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REVIEW ARTICLE

Reliability of Computer Assisted Method for Bite Mark Analysis: A Narrative Review

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ABSTRACT

Bite mark analysis is one of the fundamental characteristic of forensic odontology, aiding in the identification of perpetrators in crimes. Computer-assisted methods have emerged as a promising tool in bite mark analysis, offering improved accuracy and efficiency. This article aims to review the reliability of computer-assisted methods for bite mark analysis. This review underscores the potential of computer-assisted methods in bite mark analysis, while emphasizing the need for further research to establish their reliability and validity. Ultimately, this review aims to inform forensic practitioners, researchers, and policymakers about the current state of computer-assisted bite mark analysis and its potential applications in forensic science.

KEYWORDS

• Bite mark analysis • Computer-assisted methods • Forensic odontology

INTRODUCTION

Forensic Dentistry / Forensic Odontology defined by **(FDI)** as "branch of dentistry which, in the interest of justice, deals with the proper handling and examination of dental evidence & with the proper evaluation & presentation of dental findings."[1] It is a field of dentistry which deals with bite mark analysis and identification, mass disaster victim identification, missing person databases and identification, and other

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legal issues.[2] All of which bite mark analysis is the most practical and divisive method.

Bite mark is the result of an array created by human or animal dentitions and allied structures on any component capable of being marked by those means.[3] ABFO defines bite-marks as "a pattern left in an object or tissue by the dental structures of an animal or human,";[4] ABFO describes bite mark as "a circular or oval patterned injury consisting of two opposing symmetrical, U-shaped arches separated at their bases by open spaces. Following the periphery of the arches are a series of individual abrasions, contusions, and/or lacerations reflecting the size, shape, arrangement, and distribution of the class characteristics of the contacting surfaces of the human dentition".[5] As bite marks are the most familiar evidence found at the crime scene in cases of assault, so can be the lone link of anticipation the convict. Bite mark analysis not only explicate the nature of violence but also the lapsed time between its creation and inspection. Through bite marks it can also be acknowledged whether it was produced intra-victim or post mortem.[6] Bite marks due its unique class and individual characteristics are widely accepted legal evidence that can be produced in the court.[15] Therefore, a system which reduces human interaction to conduct the assessment would be constructive to ensure exactitude and reduce human bias.[7] Bite mark examination involves assessment of anonymous mark found on object or skin of victim to known prototypes of suspected dentition.

The approach of this paper is to summarize various methods of bite mark examination and to confirm the significance of digital method for confirming bite mark identification.

An approach towards bite mark investigation

Various guidelines have been proposed for the bite mark analysis. Leading step towards it includes:[2,8]

- Complete explanation of bite mark
- Through assemblage of substantiation from the victim
- Assemblage of the dental records of convict
- Proper analysis of the evidence

Various methods of pattern analysis in bite mark.

DIRECT METHOD

Physical methods for direct analysis of bite marks

Comparison technique: Archetypal from the questionable can be directly positioned over the bite mark on skin or photograph of the bite mark to establish concordant points.[6,9] Prepared stone dental models are opaque so they thwart the assessment of the underlying marks, making eloquent, in-depth feature assessment impossible. However, the positioning of stone dental models directly on skin and moving them to assist visualization or imitate possible bite mechanisms can cause grave complications, including a prospect of crafting iatrogenic artifacts. Such artifacts could then be jumbled with actual injury pattern information and can result in error.[5]

Odontometric triangle method: an autonomous method, in which a triangle is made on the tracing of bite marks and teeth mockups by marking three points, two on the outermost convex points of canines and one in the centre of the upper central incisors. Three angles and arms of the triangles are measured and compared in both the jaws.[6,10]

Other methods based on metric analysis include; Vectron and Stereometric graphic analysis however not much literature is present in reference.

INDIRECT METHOD

The essential idea behind indirect comparison is that an image of the biting edges of the suspect's teeth is superimposed on an image of the bite injury to see whether the images match. In various methods for indirect ways of bite mark comparison, a dental exemplars[5] of bitting surface of suspect (solid and hollow volume type) are created on clear acetate and compared to the injury of the victim.

A transparent overlay of occlusal surfaces is produced through various methods and the compared with the 1:1 scale photograph of bite mark for comparison.[6]

Bite mark photography[6]

Bite mark photographs should include:

Photographs taken in black and white and colour.

Along with ABFO scale no. 2

On and off camera flash

Photographs should be taken at an angle of 90 degree to the injury.

Oblique shots to highlight the three dimensional view of bite

Close up shots to scale 1:1 life size image

An overall body shot to notify the location of bite

If bite located on a flexible anatomic location, photographs should include positions adopted in various positions

Photographs should be taken at 24 hrs interval to assess the change in appearance of bite mark.

UV photography is indicated if the injury is fading

Various methods of overlay production Sweet and Bowers (1998)[5,5]

Hand tracing from study casts

Acetate sheet is positioned over the biting surface of study cast and perimeter of the biting surface is hand traced subjectively for comparison.

Hand tracing from wax impression

Cast is pressed over the wax sheet to make an impression and this impression later on used for making overlay by placing transparency over and hand tracing the biting perimeters.

Radiopaque wax impression

Wax impression of cast is prepared on wax sheet; on the individual tooth impression amalgam mixed with spirit is painted which is later on subjected for obtaining a radiograph image of the painted impression at 90 degree angulation. Overlay is prepared by hand tracing of radiographic image.

Xerographic method

It involves comparing the overlays generated with images of the bite mark directly by human inspection. The maxillary and mandibular study casts are placed on the glass plate of the photo copy machine. It is then photocopied on an A4 sized plain white paper. A transparent sheet is then overlaid on the photocopy image and the outlines are traced. The overlay is then scanned and the image is saved as xerography overlay.

All this methods of overlay making is proceeded by matching of the prepared overlay with the suspect cast and establishing the comparison result by various method such as *Matrix method* (Bowers 1998) in which overlays generated are compared with the bite mark images using parameters such as area measurement in millimeters and centroid position in (x,y) coordinates. These methods of comparison for bite mark analysis are quiet slanted and thus result can be human biased and result depends upon the observer elucidation and significant errors incorporated in overlay may lead to difficulty in establishing confident conclusion. However, these methods were more accepted precisely when compared to the former direct comparison methods.

To overcome the above limitation a *Human bite mark identification method based on image processing*[2] was developed and studied by Borker S and Naik H. a database of overlay images is formed by scanning the prepared overlay on scanner and both bite mark images and database of overlay are edited by MS paint software and line were drawn to for each tooth from one edge to other and then the image is transferred to the MATLAB software. The images are cropped to extract for upper and lower jaw. These images were compared on the basis of various parameters of centroid, major axis length and orientation. To establish the reliability of the method 15 overlays set were studied and of them 10 were successfully positively identified. This study has obtained 67% positive identification and has proved to be much competent and faster.

These computer generated methods are however considered as gold standard for comparing the bite marks with the dental exemplars of suspect. As all the methods have considered the 2D factor of maxilla and mandibular movement only for the production of bite mark and have disregarded the third factor of victim's reaction that can result in significant difference in the conclusion of identification.[11] Study done by Daniel MJ *et al* have established the high accuracy of this method over the wax impression and radiographic method.

ABFO has henceforth recommended an objective method using adobe photoshop (ABFO 1995) considering the 3D factors for bite production. Another landmark was laid by Dr. Heidi Christensen in 1996; by evolving a

method of scanning dental models on a flatbed scanner, then generating solid and hollow volume overlays using Adobe Photoshop. In 1998 Sweet and Bowers had compared five systems of overlay formation and have concluded computer generated method most reliable and accurate to other modalities. In 2000 Johansen and Bowers have proposed detailed directives for the computer generated method for analysis and identification of bite marks.

Methodology of Digital analysis of bite mark based on image perception.[12]

The technique involves use of flatbed scanner for scanning of the study cast which is later on used for producing hollow and compound overlay.[13] Image perception software is used to assign different colour to the different grayscale 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. This helps to establish the regions which are included in bite mark and to exclude the redundant regions. A comprehensive image of bite mark is created by making the resolution of image to be compatible with the resolution of original photograph. Part of ABFO scale is made visible in the processed image to aid in overlapping of the image to original bite mark photograph using adobe photoshop software by altering the image opacity accordingly. The processed image is used to harbour the overlay of the suspect bite mark. For comparison and establishing the outcome of the analysis, hollow and compound overlays are used.

By using the image perception software it is probable to illustrate the 2D photograph as 3D surface detail to establish the accurate comparison.

CONCLUSION

Field of forensic is expanding and there the odontologists are playing a key role to give a wide scope to the investigation of crime. Due to the uniqueness of human and individuals' dentition bite marks serve as both physical as well as biological evidence. Bite marks as fingerprint serve as a major circumstantial evidence of crime scene and can result as last nail in tomb for the convict. This can be proved as chief evidence only if proper methodology for evidence collection and analysis is followed. Diverse methods for bite mark analysis are present till date and have been tried by various researchers for same. The art of bite mark analysis is relatively novel and possibly valued and technology has set a mile stone through Computer assisted method which is proved to be the gold standard for bite mark analysis. Compared to the hand tracing methods computer assisted methods have been studied to be highly reliable and accurate and hence more advisable to use.

Conflicting Interest: None

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