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STUDY OF RELEVANCY OF VIKS BITEMARK ANALYSIS TECHNIQUE

Ahuja Vikram[1] and Singh Shubhda[2*]

[1]MDS (oral med and Radiology) Dipartment of Forensic Odontology, Mem Britesh Asso of Forensic Odontology, Chief Consultant KOSMIC dental Clinic and SIPS hospital Lucknow, India
[2]BDS, Associate dentist Kosmic dental clinic Lucknow, India

ABSTRACT

Bite mark analysis is an imperative area of forensic odontology and considered the commonest form of dental evidence presented in the criminal court .It plays an important role in the identification of suspects especially in cases of child abuse , rape and homicide . The process of comparing bite marks with a suspect's dentition includes analysis and measurement of of shape , size and position of an individual's teeth . The present study was aimed to evaluate the relevancy of "Viks Bitemark Analysis Technique", which included the radiographic investigation of bite marks and measurement of its magnification . Hand tracing methods, from either wax impressions of teeth or directly from study casts, were determined to be inaccurate and subjective.

Keywords: Forensic Science , Forensic dentistry , Bite Marks , Radiographic investigation, etc

INTRODUCTION

Odontologic evidence is the third most precise method of identification of fingerprints and DNA analysis in forensic sciences . "The criminal may lie through his teeth though teeth themselves cannot lie" is rightly said by Furness[8]. Anything diverse , such as discrepancy from normality, becomes an important tool when trying to establish an identity of a suspect.

Bite mark is "a mark made by the teeth either alone or in combination with other mouth parts"[1]. Mac Donald defined bite mark as "a representative pattern left in an object or tissue by the dental structures, either alone or in combination with other oral structures of an animal or human"[2]. According to the Old Testament, Adam was convinced by Eve to place "bite marks" in apple. The first bite mark case in Colonial America occurred during the Salem witch trials in 1692, where Rev. George Burroughs was convicted and hanged for witchcraft, including biting his victims. The contemporary history of bite marks is contemplated to have started with Sorup .

Bite mark analysis is based on the principle that "no two mouths are alike". According to Pretty and Turnbull, the central doctrine of bite mark analysis is based on two assumptions; firstly that human teeth are unique and secondly that sufficient detail of the uniqueness is rendered during the biting process to facilitate identification. Distinctiveness and uniqueness of human dentition allows the forensic odontologists to achieve a strong judgment in cases of personal identification and bite mark analysis[3]. Bite marks may unveil individual tooth marks, may present as a double-arched pattern or even a multiple overlying bruise. Bite marks can be deformed due to flexibility and elasticity of the skin. The amount of pressure given during bite, body position, and the angle of the maxilla and mandible during bite can alter the manifestation of a bite mark .

***Corresponding Author Email:** shubhdasingh2014@gmail.com

Human bite marks are found when teeth are used as weapons of anger, excitement, control, or destruction. The impression can be left on the skin, chewing gum, pencils, or pens and also found on musical instruments, cigarettes, food materials such as cheese, fruit, potato, chocolate, and so on. These are encountered in cases of crimes especially homicides, quarrels, abduction, child abuse, and sexual assaults and during sports events and sometimes intentionally inflicted to frame someone fallaciously . The terms commonly used in bite mark analysis are victim—the recipient of the bite mark and perpetrator—the person who caused the bite mark[4].

While bite marks on the body are intentionally caused, those found on food articles are usually imperceptibly left by the offenders at the scene of the crime. So, as to recognize the offender, the dental casts of suspected persons are prepared using dental material and matched. Bite marks if analyzed properly can prove the involvement of a particular person or persons in a meticulous crime. West et al. felt that bite marks on the human skin can be experimentally created to a level that permits comparison to bites delivered in combative or life-threatening situations, and more research is needed using living subjects to explore a variety of experimental situations[5], 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 . Various methods of bite mark analysis are present such as impression making from bitten substances by dental stone and hand tracing from dental study casts, photography method, photocopying, and computer-assisted overlay generation method . Bite marks can be classified[6] as

Bite marks can be classified as,

1. Non-human (animals)
2. Humans
   a) In foodstuffs (e.g. in part-eaten food stuffs abandoned by offenders at scene of crime)
   b) In human skin
      Non-criminal (erotic bites)
      Criminal (ordinary and sexual assaults which may be
      - Offensive (upon victim by assailant); or
      - Defensive (upon assailant by victim).

There are seven types of bite mark, which can be classified by four degrees of Impression:

1. Hemorrhage: a small bleeding spot
2. Abrasion: undamaging mark on skin
3. Contusion: ruptured blood vessels, bruise
4. Laceration: near puncture of skin
5. Incision: neat punctured or torn skin
6. Avulsion: removal of skin
7. Artifact: bitten-off piece of body
   Clearly defined: significant pressure
   Obviously defined: first degree pressure
   Quite noticeable: violent pressure
   Lacerated: skin violently torn from the body

The characteristics of bite marks may be affected by the type, number and peculiarities of the teeth, dynamics of occlusion, muscle function, individual tooth movement and TMJ dysfunction in the perpetrator[9].

In 1984, the American Board of Forensic Odontology established guidelines for bite mark analysis[10]. Additional workshops of the board, held in 1993 and 1994, provided further insight into the techniques available to recover, store, analyze, and evaluate bite mark evidence based on the guidelines. The biological and physical evidence from the bite mark begins to deteriorate soon after the bite is inflicted. So the knowledge of the general principles of evidence collection is required. The collection of evidence falls into several categories. This includes

- Description of bite mark.
- Collection of evidence from suspect.

This is followed by the comparison of the bite mark with the suspect's dentition. The comparison techniques have been divided into two categories

- Life sized comparisons
- Assisted comparisons

The life-sized comparisons include direct and indirect methods. In direct method, the models are placed directly over the life size 1:1 photographs and the concordant points are demonstrated. The indirect comparisons are made using transparent overlays on which the biting surfaces of the teeth are recorded. The assisted comparison involves the use of microscopes of varying types, electronic, histological, radiographic and specialized techniques including the use of experimental bite marks[11].

Bite mark investigation includes the physical and metric analysis of a suspect to a bite injury. The physical comparison of the suspect to the bite requires a comparison of the unknown mark found on skin or objects to known exemplars (Latin: Exemplare,

to show) of the suspect's teeth. These exemplars are typically plaster casts derived from dental impressions or a reproduction of the teeth obtained by other means. The test bite media commonly used include:

- Wax exemplars (aluwax, base plate wax etc)
- Styrofoam
- Volunteers skin Alternate methods (fruits, clay)

The tooth exemplar, independent of the method used to produce it is called an 'overlay' when biting surface data is transferred to clear acetate. This is physically compared to the injury on the skin or a patterned mark. The 'hollow volume overlays' records the perimeter of biting surface of each tooth and leaves the inner aspect of the tooth image transparent. This aids in visualizing the biting edges of the teeth that would most likely be seen in a resulting bite mark. The overlays can be generated by various methods such as:

- Acetate tracing directly from models of the suspect
- Acetate tracing indirectly from photocopy of the model with scale
- X-ray film overlay created from radiopaque material to the wax bite
- Alternate methods

Recently, the computer-based method is used as a gold standard for bite mark analysis and other commonly used methods are compared to it[12]. In this method, transparent overlays are fabricated from images generated by scanning the suspect's dental casts. If the evidence sample is too large to be scanned or too fragile to be moved, conventional or digital photography can be used to capture the image. When the bite mark image and the overlay are completed, a metric or non-metric analysis can be carried out. The non-metric analysis involves superimposing the overlay onto the bite mark injury and investigating points of concordance or discrepancy. A typical bite mark comparison image includes, the bite mark image as the background layer, the maxillary arch overlay layer, and the mandibular overlay layer. Each of these layers can be enhanced or moved individually.

OBJECTIVES

1. To determine the relevancy of VIKS bitemark analysis technique using wax bite patterns, study models and barium sulphate
2. To determine the method of radiographic investigation of the bitemarks
3. To evaluate its significance in forensic sciences

REVIEW OF LITERATURE

Odontologic evidence is second only to fingerprints as the best and most accurate means of identification. The dental profession has both an ethical and a moral responsibility in identification procedures.

The first treatise on Forensic Odontology as a subject in its own right was written in 1898 by Dr. Oscar Amedo who is generally recognized as the Father of Forensic Odontology.

It has been reported that the first reported crime in the history of mankind was solved when bite mark was discovered in the remains of the forbidden fruits in the Garden of Eden and was identified as those of Adam and Eve[13].

A detailed report on the human bite marks and its classification on human skin was described for the first time in the Indian literature on art of love making 'Kamasutra' by Vatsayana written seventeen centuries ago[14].

Around 900 years ago, the tooth impressions were deliberately utilized for legal personal identification[15].

Historically, it has been reported that William (1027-1087), the conqueror validated his royal documents by biting into a wax seal, thereby leaving behind an impression of his characteristic dentition. Much later the debtors coming to America from Britain, Europe to work as labourers signed their contracts by biting the seal on the agreement forms and hence became to be known as 'indentured servants[16].

The earliest attempt to admit bite mark evidence in a court of law in the United States was done in Mary Lunsford murder case (1870) in Mansfield, Ohio, USA, in which Ansil Robinson was charged with the murder of the victim who was his mistress. Evidence against Robinson included an attempt to match his teeth to bite marks on the victim's arm[17].

In 1692, Reverend George Burroughs was convicted of and was subsequently executed for the crime of soliciting young women into witchcraft. The accusers in this case displayed tooth marks on their arms. The trail judges examined Burroughs dentition and compared it to those of others in the courtroom and were sufficiently satisfied of his guilt[9].

At the Cumberland assizes in Carlisle, a burglar was convicted by identification of teeth marks that he had left in some cheese while committing the crime[13].

Several authors consider Sorup as the first investigator of bite marks. The method developed by him was known as 'Odontoscopy'. In his method tooth marks on the body were photographed. Plaster casts of the teeth of the suspect was made, dried and varnished. The incisal edges and occlusal surfaces of the teeth were coated with printers ink and an impression of the marked teeth was taken on a sheet of moistened paper and this impression was compared with the life size photograph of bite marks of the victim's body[18].

In a murder case, bite mark of the victim was compared with the plaster model of the suspect's teeth. The skin involving the bite mark was presented as evidence in the court along with the plaster models of the suspect. Since the skin had undergone shrinkage, the biting edges of the accused teeth did not fit well with the bite mark on the skin .The jury failed to take into account the contraction that usually take place after the skin is cut from the body. This case indicated that the photograph of the bite mark of the victim to be taken as soon as possible and to prepare the case against the accused with accurate linear measurements, and detailed comparisons[18].

The Sorup method of recording bite marks was modified by Humble. He was of the opinion that there is no need of using etching printing press for recording bite marks[18].

In Chantilly, a murderer was convicted on the evidence of the bite mark that the victim inflicted during her struggle for life. These bite marks corresponded with her teeth and the evidence was utilized to obtain the conviction[19].

In a method of bite mark analysis, a photograph of the bite mark on the victim was compared by means of photographic negatives to a model of the suspect's teeth. This method was technically advanced but possibly difficult for a jury to interpret[14].

A bite mark was discovered on the breast of a female murder victim in Tunbridge wells. The husband was convicted of this act when the models of his teeth corresponded with the bite marks on the victim[13].

The need to consider the dynamic of bite was first explained by Korkhaus. According to him, the force exerted during the bite action will make impressions only in areas where the force is sufficiently strong for producing marks depending on the resistance offered by the structure. He traced the edge and surfaces of the teeth on a transparent paper, which had been superimposed on photographs of bite marks of the suspect's teeth taken in a slice of plasticine. These tracings were brought into correct relationship of the plasticine slice to analyze the actual bite[20].

Test bites on the skin were used for showing the marks left by a suspect. The criticism of this method was the great danger of infection following bites in the skin and also, a comparison still had to be made between bite marks and the suspect's teeth[21].

John Furness described a method of comparing the teeth of a suspect with the bite mark found on the victim. In his method, the tooth marks on the body was photographed with a ruler placed along side the mark.

Casts of the suspect's teeth were varnished and the biting edges were marked with the printer's ink. A photograph of the cast was taken and enlarged. The negatives were printed to correspond in size with the previously enlarged photographic print of the victim's injuries and mounted on a single sheet of white cardboard. The curvature of the teeth in bite marks was compared with the curvature of the dental arch and measured from left to right. The space between the teeth and width of biting edges was compared and lines were drawn to show the similarities. This technique is still used today for court exhibits depicting bite mark comparison[18].

A study was conducted on bite marks for its identification. In this study, the author reported that there is a change in shape and size of a mark on skin, which alters with changes in body position, and this change is not in any concentric pattern. Therefore any simple enlargement or reduction of the size of photographs of bite marks on skin cannot be used unless the exact position in which the bite was inflicted is the position in which subsequent examination and photographs are made. Further, he reported that once the skin has been excised, the shrinkage is so great and so irregular as to make its value for identification of bite mark extremely doubtful[24].

A case of Illinois vs. Johnson was solved by matching the bite marks on the victim with the teeth of the suspect's dental casts. The Johnson case appeared to be the first involving a bite mark in human tissues to result in a conviction and to be appealed[17].

The three main methods of permanently recording bite marks on perishable substances include preserving the material with bite mark, photography and obtaining a permanent model in a suitable hard material. Prior to the development of modern impression materials, Plaster of Paris was used. A method described by Stoddart TJ for producing accurate permanent models of bitten perishable substances using silicone impression material for Forensic purpose is still applicable today[25].

A review on the literature dealing with the handling and examination of bite marks and its legal implications was presented. According to the author, for an effective utilization of bite marks in criminal investigations, action is needed in three areas i.e. the law enforcement personnel must understand the uses of bite mark evidence, need for further interest and research in Forensic Odontology particularly in the field of bite mark comparisons and several unanswered legal questions pertaining to the collection of bite mark evidence need clarification[3].

The mechanical factors concerned in bite marks involve firstly the forces applied to skin. These may be direct biting pressure from the teeth but in addition suction and tongue thrusting may be involved. The properties of particular skin area bitten may also affect the appearance of a bite mark. These factors should be taken into account when interpreting both simulated and Forensic bite marks[26].

In a murder case, Richard Milone was incarcerated for the murder. However, a double murder was discovered in the same area as the Milone murder. A suspect was located by comparing the bite marks from the double homicide victim to the murder for which Milone was convicted and the suspects teeth[27]

Closely adapted acetate film on the model of suspect's dentition was used for tracing the biting surfaces of the teeth on it. However this method was not recommended in all cases as free hand tracing by its very nature can introduce errors and bias[28].

A case suspected female homicide with multiple bite wounds was reported. Initially the wounds were thought to be caused by the mechanical instrument, after an autopsy it was determined to be caused by a large animal. Teeth models of the two dogs approximated with the wound marks on the victims and on the body models.[29] Tooth marks in a homicide case were analyzed by means of visual description, stereo photography, scanning electron microscopy and sterometric graphic plotting. Author was asked to reexamine a bite mark case involving an injury to a breast. Using novel technique including scanning electron microscopy, the author found that the originally convicted individual was the likely biter[30].

A theory of probability for duplication of human dentition was put forth by Keiser Neilson[31].

The need to consider at least 6 possible positions for each tooth to assess the individuality during bite mark analysis was suggested[32].

The author reported a case where a toothed weapon was found in the murder room and therefore suspected of causing injuries is described. The case demonstrated that a full dental evaluation is mandatory in any case of wounding where a toothed cause is suspected. In this report, the value of the acetate film technique for speedy and accurate reproduction of bite mark was illustrated[33].

Bite marks are routinely studied by various photographic techniques and impressions. In order to obtain an accurate mapping of incisal contours for comparison, Rawson et al described a technique for interpreting bite marks through soft tissue radiography. The author concludes that this technique can be used as an adjunct to the standard photographic technique[34].

A case of murder involving bite mark was presented. In this case in order to delineate the nature of bite marks and to aid in the identification of the murderer microbiological and histological/histochemical technique were used. This technique revealed the presence of calculus and microorganisms that supported the contention that this was a bite made by an individual with dental disease[35].

The amount of skin held in the bite may determine the shape of the mark. An ellipsoid shape may indicate that a small amount of tissue was taken and only involves the anterior teeth. The authors say that marks showing the premolar teeth in both arches are usually circular in shape[36].

In a study, computer comparison of bite mark patterns in identical twins was made. This study was conducted to determine whether bite marks are indeed unique to the individual. The computer comparison made it clear that in terms of occlusal arch form and individual tooth positions, even identical twins are not dentally identical[37].

David studied a comparison of bite mark by

xerography. Although standard photographic technique is used to detect the bite mark, the xerographic copies offers the distinct advantage of overlay technique by which the bite marks can be compared[38].

A method of identification of two bite marks inflicted by a homicide victim on different areas of the alleged perpetrators body was reported. The comparison of suspects bite mark with the victim's teeth led to the conclusion that the injuries were produced by the victim. The defendant was indicted for first-degree murder and after plea-bargaining the perpetrator pleaded guilty to second-degree murder[39].

The successful investigation of the marks depends upon the early careful examination of the substance bitten and this is particularly important when a human body has suspected bite marks. A tablet of soap with teeth marks was used as evidence for the prosecution in a trial for manslaughter of a 2½-year-old girl[40].

The scientific basis for the statistical analysis of the uniqueness of the human dentition was established. The author analyzed twelve anterior teeth and assumed that each of these teeth could occupy six positions namely buccal, lingual, mesial, distal, mesial rotation and distal rotation. They concluded that a combination of these 18 characteristics in five teeth would give sufficient confidence that no other set of teeth would be capable of producing the same mark. The concordance of eight specific teeth with eight specific tooth marks could safely be considered as being unique to a specific person[41].

The use of rigid ruler (which meets federal specification) for scale, proper camera positioning in relation to the scale and a method to evaluate the distortion in a two dimensional print that records a three dimensional object in order to improve the precision in photographic evidence for bite mark analysis was suggested. The author concluded that disregarding these factors makes bite mark analysis inappropriate[42].

A method of removing and preserving human skin exhibiting bite injuries was described. The author uses acrylic, which is placed on the skin, cyanoacrylate glue used to stick the acrylic ring to the skin and the tissue excised. Three years preservation achieved little or no post fixation shrinkage[43].

A new technique utilizing powder and brush method employed in lifting fingerprints to lift tooth prints on the body surface of both living and dead victims was suggested for bite mark identification[44].

The use of reflective ultraviolet photography technique in bite mark cases was described. This technique was considered simple and inexpensive[45].

An unusual case of a self inflicted bite mark in a woman with organic brain syndrome who committed suicide was reported. The author suggested that in all bite mark cases, the dentition of the victim should be recorded and evaluated in order to exclude the possibility of a self inflicted bite or to permit later matching of bite marks to the dentition of a suspect[46].

The author described two bite mark cases where the photographs did not contain any scale for reference. However he was able to match other tooth characteristics of the suspect to the bite marks using the intercuspal distance of the canines as a guide. He further stated that bite mark photography does not provide for exact superimposition, but is intended to preserve maximal visual information and decrease additional error in an already unpredictably distorted finding[47].

David TJ demonstrated the presence of unusual three-dimensional characteristics in a bite mark while analyzing it using scanning electron microscopy[48].

A technique of ultraviolet photography of bite marks on human skin was developed. According to the author, the ultraviolet photography appeared to be more informative and more workable pattern of the several months old bite could be obtained. This gives a better bite mark image, which could be documented[49].

In 1981, the bite mark standards committee of the American Academy of Forensic Sciences and The American Board of Forensic Odontology developed a method of scoring bite mark comparisons in an attempt to standardize a scientific approach to bite 20 mark analysis. The reliability of the scoring guide of these systems was determined from an experimental study. The study demonstrated the ability to discriminate between different degrees of match of bite marks. If the score is above a certain value then there is a high confidence level that there is a match that could not have been produced by any other set of dentition. Further, if the bite is compared or evaluated by a group of Forensic Dentists and there is a corresponding high degree of consistency, then there is an extremely high confidence level in the conclusion of identity. However, this paper was

disregarded, as overly complex and the system never gained creditability with the Forensic Dentists[50].

A guideline for the proper investigation of bite injuries was written by the members of the bite mark committee in 1986. These guidelines include a discussion of the controversial bite mark scoring system. Despite being described as dynamic these guidelines have not been updated[10].

A computerized axial tomography scanning was used to produce overlays of the dentition at varying depths, so that the teeth not involved initially in the bite were shown at the precise depth at which they began to be involved in the mark. The authors were of the opinion that this is the most accurate and desirable method for overlay production[51].

A case study of self-inflicted bite mark during an episode of myocardial ischemia indicated that the non-criminal bite marks could also exist[52].

Dorion RB developed a transillumination technique to study the bite mark evidence. In this technique the presence of subcutaneous hemorrhage can be visualized without having to section through the bite mark. This technique was also meant to be used for preserving the bite mark and fixing of skin in its original three-dimensional form. This technique was used when bites are poorly defined, barely visible or obscured by other superimposed bite marks or traumatic injury patterns. The use of this technique in conjugation with visual aids such as photography and video recording systems can also facilitate communication of bite mark evidence to another Forensic expert or to a jury or both. However, controversy surrounds the removal of tissue from victims of crime[53].

In 1987, the American Board of Forensic Odontologists designed a bite mark standard reference scale (ABFO No. 2). The use of a standard reference photogrammetric reference scale enables valid metric analysis, ensure accurate representations of nonmetric characteristics, and serve as a valuable tool for the bite mark research. The ABFO No. 2 scale is a rigid linear L shaped scale with three circles at extremities. The scale incorporates both linear and circular (20 mm in diameter) graduations to meet the diverse need of rectification and measurement of photographically recorded bite marks. The three circular reference scales allow detection and correction of errors in parallelism between the object and film planes. Its unique L shaped configuration of 1 inch width of each leg, 80 mm of inner edges of both legs ensures accurate scaling in both vertical and horizontal directions and facilitates the gridding of photographs to correct for distortion errors created by oblique camera angles[54].

A clinico-anthropological experimental study was conducted with two hundred and sixteen individuals of either sex ranging in age from 18-25 years. The bizygomatic and bigonial width of the face and upper arch and lower arch width of the bite mark impression (obtained on the impression compound by biting) for each individual were measured in centimeters. The data collected was analyzed statistically and values were compared, for deriving relationship between them, in order to facilitate personnel identification, when only bite marks alone are obtained at the crime site[14].

Various impression materials and techniques of bite mark recording were evaluated. Upon critical evaluation, the author concluded that elastomeric impression material was the material of choice for making bite impression. Reinforcement of these materials with Plaster of Paris, dental stone, multiple layers of plaster bandages, methyl methacrylate, auto curing acrylic material and orthopedic tape were reviewed. They were of the opinion that proper usage of material and technique results in an accurate and reliable match and in preserving the evidence in bite mark cases[7].

A case of artifactual injury from cardiac defibrillator simulating a bite mark was quoted in an article “Defibrillator injury suggesting bite mark”. In this article, the importance of obtaining full information and of not over interpreting suspicious injury as bite mark was emphasized[55].

The bite mark age can be estimated by using clinical judgment and understanding the concepts of normal wound healing. As per the working management protocol for human bite marks, administration of antibiotics in all cases of human bite injuries was recommended[56].

The author used direct model to victim comparison to demonstrate bite marks caused by slippage of teeth, by placing the models of dentition of suspected person directly over the breast of a deceased victim and dragging the model across the skin to demonstrate how the marks were produced in vivo[2].

The analysis of bite marks on highly curved surfaces of human skin is among the most difficult tasks encountered in Forensic Dentistry. Various forms of

dental wax or Styrofoam are used as a substrate on which the bite mark is produced by impressing study models of the suspect's dentition. Acetate overlay tracings, photography and various radiographic techniques have been used to produce the template, which is then compared with the patterned injury, usually by observing the bite injury as depicted in a photograph viewed through the overlay. However these methods can induce errors due to differences in the physical properties of skin and wax or Styrofoam. Hence, the author used skin as a template for the reproduction of a bite in two of his cases. The incisal and occlusal surfaces of the teeth on the model were inked and then placed on the skin of the victim or on the anatomically suitable volunteer in the same orientation as that of the original bite. A photograph was then taken of the inked bite mark and a transparent overlay was produced. Direct comparison of the transparent overlay was made with the bite mark photographs. This was considered as a novel technique, although it was not well accepted[57].

A quick, inexpensive and accurate technique for generating bite mark overlays using standard office photocopy machines, for use in bite mark case analysis was first determined by Dailey. According to this technique, the study casts of the dentition of the suspected person were positioned on the glass platen of the photocopier. The latter was calibrated to produce 100% image, and xerographic image was produced on a white paper. An ABFO No. 2 scale was placed along to ensure life-sized production. An error of less than 1mm of discrepancy across a 10 mm scale was considered negligible. From this image, biting surfaces were recorded by hand tracing with fine tipped felt pen over a transparent sheet of acetate. This technique was the first attempt to produce an objective overlay with precision[58].

An inexpensive and convenient method of adapting a ring of plastic to the victim's body to produce a dimensionally stable matrix for preserving the original anatomical configuration and for reducing distortion of the injury pattern during skin removal was described. In addition, these rings provided markers to record the anatomical orientation of the injury. The author suggested that numerous photographs of the skin surface and the technique of skin removal and preservation could be used as a record of the procedures followed and subsequently to assist during analysis of the evidence[59].

Tone line bite mark photography was used to reduce the interpretational bias of bite mark analysis. Tone line photography (line print photography) is a technique that yields a thin black outline of the photographed subject resembling a pen and ink sketch[60].

A method of digital imaging for enhancement of bite mark and an overlay production to improve the comparison between the dentition of a suspect and the bite mark was described. The use of digitally produced overlays appears to provide a more objective method of comparison[61].

Two methods of fabricating resin dental casts to aid in bite mark analysis were described. The author concluded that the resin dental casts allows visualization through the teeth and is less brittle than dental stone thus permitting storage without concern for breakage for number of years[62].

Franklin D. Wright emphasized the utilization of photography in the documentation of injuries in skin, which is often the only means of preserving the evidentiary value of the injuries. He further emphasized that the photography is an important means of collecting and preserving physical evidence as it relates to bite marks and patterned injuries in skin. Hence proper use and understanding of color, black and white, ultraviolet and infrared photography can greatly aid in the collection and preservation of evidence. He further described the technique and equipment for the photo documentation of the evidence[63].

Bite mark evidence, which is most often associated with violent crimes, is legally accepted and admissible in a court of law. While analyzing the legal weight of bite marks as evidence over the last 20 years it is observed that the bite mark analysis seems to have greater success as a means of excluding suspects than as analysis that attempts to match a suspect with a wound. The author stresses that it is important that the dental and legal communities understand its limitations. As professionals, dentists should be aware of the substantial weight given to bite mark evidence but at the same time to ensure that bite mark analysis does not result in proper verdict[64].

Bite mark comparison protocols include measurement and analysis of the pattern, size and shape of teeth against similar characteristics observed in an injury on the skin or a mark on an object. Several methods are used to produce life sized comparison overlays. The authors David Sweet et al proposed a computer-based technique for the production of life size bite mark comparison overlays. This method allows an

accurate and objective selection of biting surfaces of subject's teeth from the dental study casts. The comparison overlays produced by this method are referred to as hollow volume overlays[65].

A comparison of the accuracy of bite mark overlays of five common methods used was studied by David Sweet et al. Two important characteristics were evaluated: the area of biting surface of anterior teeth and the relative rotation of each tooth on its long axis. This study revealed that the computer based production method is the most accurate of all other methods studied. It produced accurate representations of the biting edges of the teeth in an objective manner. The radiographic method was determined to be more accurate than the xerographic method with respect to tooth area measurement and xerographic method with respect to tooth rotation[12].

A study was conducted to determine the ability of different observers to differentiate between human bite marks by adults and children from photographs of the bite mark. The observers consisted of accredited senior and junior dentists, general dental practitioners, final year students, police officers and social workers. Comparison of the results between the groups of observers and the standard was made using receiver operating characteristics (ROC) methodology. General dental practitioners and police officers were least able to differentiate correctly between adult and child bite marks. This study suggests the need of formal postgraduate training in the field of Forensic Dentistry. The ROC technique has not been applied to the field of Forensic Odontology[66].

A study was conducted to examine the adherence of board certified and noncertified Forensic Dentists to the American board of Forensic Odontology (ABFO) bite mark guidelines for suspect collection for bite mark analysis. A questionnaire was employed for this study. Most of the Forensic Dentists followed guidelines. The area that felt short of complete adherence was the clinical examination, detection and recording of tooth mobility and collection of salivary sample. The authors recommended that the Odontologists adhere to these aspects of evidence collection. A review of the materials used to collect evidence is also included in this study with details of application in Forensic Science[67].

The dimensional accuracy and sizing of evidence images is determined by using a linear two-dimensional scale during photographic documentation of the evidence. The presence of photographic distortion is evidenced by the scales incremental lines appearing non-parallel and not uniformly shaped. Hence, without rectification, the photographed evidence sample will not be representative of its true shape and dimension. Digital rectification method was used in a case to correct the shape distortion and render the photograph amenable for comparison with defendant's teeth by digital superimposition. This method was used in the analysis of bite mark evidence from a 1973 homicide that was prosecuted in 2000[68].

A method of fabrication of computer generated overlay production from suspect's dentition casts was described and it was concluded that human bite mark identification could benefit from digital techniques[69].

In a study, the five common overlay production methods for bite mark analysis was compared using digital images of dental study casts as a reference standard to determine the accuracy of each method with respect to the area of biting edges and then rotation of an anterior teeth. They concluded that the radio opaque impression method and hand tracing from study casts method are inaccurate[70].

The author, based on the data, models of the cast and the bite mark, a graphic volume model of the objects in virtual space was generated using three-dimensional (3D) / CAD software package. Additional overlaying the photogrammetric 3D model of the object with a two-dimensional image of the bite mark further improved the visual properties of the representation. This new computer technology allows the superimposition of such a photograph directly on the contours of the 3D model. The authors were of the opinion that this was the first 3D approach for bite mark analysis in an actual case[71].

In a web based survey of Forensic Dentists opinion on bite mark analysis, 70% believed that they could positively identify an individual from a bite mark and 22% stated that the statistical tool, the product rule should be applied to bite mark conclusion. Over half of the Odontologists used overlays for bite mark analysis with a digital method production the most popular[72].

A study was conducted to evaluate and compare the accuracy of direct comparisons between suspect's models and bite marks with indirect comparisons in the form of conventional traced overlays of suspect's models or using photocopier generated overlays. Artificial bite marks in pig skin were made

using standardized sets of models and recorded as photographs and finger print powder lifts on tape. The bite mark photographs and fingerprint lifts were coded and randomized so that a blind comparison could be made with the models, traced overlays, and photocopier-generated overlays using a modified version of the American Board of Forensic Odontology (ABFO) scoring system for bite marks. It was found that the photocopier-generated overlays were significantly more accurate at matching the correct bite mark to the correct models irrespective of whether the bite mark was recorded photographically or as a fingerprint lift. The photocopier-generated overlays were also found to be more sensitive at matching the correct bite marks to the correct models than the other two methods. The modified ABFO scoring system was able to discriminate between possible matches[73].

A new software package 'Dental Print' that generates different comparison overlays from 3D dental cast images depending on the pressure of the bite interaction. The procedure for generating comparison overlays is entirely automatic, thus avoiding 30 observer's bias. Moreover the software presented here makes it impossible for third parties to manipulate or alter the 3D images, making dental print suitable for bite mark analysis to be used in court proceedings[74].

The reliability of two methods used to produce computer generated bite mark overlays with Adobe Photoshop was assessed. It was concluded that both the techniques were reliable methods to produce bite mark overlays in assessing tooth position. The authors were of the opinion that although not completely objective, the use of computers is forging the way toward less subjectivity in the comparison of bite marks[75].

MATERIAL AND METHOD

Materials used in the study

1. Alginate impression materials
2. Die stone
3. Upper and lower perforated impression trays
4. Rubber bowl and spatula
5. Disposable gloves and mouth masks
6. Modelling wax sheet
7. Barium sulphate power (Microbar HD)
8. A 5 ml syringe
9. X-ray film



Figure 1

Equipments used in the study

1. Vibrator
2. Cast trimmer
3. X – Ray machine
4. X-Ray cassette
5. Lead apron
6. Digital Vernier Caliper



Figure 2

METHOD

Inclusion Criteria

07 subjects with complete set of natural upper and lower anterior teeth were selected for the study.

Exclusion Criteria

Subject's with orthodontic appliances, intraoral prosthesis, impaired mouth opening, position abnormalities and loss of anterior tooth structure, periodontal and gingival abnormalities, developmental tooth anomalies and severe wasting diseases were excluded from the study.

Method of Collection of Data

Each of the 07 subject's was made to sit comfortably on the dental chair and the upper and lower alginate

impressions were taken. The impressions were then rinsed thoroughly. Alginate impressions were made as per the manufacturer's recommendations since alginate material satisfies the court stipulations in the collection of evidence. The alginate was poured promptly according to the manufacturers recommendations as soon as the impressions were made, as they tend to lose dimensional stability via syneresis. Die stone was used since it is a strong gypsum product and for accurate details of the impression obtained. They were poured in die stone using the standard pouring techniques. The models were then trimmed of the excess stone and serially numbered. They were then placed carefully in cotton-lined boxes and stored.

Hand tracing from wax impression method (Wax-Imprints based method)

The upper and lower study casts were pressed into a single wafer of wax sheet by applying manual pressure so as to produce a shallow impression of the biting surfacesof the six upper and six lower anterior teeth.

VIKS BITEMARK ANALYSIS TECHNIQUE

After taking a squash –bite on the soft modeling wax , of the suspect , the indentations are filled with barium sulphate and a ball bearing of 5 mm is fixed in wax . The ball bearing should be accurately of 5 mm in diameter. The radiograph is then taken and the radiographic appearance of ball bearing is measured. Then the magnification factor is derived by dividing the radiographic diameter of ball bearing by the actual diameter of the ball bearing . Then the measurement of incisal edge in the radiograph is taken and divided by the magnification factor . Then the original measurement of indentation is obtained .

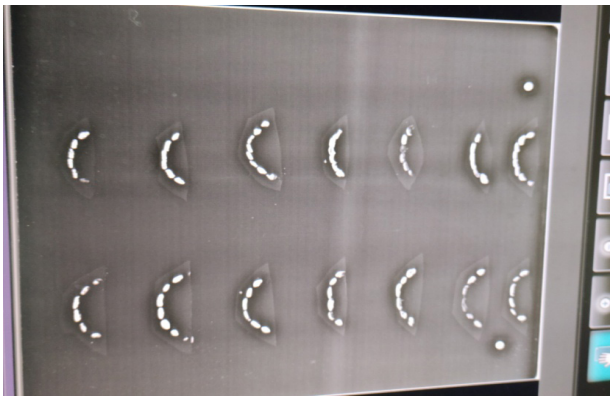


Figure 3



Figure 4

Magnification Factor = Measurement Of Diameter Of Ball Bearing On Radiograph/ Actual Diameter Of Ball Bearing=5.1/5 =1.02

Table 1: Demonstrating The Measurements Of Indentations On The Radiograph, Original Dimension And Dimensions From The Cast

Specimen 1

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	6.1	6.0	6.4
12	4.7	4.6	5.1
21	6.2	6.1	6.6
22	4.8	4.7	5.3
31	4.5	4.4	4.8
32	4.4	4.3	4.7

41	4.5	4.4	4.8
42	4.2	4.1	4.6

Specimen 2

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	6.0	5.9	6.6
12	5.3	5.2	5.7
21	6.2	6.1	6.7
22	5.4	5.3	5.9
31	4.7	4.6	5.4
32	4.4	4.3	5.0
41	4.6	4.5	5.1
42	4.5	4.4	5.0

Specimen 3

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	6.2	6.1	6.6
12	5.1	5.0	5.4
21	6.0	5.9	6.5
22	5.2	4.3	5.7
31	4.2	4.1	4.8
32	4.2	4.1	4.8
41	4.1	4.0	4.6
42	4.2	4.1	4.7

Specimen 4

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	5.9	5.8	6.5
12	4.7	4.6	5.2
21	6.1	6.0	6.6
22	4.7	4.6	5.2
31	4.2	4.1	4.8
32	4.4	4.3	4.9
41	4.0	3.9	4.6
42	4.4	4.3	5.0

Specimen 5

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	6.5	6.4	7.0
12	5.0	4.9	5.6

21	6.5	6.4	7.1
22	4.8	4.7	5.3
31	4.9	4.8	5.5
32	4.4	4.3	5.0
41	4.6	4.5	5.1
42	4.5	4.4	5.1

Specimen 6

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	7.2	7.1	7.7
12	5.1	5.0	5.4
21	7.1	7.0	7.6
22	5.0	4.9	5.5
31	4.6	4.5	5.1
32	4.4	4.3	5.0
41	4.5	4.4	5.1
42	4.5	4.4	5.0

Specimen 7

Tooth Number	Radiographic Dimension	Original Dimension	Dimension On Cast
11	6.5	6.4	7.1
12	4.4	4.3	5.0
21	6.7	6.6	7.2
22	4.3	4.2	4.9
31	4.4	4.3	4.8
32	4.7	4.6	5.2
41	4.5	4.4	5.1
42	4.7	4.6	5.3

DISCUSSION

The present study was undertaken to evaluate the reliability and accuracy of VIKS bitemark analysis technique. After careful observation of the collected data , it has been noted that only the pressure areas i. e. incisal edge of the indentation should be measured in the radiograph because on skin or in wax only the pressure areas of the bite mark reveal the accurate radiographic representation of the dental structure of the suspect. The area of the biting edge and relative rotation of each upper and lower front tooth were recorded and compared.

There maybe a minor discrepancy in the actual size and that on a cast due to the properties of the material used for cast fabrication . The dental stone used may show expansions at room temperature .

RESULTS

All the 7 specimens were analysed and dimensions were studied which stated that VIKS bitemark analysis technique for mapping the bitemark of the suspect , on the skin of the victim , by using a radiopaque substance has been found to be highly accurate and can be used by forensic odontologists for their investigations

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