SMARTPHONE CAMERA AS THE ALTERNATIVE OF 3D SCANNER FOR BITEMARK ANALYSIS IN FORENSIC ODONTOLOGY: A REVIEW

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Abstract

Bitemarks are patterned injuries caused by teeth in conjunction with other oral structures that are used as evidence in forensic investigations. Its characteristics vary from person to person, even in identical twins. By matching the existing bitemark with the suspect's bitemark, the unique dentition of each individual becomes the scientific basis for identifying bitemarks. Because bitemark proof on human skin and food is transient, it should be immediately recorded or duplicated to retrieve lasting proof, allowing for a longer time of examination, which 3D bitemark analysis can do. However, the currently available method with an intraoral scanner (IOS) necessitates the purchase of expensive specialized equipment that may not be readily available everywhere. The use of a smartphone camera on a monoscopic photogrammetry method could lead to a novel method of 3D bitemark.

Keywords: 3D scanner, bitemark analysis, forensic odontology, human rights, justice

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INTRODUCTION

Dentists and forensic odontologists are concerned about physical crime that manifests on and occurs from the orofacial structure. Forensic odontology is a branch of dentistry that uses dentists' expertise to identify individuals and plays an important role in the identification process of major disasters, sexual violence, child abuse, and other cases.[1] A medico-legal examination of various types of injuries is performed in forensic medicine, including injuries from traffic accidents, injuries from attacks with blunt or sharp objects, attacks with firearms, occupational accidents, evidence of injuries from domestic violence, and child abuse.[2]

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Forensic odontologists' primary concerns include the identification of human remains, the identification of mass accidents, the examination of bitemarks and lip prints, the estimation of age, and the investigation of cases of violence against children, spouses, or the elderly.[3] Physical crimes manifest themselves in victims' forensic wounds, which can be medico-legally classified as blunt force injuries, sharp force injuries,

projectile injuries, and other types of wounds.[2]

A forensic dentist plays a pivotal role in many criminal cases and often helps to solve a mystery in the investigation since teeth are considered vital proof in the forensic investigation.[4] Bitemarks, a patterned injury formed by teeth in conjunction with other oral structures, are a common injury encountered in criminal cases. Even identical twins have different bitemark characteristics. By matching the existing bitemark with the suspect's bitemark, the scientific basis for identifying bite marks becomes the unique dentition of each individual. This patterned injury is frequently seen in cases of sexual harassment, homicide, and child abuse, and it can occur on a living person, a corpse, or inanimate objects.[5] It is well known that perpetrators of sexual assault crimes, such as sexual murder, rape, and child sexual abuse, frequently bite their victims as an expression of dominance, anger, and bestial behavior. Bitemark wounds can occur anywhere on the body's surface, with the most common locations being the face, neck, hands, breasts, buttocks, and female genitals. Because of the pressure created by the biting teeth, a central bruising area can frequently be seen within bitemarks from the teeth. Aside from that, the tongue and suction movement allow for extravascular bleeding, which results in bruising[6–8].

The American Board of Forensic Odontology (ABFO) recommends aluwax, base plate wax, styrofoam, clay, and human skin as bitemark impression materials. Dental wax was chosen as an impression material in several studies because of its ability to record bitemarks that are eerily similar to human skin.[9] A study conducted by Daniel and Pazhani (2015) demonstrated that bitemark analysis on chocolate and cheese was more accurate than on apples.[10] Kanaparthi et al., (2020) also performed bitemark analysis on chocolate medium, and Rai et al., (2017) used apples as one of the bitemark analysis methods. However, there is a significant disadvantage to using food or cutaneous wounds as analysis media. Because bitemark evidence is impermanent, the forensic team has a relatively short time frame to analyze it, as food can rot over time and cutaneous wounds can heal. Bitemarks, as one of the valid and important forensic evidence, must be evaluated quickly before the patterned injury heals on human skin or rots in food. In this case, the bitemark should be recorded or duplicated as soon as possible. Bitemark analysis, in addition to relying on human dentition characteristics, also relies on dental records on the bite material. To summarize, a new method is required to obtain permanent bite mark evidence while also allowing for easier observation.[6,11,12]

Many changes have occurred in the methods of scientific analysis and data collection in the field of forensic odontology as a result of technological advancement. One of the advancements is in the dental imaging technique. Whereas 2D image methods such as radiographic images, photographs, and visual identification are commonly used in dental identification, 3D scanners are being used to achieve more accurate and precise results.[13–15] As a result, 3D technology is clinically acceptable and can be used in metrology and dental measurement.[16] Intraoral scanners are used in dentistry to print 3D models of prosthodontics, and the results of 3D printed models are remarkably accurate, editable, and stable. Furthermore, 3D model data is

permanent and simple to transfer to other users, locations, or devices. This enables longer-term examinations to be conducted by some experts without violating ethical code principles or degrading data quality. 3D technology opens up new possibilities for the field of forensic odontology, one of which is the use of intraoral scanners to scan bitemarks and create 3D permanent evidence.[5,9,11]

Although the use of an intraoral scanner is extremely beneficial, it necessitates specialized equipment that is costly and frequently unavailable on-site. This raises the question of whether there are any other economic methods available with the same 3D model producing effectivity, one of which is smartphone utilization. A smartphone utilization study has been conducted, which involves superimposing a 3D model on a smartphone using applications such as CAD Assistant, Exocade, and Adobe Photoshop Mix, and is thought to be suitable for dental needs.[17] The use of a smartphone camera as a 3D scanner is not widely used yet, but it opens up new possibilities for easier, more practical, and cost-effective scanning of 3D models. Users can use a smartphone to take 2D pictures from various angles, which can then be processed with a free software program to create a 3D model.[18]

DISCUSSION

Bitemarks are patterned injuries that form when teeth come into contact with a surface, typically food but also other inanimate objects and human skin, and contain records of the dentition's pattern. As a result, bite marks on human skin are classified as patterned injuries. Forensic odontologists are frequently in charge of bitemark examination and analysis. In general, the outline form is made up of two arc components, one for the maxillary arch and one for the mandibular arch, with visible tooth markings within the arch. Contusions, abrasions, and lacerations can all be seen on the bite pattern. The type of mark produced reflects the unique characteristics of dentition that result in the bite mark. There are several types of bitemarks on human skin, including partial bitemarks, avulsive bitemarks, multiple bite marks, indistinct bitemarks (also known as "smoke-ring bitemarks”). Bitemarks on human skin have a wide range of appearances. As a result, an identifiable bitemark may consist of only one maxillary or mandibular arch. Furthermore, distortion is very likely to occur in bitemarks on human skin, and the degree of this distortion cannot be measured directly or experimentally reproduced. Because of the wide range of variations, the forensic dentist must be thorough and knowledgeable before concluding that the patterned injury is, in fact, a bitemark.[19]

Bitemark analysis is important in forensic investigations because the bite pattern characterizes an individual, and even identical twins have different bite patterns. The scientific basis for bitemark identification is the unique dentition of an individual's teeth, which can be used for identification by matching the bite pattern or bitemark on the suspected perpetrator.[5,20]

According to bitemark characteristics, the maxillary central and lateral incisors produced rectangular marks, with the central incisors' marked size being larger than the lateral incisors. In the meantime, maxillary canines leave round or oval marks. The mandibular central and lateral incisors also produce rectangular-

shaped marks with little variation in width. The mandibular canines also leave marks that are round or oval in shape. In some cases, the suspect's bitemark may appear to be missing one or more teeth (unrecorded). This could be due to smaller tooth size, or there could be a clothing material that prevents the teeth from coming into contact with the skin.[6,21,22]

Bitemark analysis is dependent on the uniqueness of human dentition as well as accurate bite registration on bite material.[9] The scientific basis of bitemark analysis is the unique arrangement of human teeth, based on the principle that no two people have the same dental record in terms of size, shape, and tooth arrangement.[6,23,24] A noticeable and characteristic patterned injury may occur when tooth contact causes a characteristic physical change in the biting medium. Although biting is a dynamic process that is affected by several variables such as jaw position, teeth, substrate, biting strength, and so on, bitemarks can be useful in identifying criminals. The forensic dentist must be able to distinguish bitemarks from other cutaneous lesions, infections, or injuries. The process is then continued by determining whether or not the pattern is related to the teeth. [25–27]

Bitemark analysis begins when this patterned injury is suspected to be caused by biting. First, determine whether the injury was caused by the bite and whether the bitemark was caused by a human or an animal tooth. After it is determined that the bitemark was caused by human teeth, it will be analyzed to determine whether the bite was caused by a child, adolescent, or adult. The next step is to ensure that the existing bitemarks are of high enough quality to be studied and examined further. Following the completion of the above-mentioned bitemark analysis process, the next step is to match and several individuals suspected of being perpetrators. Furthermore, if it is proven that the bite pattern injury was caused by a human tooth, the bite mark and surrounding area must be swabbed to obtain DNA data.[19,28,29]

Dental imaging techniques are not only required for identification, but they also play an important role in diagnosis, treatment planning, and implementation. Dental scan implementation is shifting from 2D to 3D scanners to achieve more accurate and precise results.[13,30] The IOS (Intraoral Scanner) is a medical scanning device that includes a handheld camera (hardware), a computer, and software. IOS is used to precisely record an object's three-dimensional geometries, and STL (Standard Tessellation Language) is one of the most widely used digital data formats.[31] On the targeted scan object, IOS projects a light source (laser or structured light). Scanning software generates point clouds from the dentogingival tissue image captured by the imaging sensor. The same software is then used to triangulate this point, resulting in a 3D model of the dentogingival tissue. This dentogingival 3D model is an optical print and a virtual substitute for traditional printing models.[32]

Although the majority of noncontact digital 3D scanners provide adequate accuracy, many are expensive and difficult to use.[33] 3D photogrammetry, which uses a smartphone camera and free software to generate 3D models from 2D photos, is an alternative to this expensive 3D scanner. Photogrammetry is the science of obtaining measurements from 2D photographs, and it entails taking a series of overlapping photographs with a single camera from various points of view around a given object.

Furthermore, the benefits of this method include quick image capture and processing, no radiation exposure to the patient, and good results without the need for complicated training. The photogrammetric method, which has begun to be used in the medical field, is used for 3D photography. Structure from Motion (SFM) software will then recognize and match common features in multiple photos to create a computerized, true-scale 3D model. As a result, this method provides a permanent, quantifiable 3D record of an object while only requiring a consumer-grade computerized camera and basic training to ensure overlap of photographs.[14,18]

When compared to stereophotogrammetry techniques, which require all photos to be taken simultaneously, using multiple cameras with different heights and angles to the subject or object being photographed, the monoscopic photogrammetry technique can be used to form 3D models more simply and cost-effectively. Furthermore, stereophotogrammetry techniques incur significant costs for hardware, software, and other types of equipment that may not be easily retained. The monoscopic photogrammetric technique requires only one camera to take pictures of the object/subject being photographed in stages at various heights and angles. This technique can also make use of freely available software to its users.[18] When conducting photogrammetry, there are a few things to keep in mind: time and effort. Because the 3D guideline requires around 50-1000 images, you may need patience in taking each photo from different heights and points of view. Aside from that, each photo should be well-taken and have the best lighting possible. Monoscopic photogrammetry has previously been used in medical studies to detect a facial defect, but it has not yet been used in the forensic field, and it opens the door to a more convenient and low-cost examination novel method in bitemark analysis. More research is needed to compare the accuracy of 3D bitemark analysis using an intraoral scanner versus 3D bitemark analysis using monoscopic photogrammetry.

CONCLUSION

Monoscopic photogrammetry has previously been used in medical studies to detect a facial defect, but it has not yet been used in the forensic field, and it opens the door to a more convenient and low-cost examination novel method in bitemark analysis. More research is needed to compare the accuracy of 3D bitemark analysis using an intraoral scanner versus 3D bitemark analysis using monoscopic photogrammetry.

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