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Review Article

Identification of a person with the help of bite mark analysis

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ABSTRACT

Background: Forensic dentistry is an essential part of Forensic science, mainly involves the identification of an assailant by comparing a record of their dentition (set of teeth) with a record of a bite mark left on a victim. Other uses in law for dentists include the identification of human remains, medico-legal assessment of trauma to oral tissues, and testimony about dental malpractice. While the practice of human identification is well established, validated and proven to be accurate, the practice of bite mark analysis is less well accepted. The principle of identifying an injury as a bite mark is complex and, depending on severity and anatomical location, highly subjective. Following the identification of an injury as a bite mark, the comparison of the pattern produced to a suspect's dentition is even more contentious and an area of great debate within contemporary odontological practice. Like fingerprints and DNA, bite marks are unique to an individual – such as distance and angles between teeth, missing teeth, fillings and dental work. This type of impression evidence can be left in the skin of a victim and also can be in food, chewing gum and other miscellaneous items such as pens and pencils. The advent of DNA analysis and its recovery from bite marks has offered an objective method of bite mark analysis.

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1. Introduction

Identification by teeth is not a new technique. It dates back as far as 66 A.D. at the times of Nero. As the story goes, Nero's mother Agrippina had her soldiers kill Lollia Paulina, with instructions to bring back her head as proof that she was dead. Agrippina, unable to positively identify the head, examined the front teeth and on finding the discoloured front tooth confirmed the identity of the victim. During the U.S. Revolutionary War, Paul Revere (a young dentist) helped to identify war casualties by his bridgework. Teeth are highly resistant to

destruction and decomposition, effects of adverse environmental conditions like air, water and extremes of temperature, dental identification thus can be made under extreme circumstances. It was used on Adolf Hitler and Eva Braun at the end of World War II, the New York City World Trade Center bombing, the Waco Branch Davidien siege, and numerous airplane crashes and natural disasters.

Forensic odontology is still new to criminal justice officials and its success in the criminal justice field is also not so well researched. Prior to 1950, the number of cases where bite marks were used as evidence was small as compared to today.

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A large proportion was reported in Europe and Japan, but most cases originated in the USA. In 2002, over 400 forensic odontologists were listed in the American Academy of Forensic Sciences (AAFS).¹ Major dental clues, being neglected in past are now increasingly used to solve crimes.

Sorup² was the first to publish an analysis of bite marks. Human bite marks are found when teeth are used as weapons. They can be used as weapons of anger; weapons of excitement; weapons of control or weapons of destruction.³ It can be found in food, flesh, cigars, pipes and musical instruments.⁴ Bite marks in themselves provide a kind of dental identification. It is now realized that bite marks have come to provide detail of a kind comparable with the infinitesimal detail that was previously thought likely to be provided only by fingerprints.

The process of comparing bite marks with a suspect's dentition includes analysis and measurement of size, shape and position of the individual teeth.⁵ Most comparison methods involve the fabrication of overlays.⁶ There are a number of different ways to produce overlays from a suspect's dentition: hand tracing from dental study casts,⁷ hand-tracing from wax impressions,⁸ hand-tracing from xerographic images,⁹ the radio opaque wax impression method¹⁰ and the computer-based method.¹¹ Sweet and Bowers⁷ studied the accuracy of these bite mark overlay production methods and concluded that the computer-generated overlays provided the most accurate and reproducible exemplars.

It has been estimated that by use of computer there were over two billion possibilities in the charting of adult dentition.^{12,13} This would therefore rule out the possibility of two adults having exactly the identical dentition.¹⁴ And hence the theory of uniqueness is a strong point used in the analysis of bite marks to convince the court of law that a dentition in one individual is different from other human dentition.¹⁵ This uniqueness is displaced vividly in a bite mark that is well executed.² Forensic aspects of bite mark analysis can be applied in case of teeth marks left in food stuffs or in the crimes when the victim bites the assailant in self defence or on the victim found in cases of sexual offences like rape. Differences in teeth are as different as those marks found by other tools and fingerprints. Though a person's teeth may look the same, they are different in size, shape, arrangement, wear & tear, damage, age, quality and quantity and habits of the individual. A bite mark, however, is not an accurate representation of the teeth. A lot depends on the mechanics of jaw movement and use of the tongue.

Forensic aspect of bite marks analysis can be applied in the following circumstances:

- 1) Teeth marks left in the food stuffs.
- 2) Teeth marks on the criminal: When the victim bites the assailant in self defence.
- 3) Teeth marks on the victim: Found in cases of assault and murder and were usually caused during or after sexual act. It might be due to:
 - a) Self infliction by the victim.
 - b) The criminal attacking the victim usually during sexual offences like rape, and are found mostly on the breast, neck or cheek.

2. Guidelines for the analysis of bite marks

To standardize the analysis of bite marks the American Board of Forensic Odontostomatology (ABFO)² established the following guidelines in 1986:

- 1) History – Obtain history of any dental treatment subsequent to, or in proximity to, the date of the bite mark.
- 2) Photography – Extra-oral photo-graphs including full face and profile views, intraoral should include frontal views, two lateral views and an occlusal view of each arch. Often it's useful to include a photograph of maximal mouth opening. If inanimate materials, such as food stuffs, are used for test bites the results should be preserved photographically. Place a scale beside the bite mark and make a note of distance at which photograph was taken. UV light photographs can see the damage deeper into the tissue and can capture the spacing, size and shape of teeth. A blood group determination is possible in bite marks in human tissue as well as in food stuffs on account of saliva left in bite mark.
- 3) Extra-oral examination – It include observation and recording of soft and hard tissue factor that may influence biting dynamics. Measurements of maximal opening and any deviations on opening or closing should be made. The presence of facial scars or evidence of surgery should be noted, as well as the presence of facial hair.
- 4) Intra-oral examination – Salivary swabs should be taken. The tongue should be examined to assess size and function. The periodontal status should be noted with particular reference to mobility. Prepare a dental chart if possible.
- 5) Impressions – Take two impressions of each arch using material that meet the American Dental Association specifications. The occlusal relationship should be recorded.
- 6) Sample bites – Whenever possible, sample bites should be made into an appropriate material, simulating the type of bite under study.
- 7) Study casts – Casts should be prepared using Type II stone according to manufacturer's specifications, using accepted dental techniques. Additional casts should be made by duplicating the master casts.

These casts can be made from a variety of materials like silicon rubber, plastic and powders. Subjects, made a bite on a sample of bite registration wax sheet (Size 10 × 6 × 0.5 cm). Levine⁵ suggested the use of Aluwax. Bites are made with an incisive action to get impression of the incisal edges and a portion of the labial and lingual surfaces of upper and lower incisors and canines. Subjects are told to bite on apple or to bite on their own flexor surface of forearm.

Impressions of upper and lower arch are taken and plaster cast made. Only central incisors and canine are preserved and the rest are trimmed. In case of a deceased person, the bite mark be excised for further forensic bite mark analysis or the whole body may be taken to a facility where it can be examined. Each model and bite marks on bite registration wax, apple and skin is photographed with scale besides using SLR camera with extension tube for close up photography. Each photograph is enlarged keeping the scale so as to get life size

photography while printing. 1:1 photography is done for bite marks and teeth model.

Then the comparison of bite marks and teeth model is done by two methods – odontometric triangle (Objective) method and superimposition (Subjective) method. The grading for superimposition (Subjective) method given are:

Grade A – Fully superimposition

Grade B – Partially superimposition

Grade C – No superimposition

In odontometric triangle method (Objective method) a triangle is made on the tracing of bite marks and teeth models by making three points-A,B,C. Points A & B are plotted on the outermost convex point on the canine teeth. Center of upper two central incisors is selected as point C. And all the three points are joined to form a triangle ABC. Lines AB, BC, CA are measured and angles a, b, c were calculated. This was done for both upper and lower jaw. Of teeth model and compared with that of bite marks of wax, apple and skin statistical analysis is carried out and results are obtained.

3. Image perception software procedure

A photograph of a bite mark is opened with the image perception software, and a region of interest is then selected. After such selection, colours can be added to different grey scale areas of the image. The assigning of selected colours to levels of grey values enables the forensic odontologist to select regions with similar grey values or to enhance subtle differences of grey values in the picture. The human eye can only distinguish about 40 shades of grey in a monochrome image, but can distinguish hundreds of different colours.¹⁶ This will make it easier to establish which regions of pixel intensity is part of the bite mark and which are not. By omitting certain areas of pixel intensity, it is possible to isolate the region of the image which shows the bite mark. A detailed image of the bite mark is produced. The coloured image of the bite mark is now layered over the original bite mark photograph using Photoshop® of Adobe Systems.

4. Discussion

Since 1950, bite mark evidence and dentists have played a role in judicial system.¹⁴ The scientific basis of bite mark analysis is rooted in the premise of individuality of human dentition, the belief that no two humans have identical dentitions in regard to size, shape and alignment of teeth.^{13,17}

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.^{12,18} Tooth markings may also be found on foods like chocolates, vegetables, chewing gums, Styrofoam cups, cigarette but and even on steering wheel of a car,^{14,19} Bermitz et al and Pretty et al even reported a case of a murder in which the bite marks in a piece of cheese was recorded.¹⁵ Bite marks left in substances which are malleable like cheese have a more potential for

accurate identification.^{12,20} 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.²¹ 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.

Although more research is needed to explore 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 accurate 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.

More research is needed since bite mark evidence on its own does not always produce conclusive results.

5. Conclusion

The field of bite mark science is expanding, and the need for individuals trained and experienced in the recognition, collection and analysis of this type of evidence is increasing. Conclusions from bite mark analysis can assist to answer some very crucial questions about the happenings at the crime scene thus helping judicial system. The often serious nature of the crimes in which bites are found dictates that the highest level of forensic standards should be applied and that analyses of such injuries should only be undertaken if unique or, in certain circumstance, class characteristics exist. Research into more objective methods of bite mark analysis has produced techniques such as salivary DNA recovery and bacterial genotyping, although further efforts to reduce subjectivity in standard physical techniques are required.

Conflicts of interest

All authors have none to declare.

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