Emerging Applications of Dentistry in Medico-Legal Practice- Forensic Odontology

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ABSTRACT: Forensic Dentistry or Odontology is the application of dental science to legal investigations where other evidences are not easily accessible. These cases include mass disasters, homicides, sexual assault, violent crimes, child abuse cases, self-inflicted bite marks, etc. Forensic odontologists use the dentistry skills in personal identification through examination and comparison of dental evidence such as bite marks found in a crime scene or identification of human residues centered on dental registers. Bite marks are considered as an important alternate to fingerprinting and DNA analysis in forensic investigations. It aids in identifying the manner of crime based on the site of the mark. Dental impression can be created to represent the full structure of teeth helping the forensic odontologist to match the teeth of the suspect with the bite mark. The aim of the present review was to highlight the significance of dentistry in forensic investigations by discussing emerging approaches used in dentistry for medico-legal practice. The importance of bite-mark analysis as well as the role of teeth in estimating the age, gender and race of individuals in cases where evidence associated with the victims are not accessible such as mass disasters were discussed. This review can provide better understanding of methodologies used in forensic science when investigating cases dealing with teeth or dental remains.

Keywords: Forensic odontology, forensic dentistry, teeth, bite marks analysis, age estimation, gender estimation, race identification.

I. INTRODUCTION

Forensic odontology also known as forensic dentistry is the handling, examination and analysis of dental evidences with interest to the court of law [1]. It plays a vigorous role when human remains of deceased person are decomposed, burned or even not valid for visual or fingerprint procedures. These cases include the mass disasters, murders, homicides, sexual assault, child abuse and even natural disasters such as tsunami [2]. Forensic odontology began in the Garden of Eden where Eve convinced Adam to place a bite mark in apple [3]. The earliest documented medico-legal odontology case was during 66 AD when the death of Paulina was assumed through the identification of dental evidences with individual features [4]. In 1193, Maharaja of Kannauj, Jai Chandra Rathor was killed in battle and his body was recognized through his fabricated teeth [5]. Later, Dr. Amoedo was known as the father of the forensic odontologist [6]. Forensic odontology became prominent at the end of 19th century where body identification by means of dental recognition was used due to the fact that each person's dentistry possesses individual characteristics like arrangement, size, shape, color, etc [7]. Because dental evidence is a chief component in some forensic cases, well-trained forensic odontologists should follow scientific approaches for analysis of different aspects during their investigation. One of these aspects are the bite mark evidence where forensic dentists compare marks found at a crime scene with the dental imprints of accused by analyzing the profile, dimensions and position of a person teeth [8]. Bite mark can be found alone in a crime scene or associated with other mouth parts [9-10]. Their examination is founded on the individuality of dentition when compared to the bite marks of the suspect. No two mouths are similar; teeth for each individual is so unique [11]. In addition to bite mark, odontology is helpful to estimate the age of victims or offenders based on dental data especially when evidences related to the deceased are unavailable such as mass disasters [12].

The aim of the present review was to highlight the significance and analysis of bite marks in forensic science by the mean of different approaches including the dental impression, digital imaging techniques as well as three dimensional analysis of bite marks. We also discussed the importance of teeth in estimating the age, gender and race of individuals especially in cases where evidence related to the victims are not available such as mass disasters.

II. BITEMARKS AND ITS SIGNIFICANCE IN FORENSICS

According to the American Board of Forensic Odontology ABFO, Bitemark is defined as a physical alteration in a medium caused by the contact of teeth or a characteristic pattern left in a material or tissue by the teeth of an animal or human [13].

Human bite wounds created almost 1% of all emergency cases in the United States of America [14].

Bite mark examination is a chief aspect of forensic odontology in deciphering crimes and identifying individuals involved in criminal acts due to its uniqueness like an individual fingerprints and DNA.

These evidences can lead to the identification of unknown suspects at the crime scene in case the traditional common evidences such as biological tissues and fluids are not found.

Concerning the morphology, a bitemark is commonly a circular or oval patterned injury involving two facing symmetrical U-shaped arches and an open spaces between both. It can be found on mostly all areas of the body including face, hands, breast, legs, buttocks, female genitals, waist, etc [15-16]. Fig. 1 illustrates the bite mark found on the hand of a victim [17].

Fig. 1. Bitemark found in the arm of the victim [17].

Not only the body, bitemark impressions can be found on the skin, cigar, pencil, food materials. In forensic odontology, seven types of bite marks were identified. These include: hemorrhage, abrasion, bruise, laceration, incision, avulsion, and artifact [18]. Based on the degree of impression, they are further classified into clearly defined, obviously defined, quite noticeable, lacerated [19].

In forensics, in order to consider whether a bruise is a bite mark or not, some requirement should be fulfilled. First, the questioned bruise should be identifiable as a bite by observing some characteristics. By definition, bite mark characteristics are differentiating feature or pattern of the mark. These characteristic can be divided into class or individual [13].

Class characteristic allows the identification of a group and distinguishes the category to which it originates: human or non-human. Depending on the number, shape, dimensions of the contusions and the overall size of the injury, the group of origin can be precised. The human bite wounds vary from minor bruises to severe contaminated wounds and lacerations. Maxillary and mandibular arches can be determined together with the individual teeth presented in these arches. Animal bite injuries can be found on victims where specific physical aspects of teeth distinguish animal bites from human bites. Animal bites cause skin laceration, crop and open wounds instead of impact one.

For individual characteristics of bitemark, patterns of an individual rather than a group can be defined. In fact, each individual has unique special teeth features including the teeth size, shape and position in the dental arches. Individual characteristics consist of special arch such as separate arches and dental characteristic for example identifiable tooth marks, sharp canines, unusual wear patterns, etc [13].

Several researches were focused on studying the human bites and the individual characteristic of an individual's set of teeth for identification of the offenders in rape, assault and homicide [20-21]. In forensic dentistry, the identification, recovery and analysis of bitemarks is challenging. First, the bitemarks from site evidence or victim must be collected. Then, the evidence collection of suspected dentition should be realized to compare it to the bitemarks found on the victim [13].

Different approaches for bitemark analysis were proposed in the literature. These include the prototype of human skin for bite mark, the measurement of alteration in human skin in addition to the development of human dentition model [22]. Dental impression models were developed since mid-1800s for only dentistry uses [23]. Later, these models were advanced for forensic applications. In forensic dentistry, police officers and examiners may require dental impressions from a bite suspect. A consent must be taken from the suspect during the criminal investigations [24]. Various impression materials can be used. These include the gypsum, vinyl-poly siloxane impression material, alginate impression (Fig. 2). Once taken, dental impression material are poured into plaster models to produce dental casts. At this stage, along with the dental impression, photograph's of the suspect's dentition should be recorded [17].

Fig. 2. Dental impression model using water and alginate powder on dental impression tray [23].

In addition to dental impression, digital imaging techniques are also used for the analysis of bite mark with the development of computer program to examine bite marks [25-26]. Spectral imaging and photography of bite mark for examination, known in forensic dentistry, proposed the use of different types of light such as ultraviolet, fluorescence, alternative light source illumination [27-28]. Recent studies highlighted the utility of three-dimensional study of bite marks using an intraoral scanner where bitemarks are recorded with a surface scanner [29]. Assessing of bite mark injuries are still developing in forensic dentistry helping the examiners during their investigations to identify the victims and offenders.

III. TEETH AS EVIDENCE FOR AGE EXTIMATION

Individual's age estimation through teeth became a fundamental measure when unidentified human remains are found at the crime scene. Teeth are the most

everlasting fragment of the body since their ability to stay unaffected for thousands of years after death and known for their resistance to damage by fire [30-31].

Forensic dental age estimation helped in identifying numerous victims in various disasters including airlines crash. Among these, the Nepal Airlines Crash in 2014 case where two dead kids were identified and their age was estimated through teeth examination [32]. Another known scene was the DANA air crash in Lagos in 2012 where victims' identification and age estimation was realized by means of forensic odontology joined with DNA analysis [33].

Distinction in tooth development and eruption between persons has transformed the dental evidence, a vital procedure of age determination. In fact, human dentition development begins four months after conception and last till the mid-third period of lifetime when the growth of all dentition is complete [34]. The age estimation is established on the level of development of crown, root arrangements in addition to the phase of eruption. It is also helpful if a person is having a dental register or any individuality like fillings with diverse components and implants [35]. Usually, age estimation techniques include the assessment of the mineralization phase on radiographic imageries tracked by their evaluation with the standard phase to calculate the estimated age [30]. Different radiographic methods can also be used in age estimation through evaluation of ante-mortem and post-mortem dental radiographs including the intraoral periapical radiographs, lateral oblique radiographs, panoramic radiographs and digital imaging [36-37]. The radiographic photos should focus on the teeth of importance.

IV. GENDER AND RACE IDENTIFICATION IN FORENSIC ODONTOLOGY

Gender and race estimation of individuals can be realized through examination of teeth and facial remains during investigation of a crime scene or mass disasters. Different approaches were proposed for the identification of gender or sex. These approaches concern the morphological examination of the tooth and tissues of oral and paraoral region or molecular analysis [38].

The morphological analysis include diverse features examination of teeth such as crown size, shape and root length because these structures are not similar between genders. Different methods of morphological analysis are known. These include the odontometric methods, orthometric method and cheiloscopy, etc [38]. Due to the fact that morphological features are not stable and can differ through time and outer environment, the identification of gender is best recognized through molecular analysis of DNA where the extracted DNA from the teeth of an anonymous individual can be matched with the ante-mortem DNA samples.

In addition to gender, race identification is possible through dental and oral analysis. According to anthropologists, human population are classified into three races: Caucasus, Mongolian and Negroid. Previous researchers showed that morphological dental aspects including the cuspids of molars are different between these races [39]. Despite these classification, the identification of race from morphological characteristics of the teeth are still controversial.

V. DISCUSSION

Dentistry is not only a branch of medicine to study, diagnose and treat disorders in the oral cavity but also an important application in forensic science defining the forensic dentistry or odontology. Forensic odontology help examiners during incidents' investigations where human remains are unclear. It allows the identification of victims and offenders in several episodes including terrorist's attacks, airplane crash, fires, disaster victim identification and natural disasters.

Forensic Odontology was very useful in various cases such as Prime Minister Rajiv Gandhi's assassination (1991) where the dentition analysis helped in his identification [40]. In Nirbhaya rape and murder case (2015), the examination of bitemarks found on the victim's body through photographic and computer-based analysis aided to recognize the five suspects [41].

Also, in Sheena Bora murder case (2016), the facial superimposition procedure was used to confirm the identity through skeletal residues mainly jaw and teeth, [42].

In the present review, the significance as well as the applications of odontology in forensic science were summarized. First, the importance and examination of bitemarks were discussed through elucidation of various methods. Among these, the dental impression is widely used for bitemark analysis. Several factors can affect the accuracy of bitemark analysis through dental impression. These factors include the biting pressure, the appropriate impression technique as well as the generation of dental casts. Additional assessment of bitemark analysis require further development of sophisticated approaches with higher specificity to help the law enforcements and court of law.

The importance of teeth in estimating the age of persons in cases where no data related to the victims are accessible were also highlighted. Some authors mentioned some challenges related to forensic odontology age estimation methods [43]. One of these challenges is the under or over-estimation of ages on different populations caused by ethnicity differences.

Gender and race identification are also known in forensic odontology. Hence, it is very important for forensic odontologist to be familiar with all approaches used.

In addition to the bitemark analysis, age, gender and race identification, dental remainscan be an excellent source of DNA due to their resistance to extreme environmental conditions. The saliva also can be a major source of DNA because of the epithelial cells and some microorganisms such as Streptococcus Salivarius and Streptococcus Mutans [44].

VI. CONCLUSION

This article emphasized on the development of forensic odontology by discussing the efficacy of this science in crime investigations. Broad collaborations between the police, the judges and the forensic dentist experts are needed to solve medico-legal problems among the community. Altogether, forensic odontology has proved its vital role during forensic investigations through various applications.

VII. FUTURE SCOPE

To highlight the significance of dental remains in forensic science during investigations, recent case studies in India and worldwide involving bitemarks' analysis, the use of teeth for age, gender and race identification should be summarized.

Conflict of Interest. The authors declare that they have no conflicts of interest.

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