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Review Research Paper

An Overview of Bite mark Analysis

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Abstract

Human bite mark analysis is by far the most demanding and complicated part of Forensic Dentistry. Although bite marks of an individual do have uniqueness due to specific characteristics and arrangement of the teeth, when it comes to bite mark analysis, it is complicated by numerous factors, being presented as a challenge to the Forensic Odontologists. The aim of this paper is to give a brief overview of bite mark analysis: its usefulness and limitations. The study and analysis of such injuries is challenging and complex. The correct protocol for collection, management, preservation, analysis and interpretation of this evidence should be employed if useful information is to be obtained for the courts.

This article throws light on the details of evidence collection techniques and step by step method to analyse the bite mark injury. It also provides insight about the modern methods now implemented in the analysis of bite marks. Conclusions from the analysis of bite mark evidence can assist the justice system to answer crucial questions about interaction between people present at the scene of crime.

Key Words: Bite marks, Evidence, Comparison, Analysis

Introduction:

Bite mark analysis is currently contentious. [1] It is a vital area within the highly specialized field of forensic science and constitutes the commonest form of dental evidence presented in criminal court. [2] The science of bite mark identification can be used to link a suspect to a crime. Bite mark analysis can elucidate the kind of violence and the elapsed time between its production and examination. It can show if the bite mark was produced intra-vitam or post mortem and in case of several bite marks, identify the sequence of them. [3] It can be extremely useful in establishing a link between the bitten person and the biter or excluding the innocent. [4]

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Collection of Bite mark Evidence:

Two aspects of Forensic significance of the bite marks are the anatomical location and the severity. The third influence on the ability of the injury to be properly assessed is the quality of the evidence collection. [5] Bite mark evidence is collected from both the bite victim and suspect, but it should be remembered that the bite victim could be the suspect in the cases.

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 "standards" for gathering evidence and interpretation of evidence. [7] The American Board of Forensic Odontology (ABFO) and The British Association of Forensic Odontology (BAFO) 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]

Collection of Bite Mark Evidence from the Bite Mark Victim:

Both in the living and deceased victims the following vital information should be recorded:

- **Demographics**-Name, age, sex, race, case number, date of examination and name of the examiners should be recorded.
- **Location of the bite mark**-Describe the anatomic location, indicate the contour of the surface (flat, curved or irregular) and state of the tissue characters. Underlying tissue-bone, cartilage, muscle or fat
- **Shape of the bite marks**- whether it is round, ovoid, crescent or irregular in shape.
- **Colour of the mark, size of the mark**- Both vertical and horizontal dimensions should be recorded in metric system (figure 1).
- **Type of injury**- due to bite mark may be-Petechial haemorrhage, Contusion, Abrasion, Laceration, Incision, Avulsion, Artefact etc.

Data collection from the victim-Bite mark evidence should be gathered from the victim after obtaining authorization from the authorities. Determine whether the bite mark has been affected by washing, contamination, embalming, decomposition etc. [7]

Steps in Examination of Victim:

The most important evidence from the bite mark victim is photography. Numerous photographs of the injury should be taken immediately. Shots would include:

1. With and without the ABFO no.2 scale;
2. In colour and black and white;
3. On and off camera flash (oblique flashes can highlight the three dimensional nature of the same bites);
4. An overall body shot showing the location of the injury;
5. Close-ups that can easily be scaled1:1;
6. UV photography if the injury is fading;
7. If the bite is on a movable anatomic location, then several body positions should be adopted in order to assess the effect of movement.

All the photographs should be taken with the camera at 90º (perpendicular) to the 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. [6] 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.[9] Photographs of the bite marks must be of highest standard if the forensic significance of the injury is to be maximized.[6]

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 and Infra-red illumination may be necessary under some circumstances to bring out some details that may not be obvious in the normal positive print. [10]

The next step is salivary swabbing. The amount of saliva deposited with a bite mark is about 0.3ml and distributed over a wide area of 20 cm. Points that are helpful in the collection of salivary swabbing are described below—

- One square centimetre piece of Rizla type of cigarette paper held in forceps is used after wetting it with fresh water or distilled water. The whole bite mark and the adjacent area should be swabbed using light pressure and in circular motion. [11] Air dries the paper by placing it on a clear microscopic slide. After drying swabs are packed and sent to the laboratory. A control sample is prepared using same method but without swabbing the saliva.
- Saliva obtained from swabbing is used to determine the blood group antigens using absorption-elution or absorption-inhibition group testing. Identification of saliva is done by demonstrating its amylase activity in hydrolysing a starch substrate.[12]
- In case of sexual assault, oral swabs should also be taken for semen. Mouth washes (with water) can be used to obtain test samples for spermatozoa.[7,11,12]

If the bite marks have penetrated the skin, an impression of the marks should be made. [7] Ordinary plaster of Paris or dental stone was used initially for the purpose, but it was seen that the water soluble substances in the material would leach out and delicate surface lesions would be destroyed. Therefore less damaging materials like rubber-base and silicone-base impression compounds are preferred now-a-days. [9]

There are two methods for making impressions:

Method I: Pour the material covering the bite area. Place wire gauze and inject additional material over it.

Method II: A special tray is constructed using cold cure confining to the shape of bite mark and impression is made.

Master casts must be poured with type-IV stone and duplicate casts should also be made. Either visible light cure or epoxy resin

clear material may be used to make stable rigid model.

Bite print recording is similar to the method used to lift finger prints from crime scenes, finger print lifting tape can be used to lift the "non-perforating" bite marks after brushing the bite mark with finger print lifting powder.

In case of dead victims with bite marks, bite marks can be excised along with the underlying tissues after fixing an acrylic stent around the bite mark to avoid shrinkage of the tissue. The specimen is then stored in 4% formalin. [7] One interesting development in the collection of bite mark evidence from the bite mark victims is the acquisition of 3D images of the bite mark. This is performed using specialist software, such as that produced by Lumin IQ and enables by assessment of grey scale levels, a three dimensional rendition of standardized images. They may offer a means of demonstrating the depth of an injury without the problematic use of skin impressions. [6]

Collection of Bite Mark Evidence from the Suspect:

The collection of evidence from the bite suspect must commence only after proper consent has been acquired. [6] The consent has to be written, signed by the suspect as well as a witness. [9] A detailed history of the individual including history of dental treatments (after and just before the bite marks) has to be noted. [7]

Evidence collection again begins with copious photography. Shots that should be taken include:

- Overall facial shot;
- Close-up photograph of the teeth in normal occlusion & biting edge-to-edge;
- Photograph of the individual opening mouth as wide as possible;
- Lateral view. [6]

After the photographs, a thorough examination of the individual should be carried out. TMJ status, facial asymmetry, muscle tone, maximum opening of mouth, deviation while opening & closing movements have to be recorded under extraoral examination. Intraoral examination includes tongue movements, periodontal status and dental examination. [7, 11] A full dental examination is carried out completing a detailed description of the teeth present and missing, the associated restorations and carious lesions and information on the degree of attrition of teeth and measurements of individual teeth and spaces. Any abnormalities in tooth form or arch form are noted together with the relationship of the opposing teeth and jaws. [9, 11] The next stage is to take two high quality impressions of both the upper and lower arches.

If the individual wears a dental prosthesis, impressions should be taken with this being worn and also without. [6] One set of models is used as direct evidence and the other set for the purpose of comparison. [9] Alginate can be used for making impressions, but the preferred material being rubber or silicone based impression material due to its dimensional accuracy and as they can be poured multiple times, if required. (Figure 2 & 3)

The next stage is to take registrations in the dental wax in centric occlusion, edge-to edge bite and in protrusive and lateral excursions of the jaws.

These positions are again duplicated and the one set of wax bite registrations can be used to set the study models on a dental articulator and the other set of wax bite registrations used for comparison of the imprints with those of the bite marks. [9] If indicated, a buccal swab should be taken of the suspect in order to obtain a DNA sample. [6]

Bite Mark Analysis, Comparison and Evaluation:

Bite marks are never considered accidental, although some injuries caused by teeth (for example a child accidentally strikes his/her parent in the mouth leaving tooth marks on the hand) may be. The American Board of Forensic Odontology provides a range of conclusions to describe whether or not an injury is a bite mark. These are:

a) **Exclusion** – The injury is not a bite mark.
b) **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.
c) **Probable bite mark** – The pattern strongly suggests or supports origin from teeth but could conceivably be caused by something else.
d) **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. [6] 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. [7]

1. 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 cross-sectional size of the tooth is small and circular. Number of incisor teeth and the distance between individual teeth may be greater with animal bites.

2. 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.

3. 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.

4. Evaluation of the arches:

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

5. 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.

6. 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.

Pattern analysis in bite marks

It is the assessment of the bite pattern that often serves to be most revealing. [6]

Comparison techniques for bite mark analysis can be classified as direct and indirect methods. They use life-size 1:1 photographs and models of teeth.

In direct method, model from the suspect can be directly placed over the photograph of the bite mark to demonstrate concordant points (figure 4). Videotape can be used to show slippage of teeth producing distorted images and to study dynamics of the bite marks.

Indirect method involves preparation of transparent overlay of occlusal or incisal surfaces of teeth which are then placed over the scaled 1:1 photographs of the bite injuries and a comparison is undertaken. If overlay analyses are restricted to those bite marks displaying unique characteristics, the process in the hands of an experienced odontologist can be highly accurate. [6, 7, 13, 14]

There are five main methods of bite mark overlay production—

- Computer-based;
- Two types of radiographs
- Xerographic; and
- Hand-Traced.[15]

For many years, hand-traced overlays were the method of choice. According to Sweet & Bowers, computer-generated overlays were by far the most accurate in terms of both tooth area and rotation. Results demonstrated that both the main techniques were reliable, and the choice of method was down to personal preference. [15]

Odontometric triangle method: In this objective method, a triangle is made on the tracing of bite marks and teeth models by marking three points, two on the outermost convex points of canines and one in the centre of the upper central incisors. Three angles of the triangles are measured and compared. (Fig. 5)

Other special methods in bite mark analysis:

- **Vectron** –used to measure distance between fixed points and angles.
- **Stereometric graphic analysis** – This can be used to produce contour map of the suspect's dentition.
- **Experimental Marks** –may be produced on pig skin, baker's dough or rubber for analysis.
- **Scanning Electron Microscopic** analysis of bite mark wounds [7,16-18]
- **Image perception technology** [19]

However, while the overlay production method has been shown to be reliable, the application of these to the bite mark photographs and the assessment of degree of match has not much scientific support. Again, a range of conclusions is available to odontologists to describe the results of a bite mark comparison:

- **Excluded**- Discrepancies in bite marks and suspect's dentition.
- **Inconclusive**- Insufficient forensic detail or evidence to draw any conclusion on the link between the two.
- **Possible biter**- Teeth like the suspect's could be expected to create a mask like the one examined but so could other dentitions.
- **Probable biter**- Suspect most likely made the bite; most people in the population would not leave such a bite.
- **Reasonable medical certainty**- Suspect is identified for all practical and reasonable purposes by the bite mark. [6]

Human anterior teeth are unique and that this asserted uniqueness is replicated on the

bitten substrate in sufficient detail to enable a match to a single individual to the exclusion of all others. [20] While many cases have bite marks with good unique details, in majority it is not and therefore caution should be taken while assessing any bite mark injury using pattern analysis. [6]

Bite marks and DNA:

Use of DNA in bite marks was pioneered in an effort to eliminate the subjectivity associated with conventional analyses. [21] While the recovery of DNA from saliva has been reported, it is not always assured. It has been proposed that the presence of nucleic acid degrading enzymes (nucleases) within saliva can readily degrade DNA, especially if it is on a living victim, as the skin's ambient temperature accelerates the process. [6] As human mouth contains over 500 distinct species of bacteria, and every individual will have a slight different combination, dependent on oral hygiene status, dental status and presence or absence of prosthesis. One research group has suggested that the genotypic identification of oral streptococci may be of use in bite mark analysis. [22]

Therefore, it appears that the technique is a valuable addition to forensic dentistry although its use will be limited by the access to the expertise and equipment to undertake it. [6]

Bite marks on inanimate objects:

It is important for both, investigative Professionals and Odontologists to be aware that bite marks in an inanimate objects can be of assistance in criminal investigations, although the same principle of bite mark assessment applies i.e. the bite must hold a high level of forensic significance before it can be considered for comparison to a suspect for the purposes of identification. [6]

In literature, bite marks are found in a variety of non-human substrates like pencils, pacifiers, envelopes, bank books, wooden cabinets, pipe stems, and mouth pieces of musical instruments and more commonly in food stuffs such as apple, cheese, sandwiches, chocolates, chewing gums etc. [7, 23, 24]

Since the bite marks in food substances may produce exact mesiodistal dimension of teeth, records should be made as soon as possible. Saliva swabbing can be taken from the bite marks for blood group analysis or DNA analysis. [7, 12] The Forensic value of bites in non human materials is based upon the nature of the material itself and in case of perishable items, how long ago the bite took place and what steps were taken to preserve the object. [25]

Preservation and Analysis of Bite Marks in Inanimate Objects:

Storage of the food materials with bite marks can be done by placing them in airtight bags and then refrigerator or by using preservative solutions made up of equal parts of glacial acetic acid, formalin and alcohol. Long term preservation can be done by taking photographs and by preserving models.

In case of bite marks in inanimate objects like cheese, chocolate, apples etc. a 'docking' procedure may be undertaken. The dental model of a suspect is applied to the cast of the bitten object to determine if they 'dock' or match. Such analyses are relatively simple and are easily documented for presentation in court. Bites on flat surfaces like paper can be analysed using an overlay technique, similar to skin. The conclusions that are reached are the same as those for traditional bite mark analyses. [6]

In a bite mark analysis two simultaneous and opposite paths develop. The inclusive path is one in which the unique features of a suspected biter's dentition show a strong and consistent linking in a tooth-by-tooth and arch – to-arch comparison with the pattern recorded in the bitten skin or object. The exclusive path is one in which the suspected biter's dentition does not show linking with the bite mark injury in an arch-to-arch and tooth-by tooth analysis. It is usually the exclusionary process that is accomplished more frequently and easily than the inclusionary path. [7]

Conclusion:

The serious nature of the crimes in which bites are found often dictates that the highest level of Forensic standards should be applied and need for individuals trained and experienced in the recognition, collection and analysis of this type of evidence is increasing. Analysis of such injuries should only be undertaken if unique or, in certain circumstances where class characteristics exist. With recent advances in research, more objective methods of bite mark analysis like salivary DNA recovery and bacterial genotyping have become the main stay of investigation in such crimes.

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Fig. 1: Measurement of bite mark

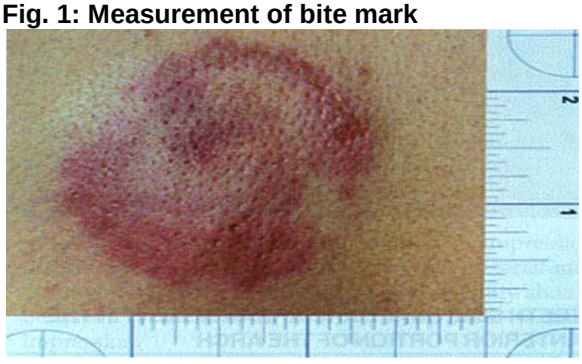

Fig.2: Impression of dentition of an individual using rubber base impression material

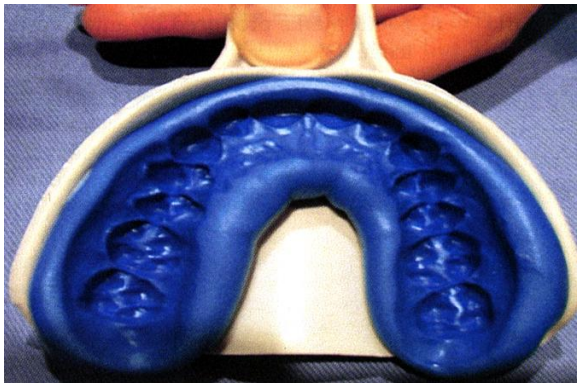

Fig. 3: Master cast (after making impression of dentition)

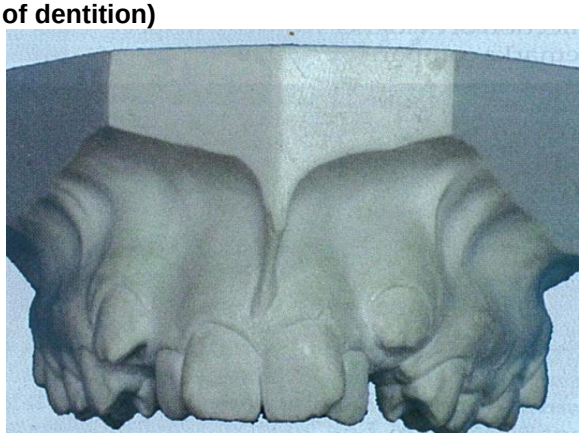

Fig. 4: Comparison of model from the suspect with given bite mark

Fig. 5: Odontometric triangle method