Journal of Forensic Science & Criminology
Volume 10 | Issue 1
ISSN: 2348-9804

Review Article Open Access

A Review Study on Gender Determination with the Help of Bite Marks Analysis

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Received Date: April 25, 2022 **Accepted Date:** April 30, 2022 **Published Date:** May 05, 2022

Citation: Sarav C, Kumar R (2022) A Review Study on Gender Determination with the Help of Bite Marks Analysis. J Forensic Sci Criminol 10(1): 104

Abstract

Bite marks are commonly observed in cases such as slaughter, sexual assault, child abuse cases, and during sports events. Bitemark is a type of 'patterned injury' which played an important role as evidence in judicial system. Bite marks can find on various body parts and various edible leftovers at the Crime Scene which can be used as evidence for identification of the criminals. Teeth impression shows sexual dimorphism and therefore helps in gender estimation. The various dental characteristics are individual-specific. A piece of exhaustive information and examination of indentations can help in the vindication of the guiltless as well as give decisive proof to the conviction of criminals. In certain violations, indentation proof is the main proof on which conviction has been accomplished, especially in rape and kid abuse cases. The present review describes the importance of bite mark analysis, estimation of gender through bite marks, and stability of teeth impression in diverse conditions. This article can give a better comprehension of the methodology used in forensic dentistry when investigating dental impressions.

Keywords: Bite Marks, Sexual Dimorphism, Dental Characteristics, Forensic Dentistry

Introduction

Forensic Odontology, conjointly called forensic dentistry is characterized as "that part of forensic medicine which deals with the correct handling and examination of dental proof and with the proper analysis and presentation of the dental findings to aid in criminal justice system" [1]. Teeth are hard and durable, and hence play an important role in the criminal investigation. The science of studying teeth as evidence appears after 1897 [2].

Bite mark identification is a very useful tool for linking the crime to the suspect. A bite is characterized as the impression made by any human or non-human dentation in the skin of living individual, corpses, or unanimated items with comparatively softened consistency [3]. Bite marks are commonly observed in cases such as slaughter, sexual assault, child abuse cases, during sports events, and sometimes deliberately imposed to deceitfully frame a person. Proper examination of bite mark can reveal features that help in establishing identity, age, gender and can elucidate the kind of violence. Each person's teeth are specific and hence two dentations can never be same [9]. Teeth impression also shows sexual dimorphism. Tooth size and shape can help in estimating age and sex [4]. In general, female teeth have been found to be smaller than those of male [5].

Bite marks are as specific as fingerprints of a person when properly handled and examined; hence they are sometimes called *'Dental Fingerprint'*[6]. For identification of the perpetrator, the dentation cast of the suspect is made utilizing dental material and matched. Some of the characteristics like missing teeth, teeth gaps, malposition of teeth, jaw width, tooth width and size can assist in identification of the biter. The bite mark analysis process involves the comparison of individual and class traits of the questioned indentation with the suspect's dentation [6].

Although, dental impressions do not include all the essentials of a perfect recognition technique (uniqueness, constancy, feasibility), but in some cases, it comprises the specific features for criminal examination [7]. Bite mark examination also have numerous limitations. Bitemarks undergoes changes depending on time, environmental condition and the surface. The dimensions of indentation can shrink in comparatively short time interval and that is the reason, it is advised to record them as early as possible [8]. Incomplete indentations are not decisive and at least 4-5 teeth must be available for solid indentation investigation.

The present review describes the importance of bite mark analysis, estimation of gender through bite marks, and stability of teeth impression in diverse conditions. This article can give a better comprehension of the methodology used in forensic dentistry when investigating dental impressions.

Pretty and Turnbull stated that the central dogma of indentation investigation depends on two presumptions. The one of that is, uniqueness of human dentation and the other one is that adequate feature of the individuality is conveyed through the biting process to empower distinguishing proof [10].

Tooth dimension guidelines dependent on odontometric examinations can be utilized for gender and age estimation [11]. ABFO scale is normally used for measuring bite marks [12]. The L shaped ABFO scale ensure the correct measuring in both horizontal and vertical direction and also works with gridding of photos to address for distortional mistakes made by slanted camera points [13]. Bernstein has narrated the utilization of photography in odontology [14]. In an article published in 1986, Gleen M. Wagner stated that, comparisons are possible even in limited material by using tool mark technology [15]. Enhancement of indentations by computers builds a good examination by further portraying special qualities of the curve and individual teeth.

Berlitz et al. described an instance of homicide with a bitemark in cheese [15]. The culprit was identified by comparing the impression pattern with a review model of the accused dentation. Teeth impression OVERLAY technique was described by Franklin and Curtis [16]. Sheasby and MacDonald, narrated the distortions in the bite marks as primary and secondary [17].

Naether et al studied the bitemarks produced in food, in diverse conditions (time and temperature) [18]. Dimensions were recorded using the digital caliper from the bitemark on food and from dental cast. An alternate method for analysis could be the superimposition of photographs [19]. Photographs have the relative permanency but represents two dimensions while the bitemarks are three dimensional. Therefore, features like depth cannot be measured [20].

González et al. directed a study and displayed that 3D comparisons are more exact as compared to photographic analysis, because the bitemarks are three dimensional [21].

Bitemarks Significance in Forensic

Bite mark assessment is the main part of forensic dentistry in interpreting crimes and identifying criminals because of its uniqueness. In cases where biological fluids and tissues are not found as evidence, bitemark can lead to the criminal identification [22].

Class characteristic helps to identify a group and recognise its origin: human or non-human. The wounds caused by human dentation may vary from contusions to lacerations and severe contaminated injuries. While the animal bite can result in skin tearing and open wounds rather than impact one. The discrete characteristics of indentation can identify a person. Each person has a unique special teeth characteristics like teeth dimensions, position and shape in the dental curves. These individual features also include special characteristic like recognizable bite marks, unusual wear shapes, sharp canines, and so on [23]. Bite marks examination can also assist in determining Gender and age.

Serial murderer Ted Bundy case was one of the famous bite mark cases of the 20th century, in which he murdered at least 100 women. There was no strong proof for conviction and then examination of bitemark proved him guilty [15]. Forensic dentistry was proved very helpful in different cases, for example, in Prime Minister Rajiv Gandhi's death (1991) the dental examination is used for his identification [24]. In Nirbhaya case (2015), bite mark analysis helped in identifying five suspects through photographs and computer-based analysis [25].

In certain violations, indentation proof is the main proof on which conviction has been accomplished, especially in rape and kid abuse cases [26]. Therefore, the inferences from examining bite marks can help identification of the perpetrator. In this way, it is a significant tool for criminal identification. But sometimes mistakes in recording, examination, and investigation of bite mark impressions can result in serious consequences [17].

Evidence Collection

Experts should make significant effort to preserve the bitemark accurately and precisely as soon as it is found. The dimensions of indentation can shrink in a comparatively short time interval and that is the reason, it is advised to record them at the earliest possible time [8].

While collecting evidence from victim, a proper procedure should be followed. The first step is documentation. Record demographics such as name, sex, age along with date and case number. Also document the location, shape, size and colour of the bitemark. Then take the photographs with ABFO scale by placing camera perpendicular to injury. Alternative light sources may also be used. Collection of swabs from bite marks is important to preserve trace evidences if present, like saliva or human cells with which DNA analysis can be performed. [27-28] UV light examination can reveal bitemarks which are not visible to naked eyes. For recording any irregularities produced by the teeth, high-quality imprints of each jaw should be taken with the help of impression material. For rigid support of impression material, plaster or type IV dental stone can be used. Prior to the collection of evidence from suspect, a consent must be taken [22]. The dentation of suspect is analysed and important findings are recorded. The examiner may require suspect's dental impression. For taking impressions various substances can be utilised including alginate impression, vinyl-poly siloxane impression material, gypsum. Generally, dental impression model is made with alginate and water [29]. Photographs of suspect's

dentation should also be taken along with impressions [30]. With the development of computer programs, imaging techniques are also used for bitemark examination. Recent studies focused on the 3D analysis of bitemarks with the help of surface scanners [15].

Bitemark As Evidence for Gender Determination

Teeth impression shows sexual dimorphism and therefore helps in gender estimation. The morphological examination incorporates different feature assessment of teeth for example, teeth dimensions and shape as they are different in male and female. Various methods for morphological examination are known such as the odontometric methods, orthometric methods, cheiloscopy, and so on [31]. Bite mark investigation includes examination of the indentation through metrical or non-metrical technique. Non metric includes shape examination whereas metric includes different dimensions like inter-canine distance, mesio-distal width of the teeth, etc.

As the gender can be identified by odontometric methods, a study was done by Litha et al to examine the buccolingual and mesiodistal sizes of the teeth and concluded that the accuracy of utilising stepwise discriminant functions to identify gender was very high (99.8%) with females having statistically smaller teeth than males [32]. It is clear that morphometric examination can perform a significant role in the recognition of accused and in gender determination [6]. But many experts believe that tooth size measurement or morphology assessment are inadequately precise for criminal investigation, especially in light of more unbiased approaches [51]. Several other researchers have also analysed the ability of odontometric examination to identify gender; Rao *et al*. utilizes the mandibular canine index for gender estimation, while other studies revealed that the results are not accurate while using this method as the accuracy was around 81-85% [49,50].

In both arches, there is a significant increase ($p<0.05$) in the intercanine and intermolar width and which is useful in forensics for identification, determining growth, and sexual dimorphism [33]. Daniel et al studied the assessment of Inter-Canine and Inter-Molar Width as a tool in sex estimation and concluded that maxillary inter-molar width may be used to determine gender correctly. Also, where canines are absent these molars may be used to determine gender [34]. A study on gender determination potential of maxillary molar concluded that the odontometric dimensions of upper jaw molars offer low to moderate accuracy for gender identification [35].

Kaushal et al studied sexual dimorphism in north Indian population by inframaxillary canine index and maxillary central incisors measurements based on morphometric examination (35,37). To study the uniqueness of the anterior dentition Kieser et al examined the canine occlusal surface, size of incisor and shape dissimilarity using morphometric procedures [38].

Canines, specifically, have the most significant level of sexual dimorphism, rendering canines highly important in identification. Intercanine width [39], Mesio-distal width of canine, [40, 41] and mandibular canine index (MCI) [42] have been proved highly significant in sex determination.

Bitemarks Under Diverse Conditions on Inanimate Objects

The forensic worth of bites in different materials depends on nature of material itself and how long ago the bite took place. Food is subject to significant shrinkage and distortion, which may compromise the investigation [43]. Therefore, it is advised to record them at the earliest possible time [8].

Mukesh Kumar and Priyanka Kapoor studied bitemarks on different surfaces and concluded that for comparing bitemarks, MORPHOMETRIC MESUREMENTS can be good criteria. They found 95% positive match for bitemark in fruit (apple), 87% in chocolate and 81% in cheese [6].
Laís Gomes et al conducted a study to estimate the steadiness of bite marks on foods in diverse circumstances (time and temperature).

The study reveals that the storage temperature doesn't apply a critical impact. But the impressions found on foods with greater dimensional strength and brief time period, are more dependable and permit their utilization as proof in criminal examinations [44]. Researchers have made diverse efforts to keep up the dimensional integrity of indentation; e.g., Formol acetic alcohol (FAA) blend can be utilized as preservative of bitten fruits [45].

Radford et al stated that the shape of the upper or lower teeth have significant differences when they occlude into a flat or three-dimensional target [46].

Body posture at the time of bite, also plays an important role [47]. The factors which serve as important tools in bitemark examination are the source who produced the mark, the substrate onto which the mark is produced and the method of lifting the bite impression. Although during bitemark examination, inanimate objects serve as a better source. skin has an equivalent precision in bite mark examination [48].

Difficulties In Bitemark Analysis

There are various factors that affect the results of bitemark examination. The imperfect photographs of bitemark can lead to great difficulties in criminal investigation. One of the major problems encountered is the distortion due to skin elasticity, anatomical location, and body position. Bitemarks are also subjected to contamination or loss of data.

Discussion

The impression of teeth or bitemarks can be used in forensic to determine the gender of the suspect. Bitemark is a type of 'patterned injury' which played an important role as evidence in judicial system. Each person's teeth are specific and hence two dentations can never be the same [9]. Human teeth show sexual dimorphism and therefore the bitemarks can be examined for determining the gender of the biter. There are various famous cases in which bitemark analysis led to the conviction of criminals.

In present Review, the significance of bite mark investigation as well as the different methods for estimation of gender through bite marks are summarized. Various factors affect the accuracy of bitemark analysis through impressions; example-biting pressure. Different researchers used different methods and parameters for determining gender from bitemarks. Some authors mentioned that the odontometric methods can accurately identify the gender while some experts believe that tooth size measurement or morphology assessment are inadequately precise for criminal investigation, especially in light of more unbiased approaches.

The mandibular canine index, maxillary central incisors measurements, the intercanine and intermolar width are the parameters which generally used by an examiner to identify gender. From the human dentation, canines have the most significant level of sexual dimorphism, rendering canines highly important in identification.

There are chances of error due to some limitations. These limitations may include shrinkage of bitemark size, measurement errors, improper generation of dental cast, etc. Also, incomplete indentations are not decisive. So, it is recommended to use bitemark examination for the exclusion of possible suspects or exonerate the innocent.

Conclusion

Bitemark examination has proved its vital role in criminal investigations through various applications. A piece of exhaustive information and examination of indentations can help in the vindication of the guiltless as well as give decisive proof to the conviction of criminals. In certain violations, indentation proof is the main proof on which conviction has been accomplished, especially in rape and kid abuse cases. Gender can be identified through proper bitemark analysis. There are chances of false positive due to errors in

recording, comparison, analysis, and also due to factors like skin elasticity, time, biter's body posture etc. Due to these limitations, it is recommended to use bitemark examination for the exclusion of possible suspects or exonerate the innocent. Further efforts are required to decrease subjectivity in standard physical techniques.

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