able to identify the perpetrator. Fingerprints and DNA evidence were not found at the crime scene. The court was reluctant to accept the validity of the method of the investigation. For this reason, the FOS controlled the method with several bite marks in cheese, butter and cooked potato. Pair-wise comparisons were made by two

odontologists. The examiners correctly identified all the true matches as well as selecting the dental models for which there were no corresponding impressions.

The characteristics of human bites are superficial abrasion and/or sub-surface haemorrhage looking like an arch. They are caused by the incisors, canine and premolars. The abrasions and/or haemorrhage caused by the canine are in a shape of points. If the perpetrator has dentures additional specific marks can be expected. They differ between bridges, crowns and dentures. Crowns and bridges may have a ceramic surface and partial dentures braces to fix at the teeth. These peculiarities can be responsible for specific wounds and additional markers for identification.

Depending on the part of the body and the constitution of the skin the bite mark can be distorted. To prevent mistakes by the pattern-associated comparison it is recommended to simulate bites at similar body parts using the study casts of the suspect (Lessig 2001, Lessig and Benthaus 2003)¹⁴ or using digital technique for a stepwise dynamic comparison (Sakoda et al. 2000, Thali et al. 2003)^{15.} Sheasby and MacDonald (2001)¹⁶ recommend a classification to emphasize the need of a scientific approach for the interpretation of the types of distortion. They introduce the terms of primary and secondary distortion. Primary distortion is defined by the dynamics of the bite. Secondary distortions have three categories: time-related distortion when a bite changes with time elapsed subsequent to the bite being made, posture distortion and photographic distortion.

Important is the differentiation of human and animal bites as well as to identify the kind of the human bite. Human bites may be classified in different ways for example, being defensive or offensive (Rötzscher et al. 2003)¹⁷.

Anatomical Location

It is important that dentists, police officers, social workers, forensic pathologists and others involved in the criminal justice system be aware of where bitemarks are most commonly found. It is also important to remember that bitemarks can be both attack injuries (and therefore present on the victim) and defensive wounds (and therefore present on the suspect) and all individuals suspected of involvement in a crime against a person need to be examined for such marks¹⁸. A survey of 148 bitemarks was conducted in order to determine the anatomical areas most likely to be bitten; the results are shown in Figure 1 in which females were four times more likely to be bitten than males, and over 50% of the males in the study were the suspects in the case reinforcing the need to examine carefully this group of individuals for bitemark evidence. Females were most likely to be bitten on the breast, arm and legs, and children on their genitals, legs and back. Most males were bitten on the hand, back or face¹⁹.

The anatomical location of a bitemark is also crucial in determining its potential to be analysed the breast is by far the most commonly bitten location, this presents a considerable problem. Breast tissue is highly mobile and easily deformed and therefore it can be difficult to determine the position of the breast during biting or the effect of the bite force on the deformity of the tissue and hence the injury ^{15,16}. Bitemarks on the arm and leg can be similarly affected, depending on their position at the time of biting.

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Figure 1: Anatomical distribution of 148 bitemark from the United States.

Presentation of bite mark injuries

Bitemarks will typically present as a semi-circular injury which comprises two separate arcs (one from the upper teeth, the other from the lower) with either a central area absent of injury, or with a diffuse bruise present²⁰.It is not unusual to see only one arch of teeth on an injury and, if this is the case, it is most often the lower teeth that are present which relates to the mechanics of biting, ie the maxilla remains stable while the mandible moves until the teeth meet ²⁰. There are three main factors that influence the severity of a bitemark injury:



Should receive medical attention as such wounds are highly susceptible to serious infections

Photographic Documentation of the bite site

All the photographs should be taken with the camera at 90° (perpendicular) to the injury. It should be emphasized to forensic photographers that it is not possible to have too many photographs of an injury. It has been recommended that bite marks are photographed at regular 24 hour intervals on both deceased and living victim as their appearance can improve. The lighting should be arranged at an angle to shadow indentations which will appear more definite on the positive print, but precautions should be taken to prevent excessive heat from the photographic lamps causing distortion of the material and filters may be used to mask or enhance various shades of coloration that are associated with the marks. Photographs of the bite marks must be of highest standard if the forensic significance of the injury is to be maximized¹⁹. In general, photography provides the safest means of obtaining a permanent record of marks. Use of stereoscopic photography is advocated by some authorities to produce greater definition of details, but this method has many inherent problems. Ultra-violet

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and Infra-red illumination may be necessary under some circumstances to bring out some details that may not be obvious in the normal positive print²¹.

It is possible for a bitemark with high forensic value to be poorly photographed and thus lost as a valuable piece of physical evidence.

Bite Mark Analysis, Comparison and Evaluation

The preceding sections have described the impact of a variety of factors upon the forensic significance of bitemarks. Only a bitemark that exhibits at least class characteristics of the biter should be analysed. This does not render the less significant bitemark worthless within an investigation. For example, if sufficient detail exists to identify the injury as a probable bitemark, this can be of assistance to investigators, especially in cases of child abuse where there may be several injuries that are ambiguous, i.e. may be accidental or non-accidental.

The American Board of Forensic Odontology provides a range of conclusions to describe whether or not an injury is a bite mark. These are:

- **Exclusion** The injury is not a bite mark.
- Possible bite mark An injury showing a pattern that may or may not be caused by teeth could be caused by other factors but biting cannot be ruled out.
- Probable bite mark The pattern strongly suggests or supports origin from teeth but could conceivably be caused by something else.
- Definite bite mark There is no reasonable doubt that teeth created the pattern. The first stage of analysis is to determine if the injury is a bite mark, and then to provide a statement on the forensic significance ¹⁹.

While evaluating the bite mark firstly the cause of the mark has to be determined, since bite marks may be caused by nonhumans or humans 22 .

Size, shape and arrangement of teeth: Human incisor teeth produce rectangular marks whereas canine teeth produce triangular marks in the cross-section. Animal bites (dogs, cats) usually puncture the skin and the crosssectional size of the tooth is small and circular. Number of incisor teeth and the distance between individual teeth may be greater with animal bites.

Size of Dental Arch: Width of adult arches from canine to canine is 2.5-4cm. Children arches are smaller than the adults whereas "dogs and cats" arches are smaller than children.

Evaluation of the bite mark photographs: Attempts should be made to thoroughly analyse the bite marks in vivo and in vitro rather than mere superimposition of marks in the photographs over the models.

Evaluation of the arches: Shape of the arch should be noted. Central lines of upper and lower arches should be established.

Suction marks: The presence of suction marks in the centre of the arch marks is a sign of bite marks of human origin. But now it is considered that suction marks are caused due to injury to the blood vessels when compressed between the jaws of the biter.

Characteristics in the mark: Ascertain the characteristics of individual marks within the arch. Areas of injuries may indicate occlusal level of particular tooth or sharp cusp. Tooth numbers should be identified. Placement of tooth marks in the arch and missing teeth should be noted.

Collection of bite mark evidence from victim

The dentist in private general practice does not often have the opportunity to deal with procedures for collecting evidence from bite victims. Detectives at the scene of the crime, pathologists at autopsy or medical personnel in the emergency suite find most bites. But since physical and biological evidence from a bitemark

begins to deteriorate soon after the bite is inflicted, all dentists should be familiar with the general principles of evidence collection. This is especially true for dentists that deal with patient population that may potentially contain victims of domestic violence, in which bites are often discovered¹⁹.Practitioners should make every effort to accurately and precisely preserve the evidence as soon as it is discovered using the following techniques, and not wait until others with more experience can be consulted or summoned. The best or only opportunity to collect the evidence may be when it is first presented and observed. If a dentist finds a patterned injury that is suspected to be a bitemark, it should be reported to the police or social welfare agency with local jurisdiction. Then, the dentist should complete the following list of procedures to properly collect the evidence:

Documentation

Make a record of the injury, including descriptive, narrative notes that document the physical appearance, colour, size and orientation of the injury²³. What is the location on the body? What is the relative contour and elasticity of the site? Can the difference between marks from the upper and lower teeth be determined? What types of injuries are present? Cuts? Bruises? Scrapes?

Photographs

Take extensive orientation and close-up photographs using an intra-oral camera with a macro lens and both colour and black-and-white film. A reference scale, such as a ruler, should be placed in the same plane as the injury and visible in the photographs to enable subsequent measurements. Be certain that the camera is positioned directly over the injury site. The long axis of the lens should be perpendicular to the bitten skin to reduce perspective distortion in the photographs ²³.

Saliva swabs: Saliva will have been deposited on the skin during biting or sucking and this should be

collected and analyzed. Use the double swab technique²⁴. First, a cotton swab moistened with distilled water is employed to wash the surface that was contacted by the tongue and lips using light pressure and circular motions. Then, a second swab that is dry is used to collect the remaining moisture that is left on the skin by the first swab. Both swabs are thoroughly air-dried at room temperature for at least 45 minutes before they are released to police authorities for testing. The two swabs must be kept cool and dry to reduce the degradation of salivary DNA evidence and the growth of bacteria that may contaminate the samples and reduce their forensic value. Then they should be submitted to the laboratory as soon as possible for analysis. If the time until submission is protracted, it is recommended that the swabs be stored in a paper evidence envelope or box that will allow air to continue to circulate around the swab tips. (The swabs should not be sealed in plastic bags or plastic containers.) The envelopes or boxes should be refrigerated or frozen during storage. A DNA sample must also be collected from the victim at this time to provide the opportunity for comparison with the sample from the bitemark. This sample could consist of a buccal swab or a sample of whole blood. The victim's DNA profile will enable analysis of any mixtures that are found in the sample from the bite, which may involve contributions from the depositor and the victim.

Impression: Fabricate an accurate impression of the bitten surface to record any irregularities produced by the teeth, such as cuts, abrasions, etc. Use vinyl polysiloxane, polyether or other impression material available in the dental office that is recommended for fixed prosthetic applications¹.Dental acrylic or plaster can be used as a rigid support for the impression material. This will allow the impression to accurately record the curvature of the skin.

First aid: Prompt medical attention should be provided for the living victim since human bites have a higher potential for infection than animal bites ²⁵. Injuries that disrupt the integrity of the skin's surface should be treated as soon as possible.

Collection of bite mark evidence from suspect

The collection of dental exhibits for forensic uses has been deemed to be an invasive procedure. Thus, dental impressions and bite samples that are seized from a suspect are susceptible to strict rules of evidence²³. They must be obtained either using a court order (warrant) or with a signed and witnessed informed consent. North American Courts have ruled that collection of this type of evidence does not violate the individual's rights against self-incrimination because he is not being required to testify against himself, only to provide physical evidence that will be used in a comparison. If the suspect refuses to provide exhibits for comparison purposes, he may be held in contempt until he complies. The Court might issue an order in this instance to authorize the use of force to obtain the exhibits. In the United Kingdom, court orders are not available to collect evidence by force. A jury is left to develop their own conclusions if the suspect refuses to submit to dental evidence collection procedures. For a detailed account of the warrant issue within the UK (excluding Scotland) readers should consult the Police and Criminal Evidence Act (PACE). In the authors' experience, suspects are usually quite co-operative during the collection of physical exhibits. However, this is not always the case and so the dentist who is requested to assist authorities to collect evidence should see that provisions to ensure their personal security are in place. Most commonly, the suspect is in custody and the dental examination takes place away from the practitioner's dental office, perhaps in a jail or remand facility. Police will usually provide transportation to and from the site and provide assistance to the dentist with respect to moving and setting up any equipment and supplies that are needed for the examination. The following exhibits and items of physical evidence are recovered during examination of the bitemark suspect:

Clinical examination

The extra-oral and intra-oral structures are examined and significant findings are noted on a dental chart. Special attention is focused on the status of the general dental health, occlusion and mandibular articulation²⁶. Results of a specific examination of such things as tooth mobility, periodontal pocketing, dental charting of restorations, diastema, fractures, caries, etc., and the function of masticatory muscles are documented.

Photographs

Full facial and profile photographs are produced in addition to intra-oral exposures to depict the upper and lower dental arches and frontal and lateral views of the teeth in occlusion²⁷. A reference scale to enable measurements to be taken from the photographs should be included in the same plane as the teeth.

Impressions

It is necessary to produce extremely accurate study casts of the teeth that record all of the physical traits and characteristics of the dentition. Accurate dental impression materials, such as vinyl polysiloxane or polyether should be used, although custom special trays are seldom fabricated for the suspect. It is recommended that two sets of study casts be produced using a hard stone, such as dental die stone²³. All of the materials, including the trays, impressions and casts are maintained in secure storage for eventual release to police authorities. The specific instructions for product handling and material mixing that are recommended by the manufacturer must be closely followed.

Bite sample

A sample of the suspect's bite is recorded in centric occlusion using either a wafer of baseplate wax or a sample of silicone putty material designed for this purpose²³. This exhibit should be photographed immediately after it is recorded. This will provide an opportunity for future comparison of the photograph and the exhibit to verify that no distortion has occurred. The suspect should be held in custody until the quality and accuracy of all of the exhibits is determined to be satisfactory.

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Forensic physical comparison of Exhibits

The most common methods to determine if the suspect's teeth caused the bitemark include techniques to compare the pattern of the teeth (shape, size, position of teeth, individually and collectively) with similar traits and characteristics present in life-sized photographs of the injury using transparent overlays. These overlays have been produced using various techniques ²⁸. The most accurate technique has been found to be a method using a computer²⁹. Other comparison methods include the direct comparison of the suspect's study casts with photographs of the bitemark, comparison of test bites produced from the suspect's teeth with the actual bitemark, and the use of radiographic imaging16 and scanning electron microscopy³⁰.Some effort has been made to standardize the comparison procedures but, unfortunately, the conclusions are often based on the expert's level of personal experience and judgement²⁰. The American Board of Forensic Odontology has worked hard to establish guidelines for independent examination of the same evidence by second and third odontologists before the primary expert submits a final report. Regardless, many cases have been disputed because of differing expert opinions, attacks on the scientific basis of physical comparisons because of the elasticity of skin and the question of uniqueness of the human dentition²⁶.

Bite mark severity index

The bitemark severity index is a scale from 1 to 6 that measures the severity. The bitemark severity index should have certain ideal characteristics such as:

- 1. Easy to use,
- 2. Be reproducible,
- 3. Be able to use on the living as well as the dead,
- 4. Universally applicable and
- 5. Integration to allow future statistical analysis.

The bitemark severity index is scaled from 1 to 6 with 1 being very mild bruising, no teeth marks present, diffuse arches visible, may be caused by something other than teeth and of low or no forensic significance. The scale gradually progresses in severity with 6 being complete avulsion of tissue, possibly some scalloping of the injury margins suggesting that teeth may have been responsible for the injury and of low forensic significance. However forensic significance is low on either end of the scale with 3 and 4 having the highest forensic significance. The drawback of this index is its low knowledge levels with the crime scene police officers. Bitemarks distort easily so crime scene police officers need to be educated in the usage of this index which would prove useful to the forensic odontologist at a later stage³¹.

Conclusion

Bite Marks Analysis is an important aspect of forensic dentistry that is considered as very valuable in solving crimes and also in the identification of a person who is involved in the criminal activities. The human bite mark is capable of withstanding the extreme conditions of the environment and is a ready source of information that can be identified even in the deceased individual. A forensic dentist is concerned with the handling and collation of dental evidence and assisted clear

enforcement agencies in the detection and resolution of criminal and civil proceedings. It is very useful in Medicolegal conditions.

Forensic odontologists must have the forensic pathologist and the methods used in autopsy, as dental evidence is the most valuable reliable method.

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