

Analysis and Identification of Bite Marks in Forensic Casework

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Abstract

Analysis of bite marks plays an important role in personal identification in forensic casework. Bite marks can be recorded in violent crimes such as sexual offences, homicides, child abuse cases, and during sports events. The arrangement, size and alignment of human teeth are individualistic to each person. 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 are 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.

Key Words: Bite Marks, Class Characteristics, Individual Characteristics, Forensic Dentistry

Introduction

“The criminal may lie through his teeth though the teeth themselves cannot lie” Furness [1]. 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 [2,3]. In other words, a bite mark may be defined as a mark having occurred as a result of either a physical alteration 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 [4,5].

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 [6]. In cases of sexual assault, face, lips, breasts, shoulder, neck, thigh, genitals and testicles are mostly involved [7,8]. 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. [9-11]. 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 intentionally caused, those found on food articles are usually unnoticeably left by the offenders at the scene of crime [12]. In order to identify the offender, the dental casts of suspected persons are prepared using dental material and matched. Bite marks if analysed properly can prove the involvement of a particular person or persons in a particular crime [13].

The present paper describes the classification, characteristics, mechanism of production, and appearance of bite mark injuries, and collection of evidence, comparison techniques, and technical aids used in the analysis of the bite marks.

Classification of Bite Marks

Bite marks can be broadly classified as non-human (animal bite marks) and those inflicted by humans. Based on the manner of causation, the bite marks can be non-criminal (such as love bites) as well as criminal which can further be classified into offensive (upon victim by assailant) and defensive (upon assailant by victim) bite marks [14,15].

There are seven types of bite marks [16]; ‘Haemorrhage’ (a small bleeding spot), ‘Abrasion’ (undamaging mark on skin), ‘Contusion’ (ruptured blood vessels, bruise), ‘Laceration’ (near puncture of skin), ‘Incision’ (neat punctured or torn skin), ‘Avulsion’ (removal of skin), and ‘Artefact’ (bitten-off piece of body). These further can be classified into four degrees of impressions; ‘Clearly defined’ that results from the application of significant pressure, ‘Obviously defined’ which is the effect of first degree pressure, ‘Quite noticeable’ due to violent pressure and ‘Lacerated’ when the skin is violently torn from the body [17].

The following classes that are of proven significance in practical application regarding bite marks are:

Class I: It includes diffused bite marks, which is having limited class characteristics and lacks individual characteristics. Such as bruise, diffused bite mark, a smoking ring or, a faint bite mark.

Class II: This pattern of injury referred to as a single arch bite or the partial bite mark as it has some individual and some class characteristics.

Class III: This classification includes both individual as well as class characteristics. This bite has great evidentiary value and used mostly for the comparison purposes. The main sites for this type of bite on the body are buttocks, shoulder, an upper arm or the chest. The pressure and deep penetration of tissue is held to record the lingual surface of anterior teeth.

Class IV: Mainly, avulsion or laceration of the tissues is caused by the bite. In this class, class characteristics and

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individual characteristics are not present. This type of bite is commonly found where there is avulsion of an ear or finger [18].

Characteristics of Bite Marks

Class characteristics

According to the Manual of American Board of Forensic Odontology (ABFO) [18], a class characteristic is a feature, characteristic, or pattern that distinguishes a bite mark from other patterned injuries. It helps to identify the group from which the bite mark originates. 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 [19].

In a bite mark, the front teeth which include the central incisors, lateral incisors and the cuspids are the primary biting teeth according to tooth class characteristics [20]. 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 uniform in width, while the mandibular cuspids are cone shaped [21].

The bite mark characteristics help in determining if the marks were from maxillary teeth or the mandibular teeth. According to the bite mark characteristics, the maxillary central incisors and lateral incisors make rectangular marks of which the centrals are wider than the laterals and the maxillary cuspids 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 cuspids produce round or oval marks [22].

Individual characteristics

Individual characteristics are deviations 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 [18]. 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 [23]. The teeth of different individuals differ from one another with respect to their size, their position in the dental arches and in their shape (Figure 1). 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 [24]. 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,



Figure 1. Images of different bite marks on human skin.

muscle function, individual tooth movement and TMJ (Temporomandibular joint) dysfunction in the perpetrator [25].

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 application by incisal edges of anterior teeth/occlusal edges of posterior teeth [26]. Severity of bite mark depends upon duration, degree of force applied and degree of movement between tooth and tissue. Clinical presentation of tooth pressure indicates pale areas representing incisal 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 scraping against tooth surface commonly involving the anterior teeth. Clinical presentation can be in the form of scratches and abrasions. Scratches and abrasions that indicate irregularity and peculiarity of incisal edges are useful in identification [21].

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 [24].

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 [27,28]. Rarely atypical human bite presentations are reported that need careful analysis and explanations regarding its production [29,30].

The dermal properties, anatomical site of the bite, age of the victim and weight are responsible for the distortion produced by bite marks [31,32]. Body parts with loose skin bruises easily due to excess subcutaneous fat, lesser fibrous tissue and muscular tone [13-15]. 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.

Collection of Evidence in Bite Mark Analysis

Collection of evidence from the victim

DNA present in salivary trace evidence can be obtained by swabbing the bite site. The double swab technique [22] involves moistening the site with a swab, moistened with sterile saline, and then removing of the moisture with a second dry swab and both swabs can be sent for analysis [33]. Then, DNA fingerprinting can be done from salivary trace evidence of biter's exfoliated epithelial cells.

An important element of dental forensic examination is photography [31]. Magistrates and investigators often require it, because pictures are able to show the maxillary and mandibular teeth, their characteristics, pathologies and dental treatment. Photographs of the bite mark surface are taken and tissue samples are collected from the victim. Close up photographs of bite marks are taken under high resolution and colour balance is maintained while using colour films. A colour photographic film is used whenever required [34]. A scale should be kept in the same plane and adjacent to the bite marks and chances of distortion should be negated during photography of the bite marks. Currently, photographic evidence is the most common initial method for recording the presence and the details of skin bite marks. The lighting conditions and reconstruction of the particular position of the body where the bite mark was given at the time of infliction of bite to reduce the postural effects and photograph components of the secondary distortion should be properly managed. It is suggested that the orientation of the camera should be set up at 90° to the centre of the wound to reduce distortion.

Collection of evidence from the suspect

Inanimate materials, food stuffs and objects on which test bites are taken are photographed precisely. Extra oral examination includes the examination of hard and soft tissues factors, TMJ status and facial asymmetry muscle zone. Maximum inter incisal opening, deviations in opening/ closing the jaws, occlusal disharmonies, facial scars, evidence of surgery and presence of surgery should also be well photographed. Intra orally, salivary evidence, examination of tongue for size and

function, abnormality in form of ankyloglossia, periodontal examination and condition of teeth are noted [35].

Two impressions of each arch with ADA (American Dental Association) specified material is followed by obtaining dental casts with type II stone called MASTER CAST. Duplicate casts can be obtained from master cast [18]. Teeth and soft tissues should not be altered by carving, trimming or making other alterations. Sample bites are made into appropriate material simulating the type of bite under examination.

Bite Mark Analysis and Identification

The exact identification of a living person using individual traits and characteristics of the teeth and jaws is the basis of forensic science [36]. The bite marks left on a person may be used to identify the perpetrator. Bite mark identification is based on the individuality of a dentition, which is used to match a bite mark to a suspected person. One can exactly match the bite marks to the accused biter's dentition [37]. The most important step in bite mark analysis is to recognize a patterned injury as a human bite mark followed by pattern analysis of the bite mark which provide the individual information about the suspect or an offender and relate the person who is involved in the crime. Bite marks with high evidence value that can be used in comparisons with the suspects' teeth will include marks from specific teeth that record different characters. The surface abrasion or sub-surface haemorrhage caused by human bites appears as an arch. They are caused by the incisors, canines and premolars. Contusions are the most common type of bite mark. It can be determined from the type of bleeding under the skin whether the victim was alive or dead at the time the bite mark was delivered [38,39].

It is important to have individual characteristics in the bite mark to identify the perpetrator. Use, misuse, and abuse of the teeth result in features that are referred to as accidental or individual traits. If individual traits are not present in the teeth in the bite marks, the forensic significance of the bite mark is reduced [38]. Sometimes, palatal rugae impressions obtained along with the impressions of teeth can also help in the identification of the individual involved in crime. These are present in the form of a crest and are usually three to seven in number [40].

One of the most remarkable, difficult and sometimes troublesome challenges in forensic dentistry is the identification, recovery and analysis of the bite marks with the suspected biters. In a study by Page et al. [41] on retrospective analysis of bite mark casework of 119 cases, it has been observed that the practice of bite mark analysis does not much strengthen odontology evidence as well as position of forensic practitioner in the courts of law. They further suggested that the forensic practitioners should be quite careful while giving opinion regarding the origin of the bite mark and the identification of the criminal on the basis of bite mark evidence. The conviction whether the accused is the biter or not is based on the expert testimony of the forensic odontologist after matching a bite mark with that of the dentition of the accused. In a recent communication, Pretty

and Sweet [42] described the current status and a paradigm shift in the analysis of bite marks following some recent research and case studies of wrongful convictions on the basis of bite marks. They further stressed that though the bite marks analysis has the ability to defend the innocent, protect children from harmful care givers, and convict the guilty, this at the same time, may also be the enemy of natural justice.

Conclusion

Bite mark analysis is an important aspect of forensic dentistry that is invaluable in solving crimes and in identification of persons involved in 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. The science of bite mark identification is quite new and potentially valuable. Bite marks if analysed properly not only can prove the participation of a particular person or persons in crime but also help in exoneration of the innocent. The field of bite mark science is continuing to develop, and so is the need for those who are trained and experienced in the identification with regard to the cases relating to the bite marks.

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References

1. Furness J. A new method for the identification of teeth marks in cases of assault and homicide. *British Dental Journal* 1968; **124**: 261-267.
2. MacDonald DG. Bite mark recognition and interpretation. *Journal of Forensic Science Society* 1974; **14**: 229-233.
3. Whittaker DK, MacDonald DG. A Color Atlas of *Forensic Dentistry*. London: Wolfe Medical Publications; 1989.
4. Wagner GN. Scientific Methods of Identification. In: *Forensic Dentistry*. New York: CRC Press; 1997. pp. 1-36.
5. Sweet D, Pretty IA. A look at forensic dentistry- Part 2: Teeth as weapons of violence- identification of bite mark perpetrators. *British Dental Journal* 2001; **190**: 415-418.
6. Lessig R, Wenzel V, Weber M. Bite mark analysis in forensic routine case work. *Experimental and Clinical Sciences International Online Journal* 2006; **5**: 93-102.
7. Levine LJ. Bitemark evidence. *Dental Clinics of North America* 1977; **21**: 145-158.
8. Wagner GN. Bitemark identification in child abuse cases. *Pediatric Dentistry* 1986; **8**: 96-100.
9. Endris R. *Praktische Forensische Odonto-Stomatologie*. Heidelberg: Kriminalistik Verlag; 1979.
10. McKenna CJ, Haron MI, Brown KA, et al. Bitemarks in chocolate: a case report. *Journal of Forensic Odontostomatology* 2000; **18**: 10-14.
11. Saglam AS, Gökdemir K, Kedici PS, et al. Bitemarks in forensic odontology. *Journal of Forensic Odontostomatology* 1998; **16**: 30-34.
12. Röttscher K, Pilz W, Solheim T. Bissspur – Zahnspur. In: Madea B, Brinkmann B, editors. *Handbuch gerichtliche Medizin*, volume 2. New York: Springer Berlin-Heidelberg; 2003. pp. 1699-1728.
13. Layton JJ. Identification from a bite mark in cheese. *Journal of Forensic Science Society* 1966; **6**: 76-80.
14. Solheim T, Leidal TI. Scanning electron microscopy in the investigation of bite marks in foodstuffs. *Forensic Science*

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Authors' contributions

SK conceived, designed contributed the major portion of the manuscript. KK and TK wrote, reviewed, added their experiences and edited the whole manuscript. PMC contributed to all sections of the manuscripts and compiled the references. All the authors have read and approved the final version of the manuscript.

Conflict of interest statement

The authors declare that there is no conflict regarding this article.

International 1975; **6**: 205-215.

15. Webster G. A suggested classification of bite marks in foodstuffs in forensic dental analysis. *Forensic Science International* 1982; **20**: 45-52.
16. Shamim T, Varghese VI, Shameena PM, et al. Human bite marks: The tool marks of the oral cavity. *Journal of Indian Academy of Forensic Medicine* 2006; **28**: 52-54.
17. Sweet D. Human Bite marks: Examination recovery and analysis. In: Bowers CM, Bell G, editors. *Manual of Forensic Odontology*. Ontario: Manticore; 1995.
18. ABFO, *American Board of Forensic Odontology - Diplomates Reference Manual*; June-2010.
19. Pretty IA, Sweet D. A look at forensic dentistry- Part 1: The role of teeth in the determination of human identity. *British Dental Journal* 2001; **190**: 359-366.
20. Saferstein R. *Criminalistics: An Introduction to Forensic Science*. 9th edition. NJ: Upper Saddle River; Prentice Hall, 2007.
21. Beena VT, Gopinath D, Heera R, et al. Bite Marks From The Crime Scene- An Overview. *Oral and Maxillofacial Pathology Journal* 2012; **3**: 192-197.
22. Bowers CM. *Forensic Dental Evidence: An Investigator's Handbook*. Boston: Elsevier Academic Press; 2004.
23. Knight B. *Forensic Pathology: 2*. Arnold Publishers; 1996.
24. Clark DH. *Practical Forensic Odontology*. USA, Maryland: Elsevier-Butterworth Heinemann Ltd; 1992.
25. Kanchan T, Menezes RG. Double human bite—A different perspective. *Journal of Forensic and Legal Medicine* 2009; **16**: 297.
26. Vale GL. Dentistry, bite marks and investigation of crime. *Journal of California Dental Association* 1996; **25**: 29-34.
27. Dorion RB. Bite Mark Evidence. *Journal of Canadian Dental Association* 1982; **48**: 795-798.
28. Stavrianos C, Vasiliadis L, Papadopoulos C, et al. Loss of the Ear Cartilage from a Human Bite. *Research Journal of Medical Sciences* 2011; **5**: 20-24.
29. Sweet D, Lorente JA, Lorent M, et al. An improved method to recover saliva from human skin: the double swab technique.

Journal of Forensic Sciences 1997; **42**: 320-322.

30. Pretty IA. The barriers to achieving evidence base for bite mark analysis. *Forensic Science International* 2006; **159**: 110-120.

31. Rawson RD, Vale GL, Herschaft EE, et al. Analysis of Photographic Distortion in Bite Marks: A Report of the Bite Mark Guidelines Committee. *Journal of Forensic Sciences* 1986; **31**:1261-68.

32. Vale GL, Sognaes RF, Felando GN, et al. Unusual Three-dimensional Bite Mark Evidence in a Homicide Case. *Journal of Forensic Sciences* 1976; **21**: 642-665.

33. Lessig R, Benthaus S. Forensische Odontostomatologie. *Rechtsmedizin* 2003; **13**: 161-8.

34. Bush MA, Miller RG, Bush PJ, et al. Biomechanical factors in human dermal bite marks in a cadaver model. *Journal of Forensic Sciences* 2009; **54**:167-76.

35. Pretty IA. Forensic Dentistry: 2. Bite marks and Bite Injuries. *Dental Update* 2008; **35**: 48-50.

36. Cottone J, Standish SM. *Outline of Forensic Dentistry Yearbook*, Chicago IL: Medical Publishers, 1982.

37. Rothwell RR. Bite marks in forensic dentistry: a review of legal, scientific issues. *Journal of American Dental Association* 1995; **126**: 223-232.

38. Wright FD, Dailey JC. Human bite marks in forensic dentistry. *Dental Clinics of North America* 2001; **45**: 365-97.

39. Williams PL, Warwick R, Dyson M, et al. *Gray's Anatomy*. New York: Churchill Livingstone 1989.

40. Velden AV, Spiessens M, Willams G. Bite mark analysis and comparison using image perception technology. *Journal of Forensic Odontostomatology* 2006; **24**: 14-17.

41. Page M, Taylor J, Blenkin M. Reality bites— A ten-year retrospective analysis of bitemark casework in Australia. *Forensic Science International* 2012; **216**: 82–87.

42. Pretty IA, Sweet D. A paradigm shift in the analysis of bite marks. *Forensic Science International* 2010; **201**: 38-44.