ISSN 2219-6749

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The Journal of Forensic Odonto-Stomatology

Volume 12, n. 2 - Dec 1994

OFFICIAL PUBLICATION OF THE
INTERNATIONAL ORGANIZATION FOR
FORENSIC ODONTO-STOMATOLOGY

CONTENTS

COMPARATIVE REVIEW OF BITEMARK CASES FROM PRETORIA, SOUTH AFRICA

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ABSTRACT

Bitemark evidence has become more scientifically based and is currently widely accepted in the legal process. Bitemarks can be inflicted by humans or animals on humans, animals and a variety of inanimate objects and can be found on any part of the body, with their quality and appearance being influenced by a variety of factors. The purpose of this study was to record the experiences with bitemark cases presented to forensic odontologists at the University of Pretoria from 1983-1993 and to compare them with trends and findings elsewhere. Sixteen cases are presented, of which 14 were bitemarks inflicted by humans and two by dogs. Thirteen cases occurred in human tissues, three in inanimate objects. Of the bitemarks in human skin, most were present on the arms, followed by the face, thorax and back. Bitemarks over the entire body were seen in the two victims bitten by dogs. The male:female ratio was 4:1 and in 46% of cases single marks were present while the rest were multiple. Eight of the victims had been assaulted. Two cases were associated with sexual behaviour (rape), two were inflicted by dogs, and the circumstances surrounding one case were unknown. A variety of factors complicated the investigations. The major factors responsible for disqualifying bitemarks as evidence included mutilation, removal of tissues, inexperience of officials involved and multiple bitemarks. The results of the study confirm the importance of bitemarks as forensic evidence. Humans are the primary victims with the arm being the anatomical site most often involved. Inexperience on the part of the investigating officers and other officials in the handling of these cases strongly emphasises the need for proper training and education of these personnel. **(J Forensic Odontostomatol 1994; 12:2, 23-29)**

Keywords: Bitemarks, identification, forensic odontology

Running title: Identification of bitemarks.

INTRODUCTION

Bitemark evidence has reached a high level of scientific reliability[1] and is widely accepted in the legal process.[2,3] The individuality of bitemarks stems from the uniqueness of the human dentition which is presently undisputed.[4]

The earliest reported attempts to admit bitemark evidence in a court of law were the cases of George Burrows (1692), A I Robinson, Ohio (1870)[5] and a burglary case in 1906 where a bitemark in cheese served as evidence.[6] Since these historical contributions of bitemark evidence to the law, only few cases were reported in earlier times, but more recently the numbers have increased.[1]

Bitemarks can be inflicted by humans and a variety of animals, and apparent bitemarks by mechanical means can be found in human or animal skin, body tissues, various foodstuffs and other inanimate objects. [7-11] It is important to determine whether a wound is definitely a bitemark,[11] since a variety of marks may be misinterpreted as bite injuries.[12]

The most common types of human activity associated with bitemarks include rape, homosexual acts, other forms of sexual behaviour, child abuse and self-defence.[9,13,14] Bitemarks are in most instances present on the body of the victim and inflicted by the assailant, but in some cases the wound can be self-inflicted,[14] and either accidental or intentional,[11,13,15] and may be present on any part of the body accessible to the victim's mouth.[11,13] These self-inflicted bites may be the result of attempts to counteract pain,[13] for example during an episode of myocardial ischemia[16] or even as part of a suicide attempt.[17]

Bitemarks can be present on any part of the human anatomy and in over 40% of cases two or more bites were present in a series reported by Vale and Noguchi.[9] There is also a variation in the anatomical distribution of bitemarks in different series.[9,18-21] Apart from any other anatomical sites, Speirs[21] reported 59 bitemarks on different parts of the upper limb and only 7 on the breast, Lowry[19] reported 93 out of 122 on the hands and fingers, Marr *et al.*[20] 546 out of 892 on the upper limb and only 103 on the trunk, Vale and Noguchi[9] 32 on the arms and 17 on the breast, while Harvey[18] reported 23 on the breast and only 10 on the arms. A difference in distribution between males and females was also found by Vale and Noguchi.[9]

The classical bitemark comprises imprints of both upper and lower anterior teeth in an oval or circular pattern. A wide variety of patterns can however be seen, for example, a single circular puncture, an imprint of only one arch or even the presence of imprinted marks of premolars and molars.[13] The quality and appearance of any bitemark is determined by a large

number of factors. Apart from factors associated with the circumstances surrounding the incident, various intrinsic as well as extrinsic factors can affect the quality of a bitemark and its applicability as scientific evidence.[13]

Considerable variations exist in bitemark impressions in foodstuffs and they differ from bitemarks in flesh since true penetration of the object generally occurs which leaves impressions made by the labial aspects of teeth rather than by the biting edges.[10]

The present study was undertaken to record the bitemark cases presented in the decade 1983-1993 to forensic odontologists at the University of Pretoria and to compare these results with trends and findings elsewhere.

MATERIALS AND METHODS

All bitemark cases referred to the Department of Oral Pathology and Oral Biology, Faculty of Dentistry, University of Pretoria by the State Pathologist (Northern Transvaal Region) during the period 1983 to 1993 were reviewed and compared. Consultations requested by district surgeons and the Police during the same period were also included. The total number of cases was 20, of which 4 were excluded from the study since the wounds in these cases were not investigated for identification purposes. The 16 cases were compared regarding anatomical distribution, gender of victims, number of bitemarks and circumstances surrounding the cases.

RESULTS

The total number of cases included in the study was 16 of which 14 were inflicted by humans and two by dogs. In 13 of the bitemark cases humans were the victims and three were inflicted on inanimate objects. These three were all found at scenes of burglary, two of which were bitemarks on aluminium caps of plastic soft drink containers and the other in a piece of chewing gum left at the scene of crime.

Comparison of the bitemark cases on humans revealed the following:

1. Anatomical distribution (in cases where numerous bitemarks were present in one area, the area was counted only once in order to reflect areas rather than the total number of bitemarks).

   The upper extremities were involved in 50% of cases, the face in 19%, the thorax in 12.5% (in one case multiple bitemarks were present on the skin of the thorax - Fig.1), the back in 6%, while diffuse bitemarks over the entire body were present in 12.5% of cases (the two cases where the bitemarks were inflicted by dogs).
2. Gender

   Ten males and three females were involved.
3. Number of bitemarks per case

   In six cases single bitemarks were present, two bitemarks were seen in two cases and multiple bitemarks in five cases.
4. Circumstances surrounding the cases.

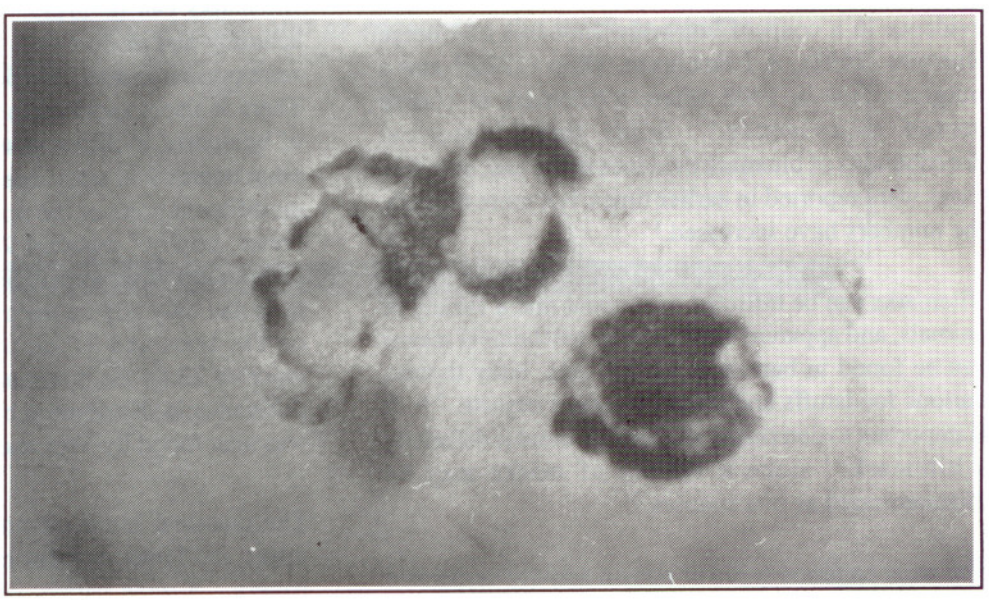

Fig. 1. Several bitemarks on the skin of the thorax in a victim of sexual assault.

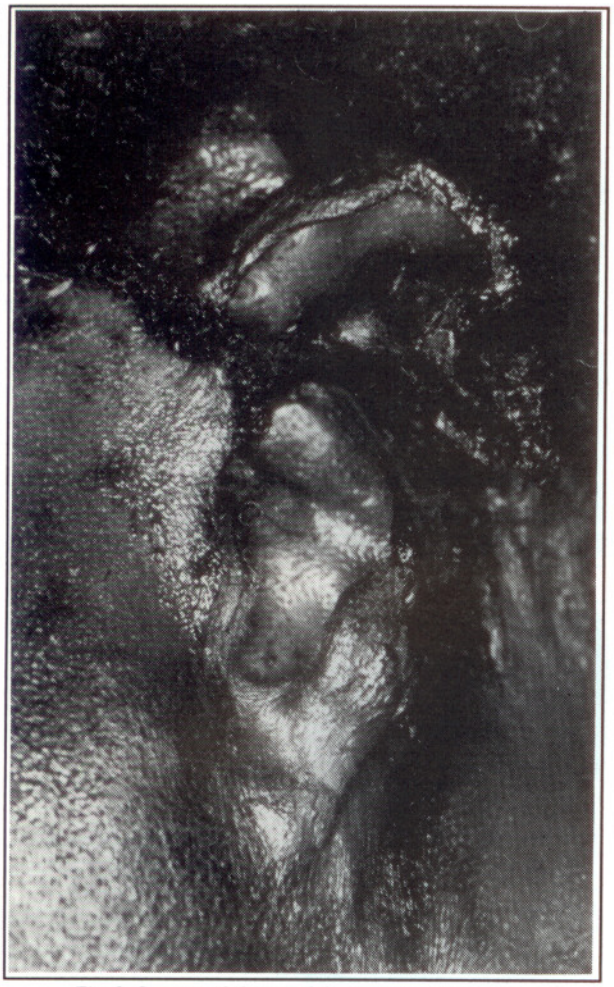

Fig. 2. Severe multilation of the ear in a rape victim.

Eight of the victims were assaulted (including one case of a self-inflicted bite), two were victims of rape, two were attacked by dogs and the circumstances surrounding one case were unknown. Twelve of the 13 victims were deceased.

A number of complicating factors was encountered, resulting in disqualification of findings as scientific evidence in several of the cases. These factors included:

1. Penetration of the skin with associated laceration and severe mutilation in some cases (Figs.2 and 3).
2. Lapse of time between recognition of bitemarks and consultation of forensic odontologists, resulting in time related changes in the bitemarks.
3. Unavailability of records of the bite pattern of the victim in a case of a self-inflicted bitemark, since the victim was already buried at the time forensic odontologists were consulted.
4. Performance of an autopsy prior to examination of a bitemark on the thorax, resulting in distortion of the mark.
5. Skin temperature was too low and interfered with the setting process of the impression material.
6. Inadequate photographic material presented to forensic odontologists in cases where they were not present at the post-mortem examination.
7. Advanced decomposition.
8. Dissected piece of skin containing the bitemark was the only material presented for forensic odontological investigation.

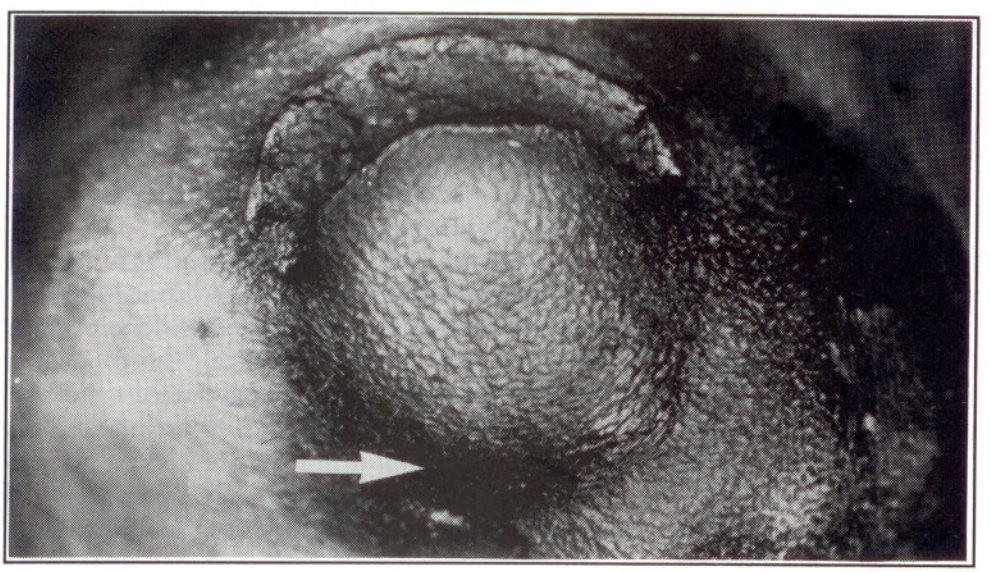

Fig. 3. Extensive damage to the chin of a victim. Note the laceration caused by the upper teeth and the subcutaneous bleeding as a result of the action of the lower anterior teeth (arrow).

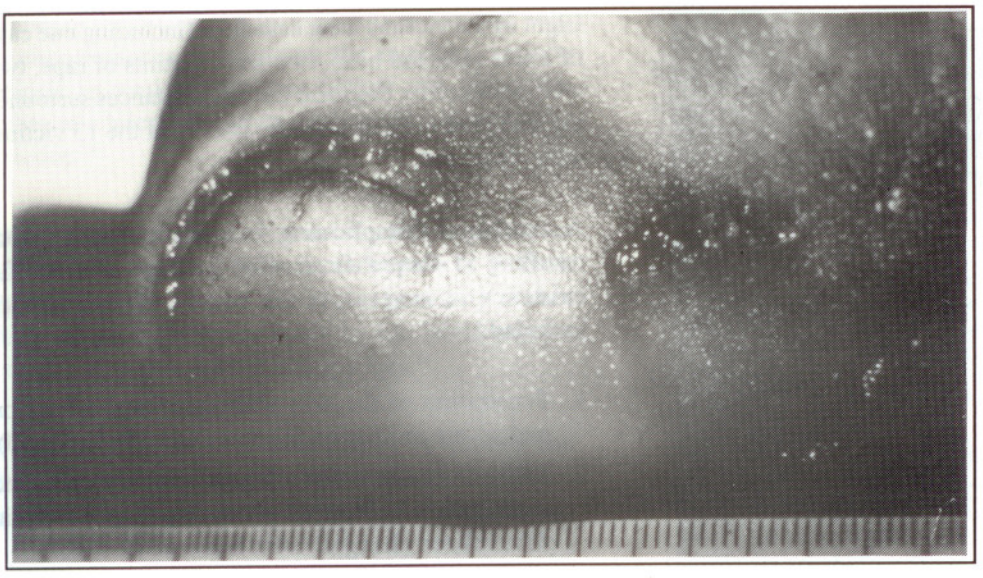

Fig. 4. A bitemark on the chin of a victim showing penetration of the skin, as seen during the initial examination.

Fig. 5. The same bitemark as in Fig. 4 after 24 hours, clearly showing changes due to cooling and drying of the wound.

9. Time-related changes in the quality and appearance of bitemarks (Figs.4 and 5).
10. Numerous and confusing bitemarks on a wad of chewing gum.
11. Multiple bitemarks especially in the cases where the victims were attacked by dogs (Fig.6).

DISCUSSION

Most of the bitemarks in this study were present on the human body. This is in accordance with the findings of other studies[9] where the number of bites in inanimate objects and those inflicted by animals was also low. Circumstances surrounding the cases in this study however, differed markedly from other reports in that more cases resulted from assault than from sexually related (including rape) events where, according to other authors,[9,13,14] the latter group forms the majority of bitemark cases. The reasons for this difference are not certain. Possibilities are that the histories were incomplete or that forensic odontologists were not consulted in all instances. There is probably a strong relationship between the difference in circumstances and the difference in the gender of victims, when this study is compared with that of Vale and Noguchi[9] where the male:female ratio was 1:2, while in this study the ratio was 4:1. Female victims were most often involved in sexually related crimes while males were mostly the victims of assault.[9]

The anatomical distribution of bitemarks investigated in this study is comparable to that of Vale and Noguchi[9] and others[19-21] in that more bitemarks were found on the upper limbs than on the thorax. This contradicts the findings of Harvey[18], who described more than twice as many bitemarks on the breasts than on the upper limbs. The cases in our series were restricted to the arms, face, thorax and back, and only the bitemarks inflicted by dogs were found on other areas of the body. The number of bitemarks per case however, corresponds with other reports[9] where up to 40% or more of cases showed multiple bitemarks. The total

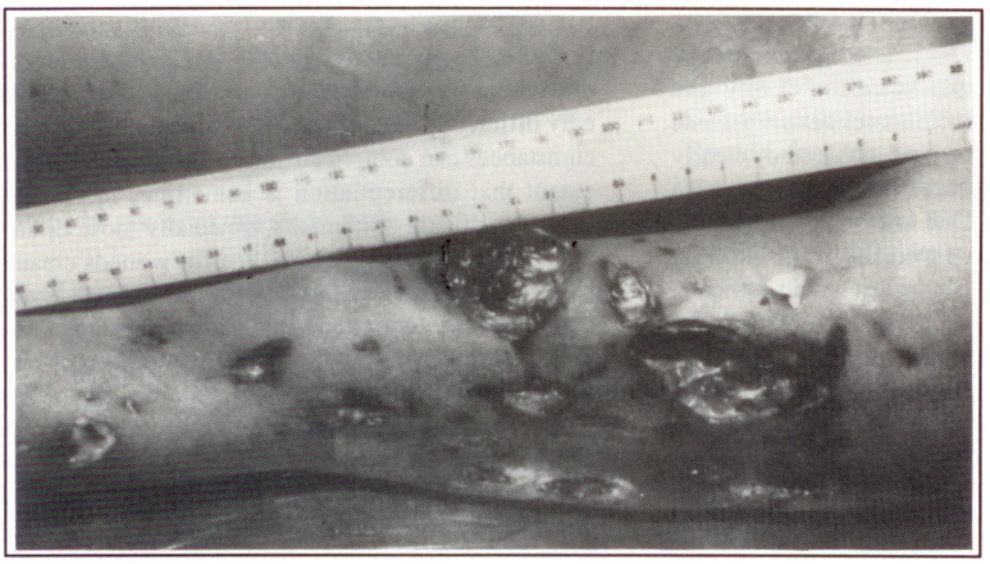

Fig. 6. Multiple bitemarks showing extensive lacerations on the upper arm of a victim bitten by a dog.

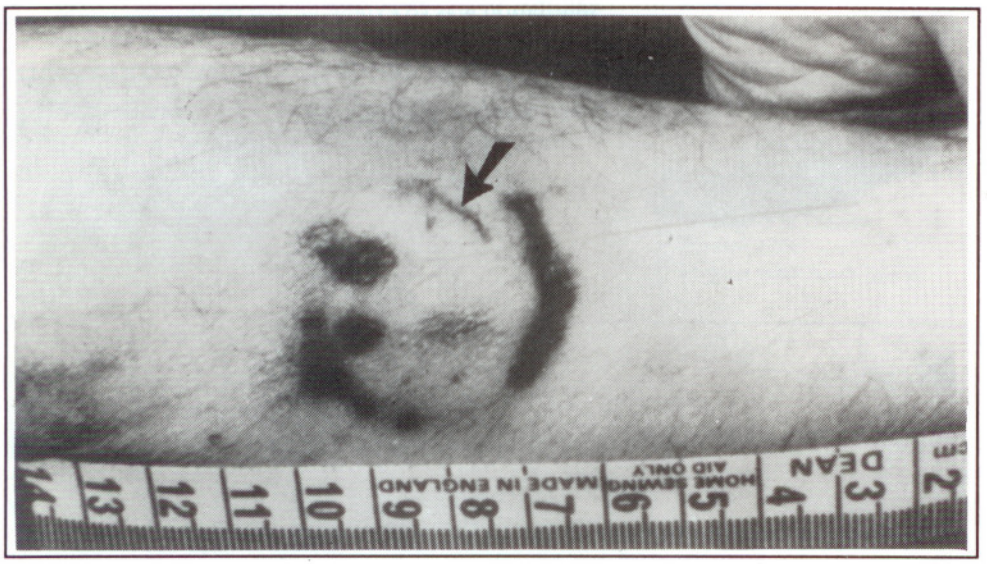

Fig. 7. A self-inflicted bitemark on the inside of the lower arm. Note the lacerations (arrow) caused by a fractured crown of a maxillary central incisor tooth.

number of bitemarks was not taken into account in this study since 30 or even more bitemarks were seen in a specific area in some cases. Had this been done, statistical distortion would have been inevitable[9] and the distribution was considered to be of more importance than the individual bitemarks.

All the cases in the current series were associated with violence and only one case was a self-inflicted bite. The bitemark in this case made a particularly important contribution to clarification of the circumstances surrounding the case. Figure 7 clearly demonstrates lacerations caused by a fractured maxillary central incisor tooth which was fractured with the other anterior teeth earlier in the confrontation by a violent punch on the mouth. The bitemark was accidentally self-inflicted by the victim in a desperate attempt at self-defence while one assailant was sitting on him and another one was attacking him with a knife. This is unusual as bites in self-defence are usually present on the fingers, hands and fore-arms of the assailant.[22] Self-inflicted bites associated with criminal attacks (as in the current case) are most often seen on the inside of the fore-arm, as a result of forceful manipulation of the victim's arm against his own teeth,[15] usually to stifle a cry.[11]

The variation in appearance of different bitemarks was clearly demonstrated in this study. Penetration of the skin almost invariably resulted in pronounced laceration and severe mutilation in some cases. In these cases it was almost impossible to compare the bitemark with the offending dentition bite pattern and to draw any conclusions regarding the identity of the assailant. A number of factors listed by Dorion[13] and described by others[11,22] are said to contribute to the nature of penetrative wounds, including the anatomical site bitten (ears and chin in this series), emotion, force of bite, position and action. It is important to be aware of all the factors which can affect the clarity and quality of a bitemark and to account for the possible role that could have been played by each of these factors.

Bitemarks undergo considerable change with time, especially in living victims.[11] It is advisable to take photographs every 24 hours, since the clarity and appearance may change and sometimes details become clearer after a few days.[22] One case in this study clearly showed that bitemarks in deceased victims can also change, but for the worse. Due to cooling of the body and drying of the wounds, especially in penetrating wounds, considerable detail can be lost within 24 hours.

In contrast with a case described by Whittaker,[22] where the lobe of an ear was removed by a bite inflicted by a "sportsman" wearing a mouthguard, a case is included in this series where only imprints of the lower teeth were left on the cheek of an opponent by a player wearing a mouthguard (Fig.8). During the court hearing of the former case, it was demonstrated that the wearing of mouthguards does not prevent soft tissues from being bitten or even torn.[22]

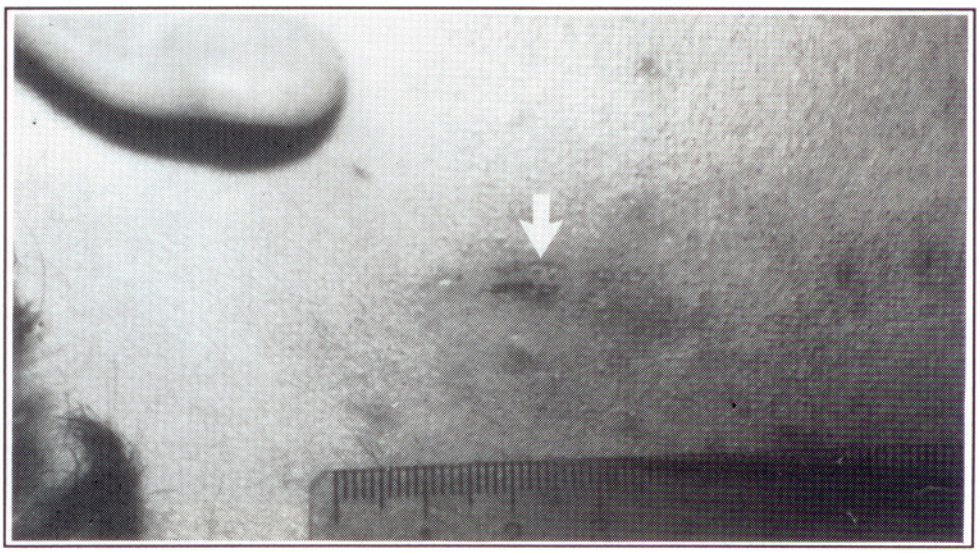

Fig. 8. Two imprints (arrow) caused by mandibular anterior teeth of a sportsman wearing a mouth guard. Note the absence of any marks left by maxillary teeth.

Partially eaten food and other inanimate objects containing bitemarks are not uncommonly found at the scene of a crime, but not frequently used for identification purposes.[11] In the three cases included in this study alert police officers spotted objects bearing suspicious marks and which resulted in substantial contributions to the legal process. Webster suggested a classification of bitemarks in foodstuffs based on the depth of penetration of teeth into the substance, and on the type of material bitten. One of the current cases could fit into Webster's type 1 bite since numerous incisal edge marks of upper and lower anterior teeth were present on a wad of chewing gum. A case where chewing gum had been an important piece of evidence in a homicide investigation, was reported by Sperber.[23] In this case, imprints of the lingual surfaces of upper and lower anterior teeth were clearly visible, resulting in a successful comparison with a suspect's dentition. In our case, however, comparison of the marks with any dentition was impossible because of the numerous and overlapping impressions of the incisal edges of the teeth.

It is important to distinguish between bitemarks inflicted by humans and animals.[11,13] Although the routine bitemarks of humans and animals would be markedly different and could easily be distinguished,[24] circumstances can complicate the appearance to such an extent that differentiation is sometimes in fact extremely difficult. Bitemarks, especially those of animals, can also easily be mistaken for wounds created by a variety of mechanical objects. A thorough investigation of the entire body, and gathering of the maximum information from the investigating team, is thus of major importance.[24] Although fatalities due to dog bites are reportedly rare and most of the victims are children,[25] the current series included two fatal attacks by dogs, both victims being adult males. In both cases, human causation was excluded owing to the classical appearance of dog bitemarks in some areas and the extent of tearing that was present. In some areas, mutilation was so extensive that the injuries could have been mistaken for cuts made by a sharp instrument, as in the case described by Sperry and Campbell.[12] This is in accordance with the description[26] of wounds resulting from dogs attacking in anger. The bitemarks were present over the entire body with the areas most severely bitten, being the upper and lower extremities, neck and head.

The reliability of bitemark evidence and the significance of the contribution that a well executed bitemark investigation can make to the legal process is no longer questioned.[1] However, owing to the complicated nature of these investigations, as demonstrated in this series, an experienced forensic odontologist should always be included in the investigating team. Apart from that, law enforcement officers and other officials involved, should be alert to the possibility of the presence of bitemarks[9] and the complicating factors surrounding such investigations. A number of unfortunate complications, described above, could have been prevented if all concerned had realised the importance

of correctly handling bitemark cases. This emphasises the need for proper education and training of these personnel.

CONCLUSIONS

From the results of this study, it can be concluded that:

1. Humans are the primary victims involved in bitemark cases.
2. The upper limb is the anatomical site most often involved.
3. Bitemark investigations, properly executed and which overcome the problems caused by the vast number of complicating factors that could influence these investigations, can play a determining role in legal procedures.
4. Active participation by an experienced forensic odontologist, during the entire bitemark evaluation process, is of utmost importance.
5. Inexperience of investigating officers and other officials in the handling of bitemark cases strongly emphasises the need for proper education and training of these personnel.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to Prof JD Loubser and the staff of the Medico-legal Laboratory, Pretoria, for their kind cooperation, assistance and the provision of cases. The authors would also like to thank district surgeons and the Police for providing material and Mrs A Kitching for typing the manuscript.

TECHNICAL NOTE

Although a scale is not present on all the illustrations, its importance for proper analysis of bitemark evidence cannot be overemphasised. In all cases the identification process was conducted with the aid of a proper scale. Apart from photographs including a scale, several were taken without it to convince the Court that no evidence had been obscured in the photographs - these illustrations were selected to demonstrate our findings in this paper.

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IMAGE EDITING AND COMPUTER ASSISTED BITEMARK ANALYSIS: A CASE REPORT

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ABSTRACT

Bitemark evidence in a homicide usually involves a perpetrator biting the victim prior to or around the time of death. This paper presents a case in which a homicide victim bit his assailant. A suspect taken into custody was found to have what appeared to be a human bitemark on the proximal phalanx of his right thumb. Scale photographs of this injury were obtained and compared to the dentition of the deceased using digitized computer images for superimposition. Three different approaches for comparison with the bitemark photograph were utilized: comparison with radiographs of amalgam-filled impressions of dental casts, a transparent overlay technique and comparison with photographs of a simulated bitemark inked onto the hand of a volunteer. A review of these techniques as they apply to computerized bitemark analysis is presented. **(J Forensic Odontostomatol 1994; 12:2, 30-36)**

Keywords: Bitemark, homicide, computer analysis, digitization, superimposition, overlay

Running title: Computer-assisted bitemark analysis.

INTRODUCTION

The key to the credibility of bitemark evidence is the premise of individuality in human dentitions. This uniqueness has been confirmed by numerous investigators[1,2] with significant differences being found even between identical twins.[3] Characteristics such as tooth size, shape, wear, tippings, rotations, spacing and restorations in individual dentitions can all act as signatures aiding in identification.[4] When the quality of the bitemark permits, overall arch morphology can also be used for identification purposes. In these cases, measures such as inter-canine distance, arch length and arch width can be employed to aid in match determination.[5]

Another controversy over bitemark analysis involves the nature of the substance into which the bitemark is registered. Bitemark evidence has been found in a multitude of materials ranging from human flesh to sandwiches.[6,7] It has been argued that the distortions to which bitemarks are subjected may preclude their usefulness in acting as "dental fingerprints".[8,9] A bitemark is the result of a complex interaction between the dentition of the biter (which is under control of the masticatory apparatus and its associated influences from higher centres) and the nature of the material being bitten.[8,10,11] Many variables contribute to the registration of a bitemark such as tissue elasticity, location, depth of penetration, multiple superimposed bites, the mental state of the aggressor, the biting force and duration, tongue pressure, suction and sliding movements to name but a few.[4,12] Other factors which may alter the bitemark include the victim being alive or dead, any inflammatory response and distortions from photographic methods used to record the injury.[5,13-15]

Bitemark investigation usually involves a comparison between the dentition of the alleged biter and a photograph of the bitemark. Photography is used primarily because it is one of the most convenient ways of recording the bitemark, although for deceased victims there are more direct methods of preserving and analysing the wound.[16,17] Traditional methods of comparison have included placing dental casts directly onto a 1:1 photograph of the victim's wound,[4] or using a transparent overlay tracing or radiographic image of the bitemark pattern superimposed on the photograph.[18] Simulation of the bitemark has also been employed and involves pressing the incisal edges into various materials such as plasticine, or inking the cast to yield an imprint of the bite pattern.[19,20]

Various methods of image enhancement have been utilized to assist in interpretation of bitemarks, including reflex microscopy, toneline photography and solarization.[21-23] Additionally, computer technology has helped to revolutionize the field of bitemark photography, allowing the forensic odontologist to manipulate and superimpose images with ease.[3,24] The purpose of this paper is to report a homicide case in which bitemark evidence was a feature. Computerized image editing was employed and is discussed as it applies to three previously used techniques of match determination.

CASE REPORT

A 35 year old male taxi driver picked up an individual on the evening of 3 July, 1992. A fight between the driver and passenger ensued, both in and out of the vehicle, during which the driver received a fatal blow to the right occipital region with a 22 kg stone. On the following day a suspect was apprehended with a bitemark evident on the proximal phalanx of his right thumb. Scale photographs of the bitemark were obtained by the investigating officer. (Fig.1) The bitemarking on the suspect consisted of both crushed tissue and laceration. There were two distinct markings, one larger, one nearer the distal aspect of the thumb and a smaller semi-circular marking proximal to the distal marking. Whereas the distal marking involved penetration of the tissue, the proximal one did not. The orientation of both markings was such that the mark was made while the suspects thumb covered or entered the victims mouth.

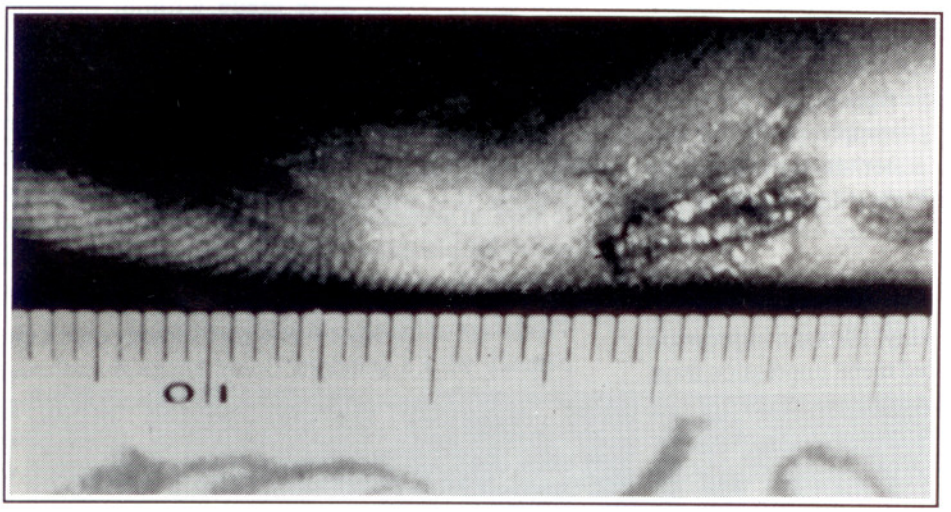

Fig.1. Scaled police photograph of the right hand of the suspect showing the original bitemark over the proximal phalanx of the thumb. Photograph was taken within twenty-four hours following the murder.

The victim's body was examined by the authors on the morning of 6 July, 1992. Extra-oral examination revealed a clean shaven individual with normal facial features and symmetry. Multiple contusions and lacerations were evident on the left side of the frontal, peri-orbital and malar regions of the face. Measurements of border movements of the lower jaw were generally normal, and the subjects incisor teeth could be manipulated into end-to-end contact. The lips were dry but suitable for examination. There were multiple, small contusions present on the anterior middle two thirds of the lower lip. There was a second discrete contusion present on the upper lip adjacent to the right lateral incisor and the outlines of these lesions suggested that the subject had bitten himself. (Fig.2) No extra-oral scars or burns were noted.

An intraoral examination was performed and all restorations, missing and malposed teeth were recorded. Significant disto-labial rotation of the right maxillary central incisor and lingual displacement of the adjacent lateral incisor were noted. The periodontal condition was excellent with no notable dental mobilities and no avulsions. A LeFort type 1 maxillary fracture was evident. There was however no evidence of submucosal haemorrhage, as would be expected in a living individual who suffered this type of trauma to the maxilla and its associated periosteum. Manipulation of the mandible, which was intact, revealed an apparent posterior crossbite

Fig.2. (a)Contusions present on lips during examination of the victim: view of mandibular anterior region showing bruising of lower lip.

Fig. 2.(b) discrete contusion present on upper right aspect of victim's lip, adjacent to the lateral incisor.

involving the upper and lower second and third molars on the right side. The left maxillary central incisor was slightly discoloured (grey), and had an old fracture along its incisal edge, extending into dentine. All other teeth had normal colouring. The tongue was absent due to prior autopsy procedures.

MATERIALS AND METHODS

A 35mm camera* loaded with Ektachrome 100 ASA film† and equipped with an auto-thyristor ring-flash¥ and 100mm macro lens§ (capable of 1:1 shots) was used to record the oral structures, impression procedure and all subsequent analyses. Photographs were taken of the oral cavity in general, the upper anterior teeth, contusions on the upper lip, the lower teeth, the teeth in maximal intercuspation, the right side of the head, as well as various views of the impressions and bite registrations obtained. All materials were correctly and carefully handled to ensure that no distortion occurred.

Two complete sets of impressions were taken using Reprosil¶ medium-body polyvinyl siloxane impression material and standard perforated metal impression trays without any modifications#. A rigid plastic perforated disposable tray was also used for one of the maxillary impressions**. Setting time was prolonged initially due to cold storage of the body, but impressions were not removed in any case until the material was completely set (~10 min.).

Bite registrations were taken using pink bite wax††; two of which were taken in maximum intercuspation and two with anterior incisal edges in approximation. Additionally, an anterior bite registration was made with the subject in maximum intercuspation using Reprosil medium body impression material. Study casts were poured up with Die-Keen crown and bridge stone¥¥, and mounted on hinge-type articulators. An attempt was then made to determine whether or not the bitemark present on the suspect could be attributed to the dentition of the deceased.

METHOD 1: Radiographic Technique

This approach compared digitized images of the scaled bitemark photograph to an outline of the incisal edges obtained from radiographs of amalgam-filled impressions of the victim's dental casts. The casts were lubricated with petroleum jelly for the purpose of fabricating a customized acrylic tray§§, which was then loaded with Reprosil heavy-body polyvinyl siloxane impression material. The resulting impression was a highly accurate and stable registration of the incisal edges of the deceased. The impression was carefully filled with dental amalgam¶¶, and radiographed with a Boley gauge set at 1.0cm, using a standard intraoral dental X-ray generator## (70 kVp, 7mA, 0.066s) and Kodak ANSA speed D occlusal radiographic film*** (Figure 3a).

The radiographic images obtained were digitized on a Macintosh IIci computer††† with an X-ray scanner¥¥¥ and manipulated with the Adobe Photoshop image editing software§§§. These images were compared with a similarly digitized negative of the bitemark photograph. (This negative was converted to a positive image on the computer with the INVERT function of the image editing software). Since both images were recorded with reference scales and were sized to match, the comparisons were made without procedural distortion.

METHOD 2: Transparent Overlay Technique

This method of comparison was slightly modified from the technique as it was originally described.[25] A Xerox photocopier### was calibrated for distortion and found to have an accuracy of approximately 99.5%. The stone casts were placed face down on the copier with the incisal edges in direct and level contact with the glass.

The image of the casts was copied directly onto a transparency with a standard Boley gauge for reference. The resulting image gave an accurate and clear representation of the incisal and occlusal edges of the study casts (Fig.3b). Using the computer, this image was superimposed on the scaled 1:1 photograph of the bitemark.

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* *model X-700, serial # 401325, Minolta Camera Corporation Ltd., Osaki 541, Japan*

† *Eastman Kodak Company, Rochester, New York 14650, U.S.A.*

¥ *model MX-2D, serial #3A85A, Sunpak Corporation, Tokyo Japan*

§ *serial 22712196, Vivitar Corporation, Santa Monica, CA 90406-2100, U.S.A.*

¶ *L.D. Caulk, Dentsply International, P.O. Box 359, Milford Delaware, 19963-0359, U.S.A.*

\# *Coe Laboratories Inc., 3737 West 127th Street, Chicago, Illinois, 60658*

** *Traylon Disposable Plastic trays, Weil Dental Supplies Ltd., 18 Grenville St., Toronto, Canada*

†† *pink thin #402, Healthco, 6300A Viscount Rd. Missisauga Canada, L4v 1 H3.*

¥¥ *Miles Dental Products Inc., 4315 South Lafayette Blvd., Indiana, 46614, U.S.A.*

§§ *Instant Tray Mix, Lang Dental Manufacturing Company, Inc., Wheeling, Illinois, 60090, U.S.A.*

¶¶ *Sybralloy Kerr Division of Sybron Corp., P.O. Box 455, Romulus, Michigan, 48174, U.S.A.*

Seimens Heliodent 70 model #5337 241 X 134, Germany.

*** *Eastman Kodak Company, Rochester, New York, 14650, U.S.A.*

††† *Apple Computer, Inc., 20525 Mariani Avenue, Cupertino, CA, 95014-6299*

¥¥¥ *Model 3CX, XRS Corporation, 4030 Spencer St., Torrance CA, U.S.A.*

§§§ *Adobe Systems Inc., 1585 Charleston Road, Mountain View, CA, 94039-7900, U.S.A.*

model 5047 serial # 203091, Rank Xerox Ltd., Buckinghamshire, England.

METHOD 3: Simulated Inked Bite

The third method of analysis involved inking the incisal surfaces of the study models and simulating the bite impression which would have been left by the dentition of the deceased. A standard office ink pad was used to mark the models for this procedure. The hand of one of the authors was used to record the bite impression, and a scaled 1:1 photograph of this image was obtained (Figs.3c,d). The digitized version of the photograph was then compared on-screen with the bitemark photograph obtained by the investigative officer.

RESULTS

The results of each comparative method are shown in Fig.4. The software utilized in this case allows for direct superimpositions to be made. For publication purposes, clarity was improved by placing the bite registrations adjacent to (as opposed to directly over) the bitemark picture. Each comparison was made with scaled images to ensure that a 1:1 comparison was made. The original bitemark photo obtained from police was a high quality colour print. The bitemark consisted of two discrete lacerations present on the hand of the suspect. The arrangement of these markings was in agreement with the relationship between the right maxillary central and lateral incisors of the victim. The distal marking on the thumb closely matches the incisal edge of the right maxillary central incisor. The proximal marking is less discrete, with minimal penetration of the epithelium, and corresponds well with the lingual aspect of the adjacent lateral incisor of the deceased. A slight discrepancy between the angulation of the two markings and the teeth as recorded on the study models is evident. The mobility of the tissue bitten, and variation in thumb flexure could easily account for this (Figs.3c,d). When viewed with the contusions present on the upper and lower lips of the deceased, it was concluded that the markings are consistent with the victim biting the hand of the aggressor as depicted in Fig.5.

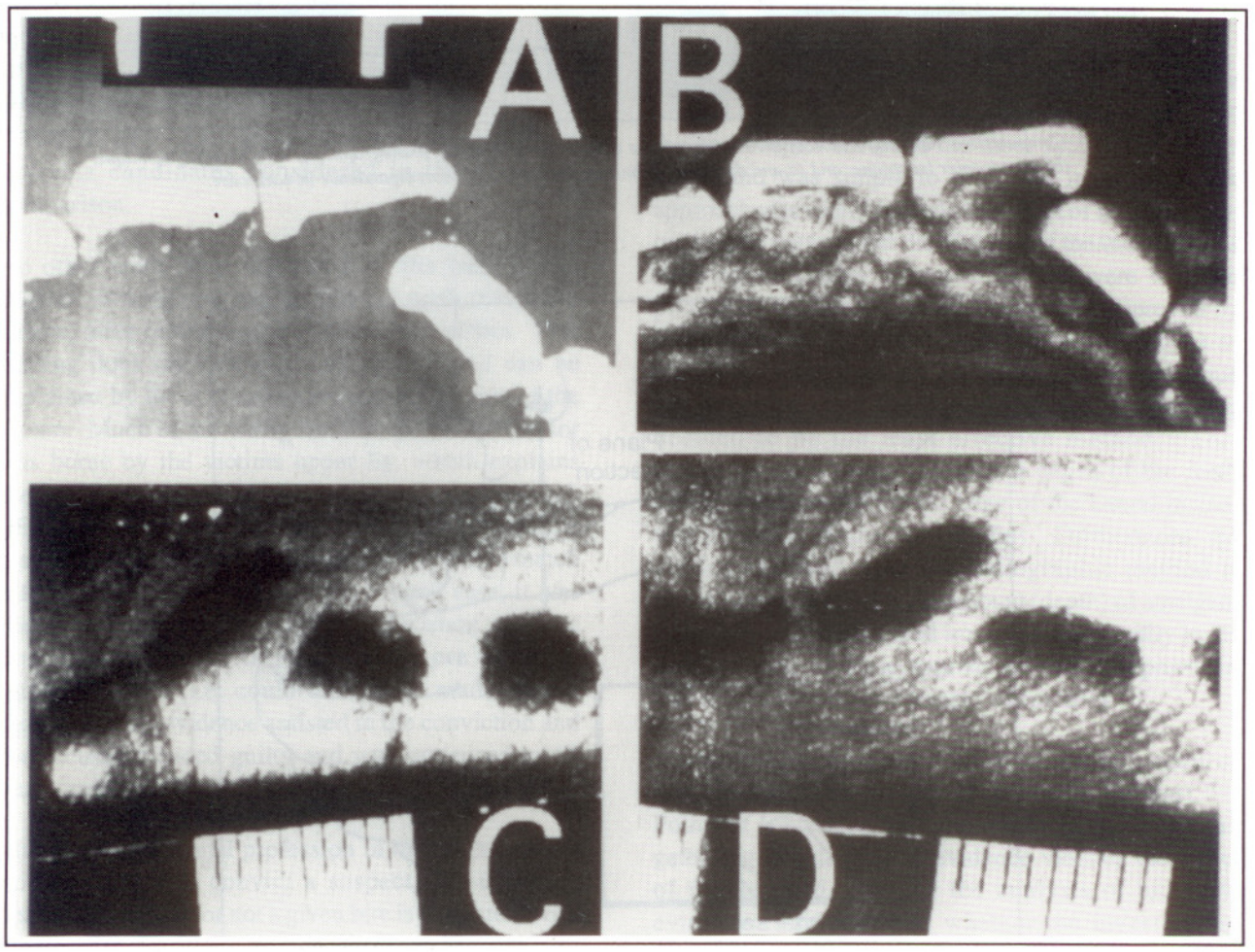

Fig.3. Various images used for comparison with the bite mark photograph, (a) radiographic image of impression made from the study casts of the victim and filled with amalgam to register an outline of the incisal edge, (b) transparency image of the victim's maxillary cast created by the photocopier technique. The spatial relationship between the right central and lateral incisor is evident in this view, (c) photograph of simulated bitemark created by inking the incisal edges of the cast of the victim and impressing it onto the hand of a volunteer with the thumb flexed slightly and (d) as in c but with the thumb straightened.

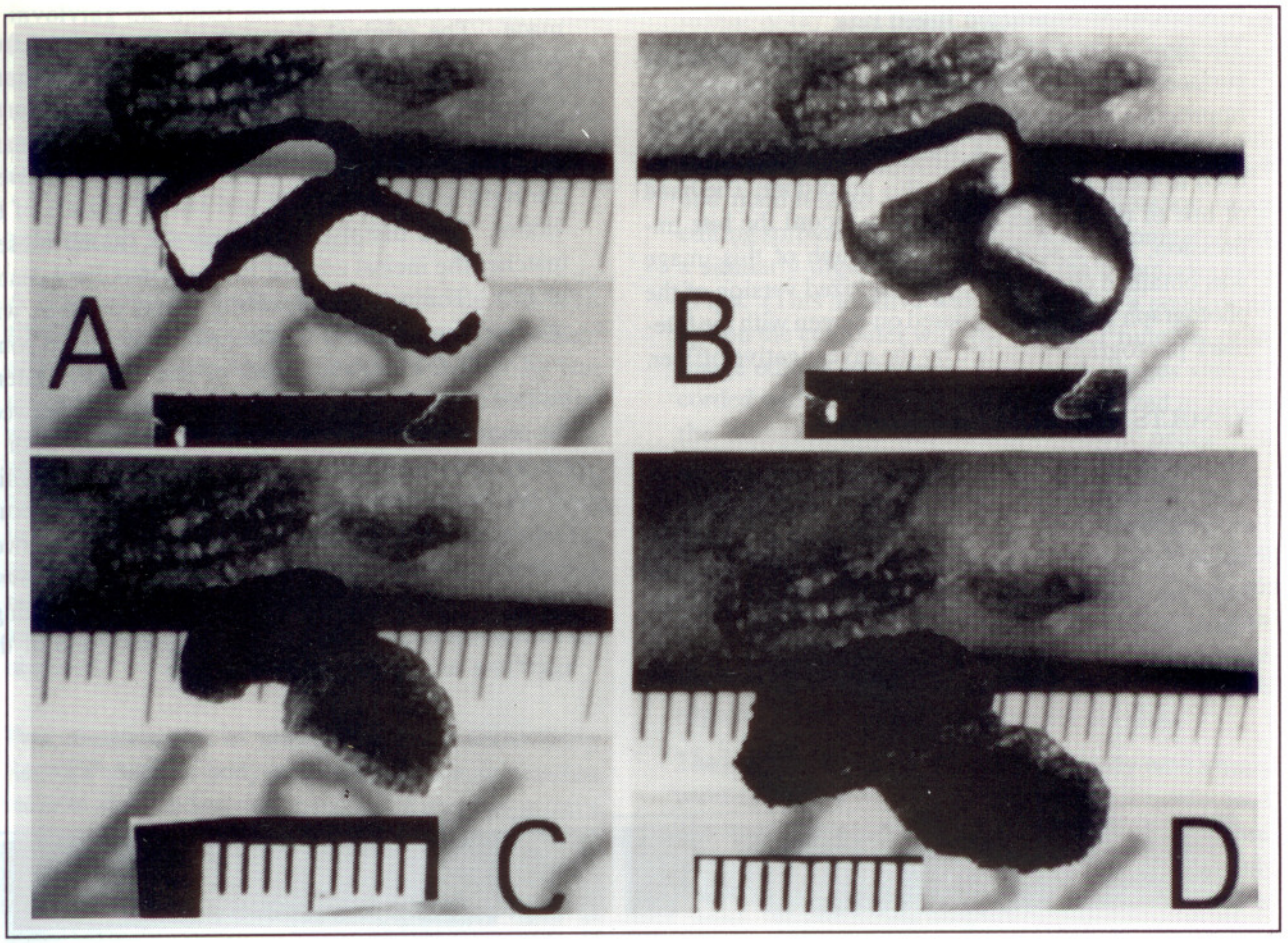

Fig. 4. Computerized superimposition of tooth registrations onto original bitemark photograph: (a) radiographic technique, (b) photocopier technique, and (c and d) inking technique. Note the scale correspondence in each case.

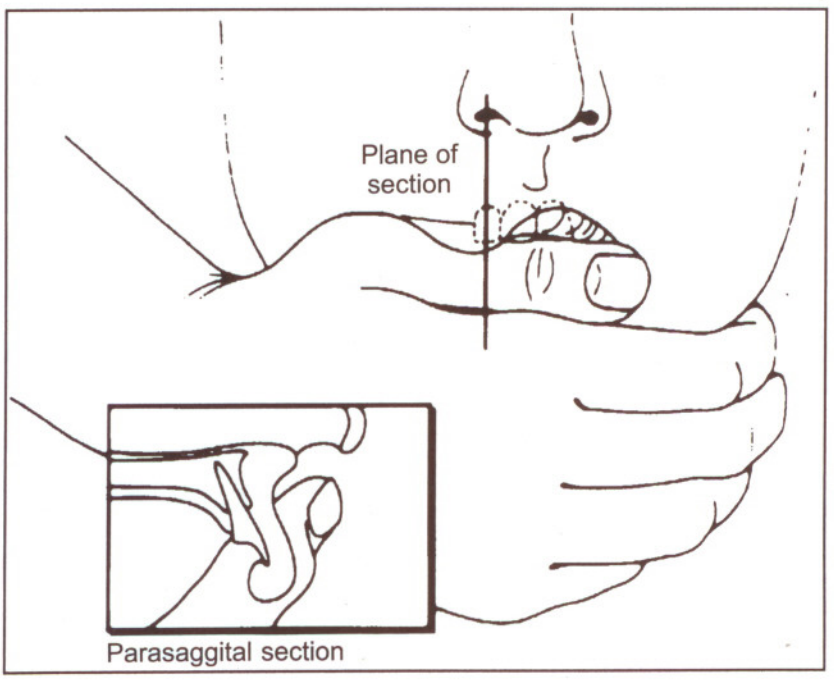

Fig. 5. Artisitic reproduction of the proposed biting scenario. Notice the infolding of the right aspect of the upper lip, and of the entire lower lip.

DISCUSSION

The methodology of bitemark analysis has generated considerable debate. There is disagreement as to how a match should be defined. A point-by-point comparison has been suggested as being the most quantifiable approach to bitemark analysis. In 1984 the American Board of Forensic Odontologists published guidelines for bitemark analysis in an attempt to standardize the methodology.[26,27] Obviously, many points of correspondence between the bitemark and the study casts permits more definitive conclusions to be made as to the degree of matching between the two. However, the number of points of comparison required to positively identify a bitemark varies from case to case.[28]

In the present case only two teeth were registered in the bitemark, making comparisons of arch morphology impossible. Fortunately the relative positions of these two teeth was highly characterized, increasing their value in the analysis of the bite. The incidence of disto-labial rotation of the upper right central incisor has been estimated at 10.4% of individuals, whereas distal displacement of the upper right lateral incisor has been estimated at 7.4%.[29] Assuming independent expression of these traits, the likelihood of both traits presenting in the same individual would be approximately one person in 130. This greatly reduces the number of possible candidates considered in the bitemark comparison.

No other teeth were registered on the hand of the suspect, although all twelve anterior teeth (canine to canine) were present in the mouth of the victim. This finding does not rule out a match,[12,30] and can be explained by the contusions present on the lips of the victim. Much of the biting force of the lateral incisor was borne by the victims upper lip, which explains the partial registration of this tooth seen in the bitemark (Fig.1) and the lower lip was likewise folded over the mandibular anterior teeth. Although a definitive match may have been impossible in the present case, it was concluded that the bitemark was consistent with the dentition of the victim and that there were no inconsistencies (i.e. could have been made by the victim)[31]. This evidence assisted in the conviction and the accused pleaded guilty and was sentenced to 13 years in jail.

The role of the dental profession in bitemark cases is not to attempt to convict a suspect, but rather to determine whether or not a given bite is consistent with a particular dentition. Ruling out an individual may be just as important as finding a perfect match. In the present case the bitemark evidence alone is inconclusive, but when combined with the circumstances of the case it becomes significant.[12] At all times the participating dentists must be clear of their role in the case; an unbiased approach is essential. Bitemark analysis should stand independently from conclusions of guilt or innocence.

Computers have been used previously for bitemark analysis by a number of investigators.[3,19,24] They offer numerous advantages to the forensic odontologist, the most obvious of which is the relative ease by which images can be manipulated. The software used in the present case is a particularly powerful tool for this type of application. Scale photographs of different magnification can be standardized for convenient comparison, cut-and-paste functions allow images to be readily superimposed and many variables can be controlled to aid in the display of the critical features of a bitemark or bite registration, including density levels, brightness, contrast, transparency, edge enhancement and numerous useful filters. The operator is at liberty to work at any magnification desired; enlarged on-screen images are, in the authors' opinions more revealing than an original 1:1 photograph. With a slide generating computer peripheral device, prints or slides of the results can be made to enhance courtroom presentation.

Three methods of bitemark analysis were used in the present case. The transparent overlay generated from the photocopier recorded the most detail of the study casts, and was simple to do. The inked bitemark approach was useful to study the effect of hand position on the bite pattern, but the outlines of the incisal edges were not as clearly displayed as they were with the photocopy technique. Sharpness may be improved by using acrylic study models which do not absorb ink as readily as stone plaster. The radiographic technique was also useful, but due to a relative lack of detail was deemed to be the least effective method. This technique shows only the incisal edges of the teeth and in this case the incisal edge of the lateral incisor was obscured by the victim's lips. Furthermore, the outline obtained from the radiographic method is largely dependent upon the amount (depth) of amalgam filler used. Computerized image editing readily lends itself to each of these approaches and is a powerful tool in contemporary forensic odontology.

The acceptability of bitemark evidence in a court of law has been the subject of debate in the past.[32-34] Points of contention have included whether or not the gathering of this type of evidence violates the rights of the accused, whether the analysis of bitemark evidence is reliable and whether the investigating dentist is qualified to draw conclusions based on such evidence.[33,35,36] The taking of dental impressions, bite registrations and salivary samples is also permitted, so long as proper investigative procedures are followed.[37]

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Keith Oxley of the Department of Photography, and Illustration Services within Princess Margaret Hospital for their valuable assistance with the figures.

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A BITEMARK CASE WITH A TWIST

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ABSTRACT

This is a case report in which the bite patterns of two suspects were compared to a bitemark on the breast of a murder victim. Each suspect had sufficient concordant features to have been found guilty of producing the bitemark. The irony in this case is that the bitemark was not inflicted by the murderer.

The admissibility of bitemarks as evidence in a court of law is still questionable. The present case illustrates the dilemma that may arise when bitemarks are evaluated. **(J Forensic Odontostomatol 1994; 12:2, 37-40)**

Key words: Bitemarks, concordant points.

Running title: Bitemarks

INTRODUCTION

Bitemarks may be found in the flesh of a victim or a suspect after an assault, rape or murder, in foodstuffs or in a variety of other materials discovered at the scene of a crime. They have been used as a method of identification for more than a century. The case of Ohio vs Robinson (1870) represents an early attempt to admit bitemark evidence in a court of law.[1] There are, however, differing opinions regarding the interpretation of bitemarks as evidence[2] and the validity and the scientific basis for the use of bitemarks as evidence has been challenged in the courts.[3] This has raised the possibility of failure of bitemark evidence according to the Frye standard[4] which questions the accuracy of a tooth mark in a soft material such as human skin when compared to tool marks in a rigid matrix.

The interpretation of a bitemark is complicated and requires a considerable amount of experience of the mechanics of biting and the subsequent changes that occur in the tissues or material bitten, and is a highly specialized task belonging only to a forensic dental expert.[5] Unlike fingerprints where twelve concordant points are necessary before a suspect can be positively identified,[6] some examiners believe that a minimum of four or five concordant points, sometimes even less, are sufficient for an identification to be made from a bitemark.[7]

The authors were requested to examine a bitemark on the breast of a deceased woman (DR4243/91) and to establish which of two suspects was responsible for inflicting this lesion.

MATERIALS AND METHODS

Colour photographs were taken of the bitemark which was situated on the lateral side of the left breast four centimetres above the nipple (Fig.1).

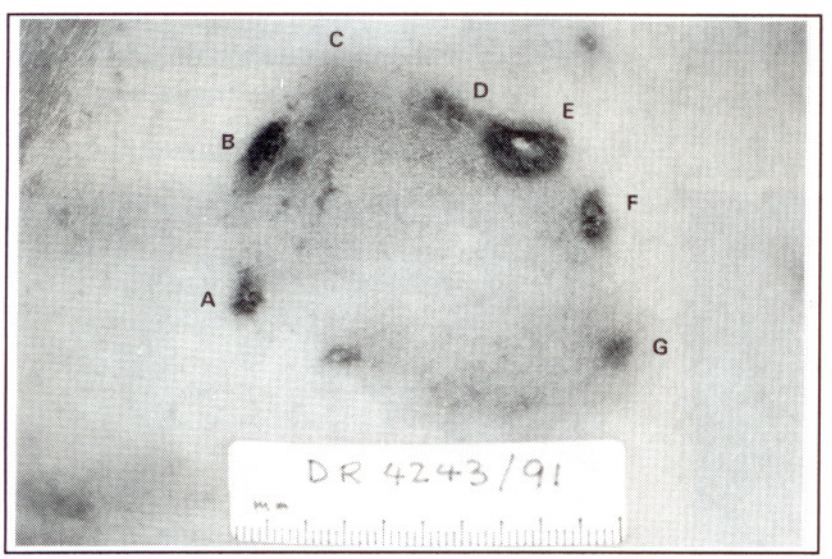

Fig. 1. The bitemark on the left breast.

An impression of the bitemark was taken with President* putty and light bodied impression material (polyvinylsiloxane) and a plaster model cast.

After obtaining permission from each of the suspects, impressions were taken of their upper and lower teeth using alginate impression material. Plaster casts were made of the upper and lower dentitions (Figs.2-7) and wax bite registrations were recorded for each suspect. The models of the upper teeth of both suspects then were used to make patterns of the bitemarks in softened Aluminex** grey wax (Figs.8,9).

The bite impressions in the Aluminex wax of both suspects were now compared with the bitemark on the breast and by measuring the sizes of the bruises and the spaces between them and then relating these to the impressions in the wax bite it was possible to match one of the dentitions with the bite. The bruises were labelled A to G in a clockwise manner (Fig.1).

For comparison purposes all the photographs of the bitemark and wax bites were made life size (1:1).

* *Corténe AG; CH-9450 Altstätten Switzerland*

** *Associated Dental Products Ltd. Purton, Swindon Wilts.*

Fig.2. The front aspect of suspect 1's dental plaster models.

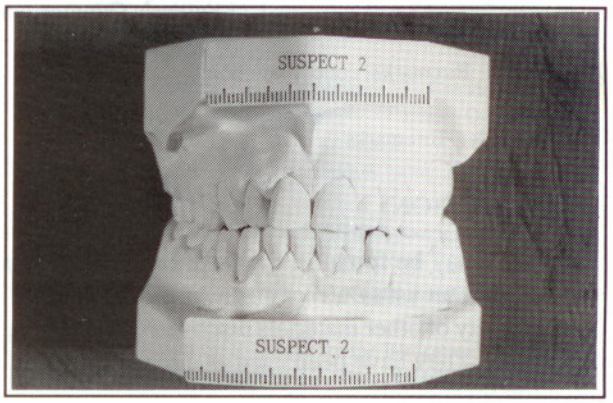

Fig.5. The front aspect of suspect 2's dental plaster models.

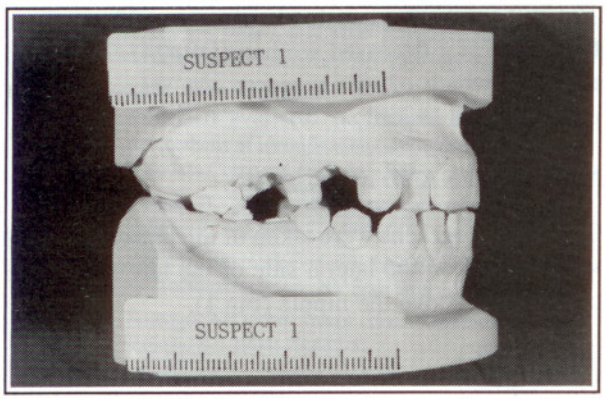

Fig. 3. The right aspect of suspect 1's plaster models

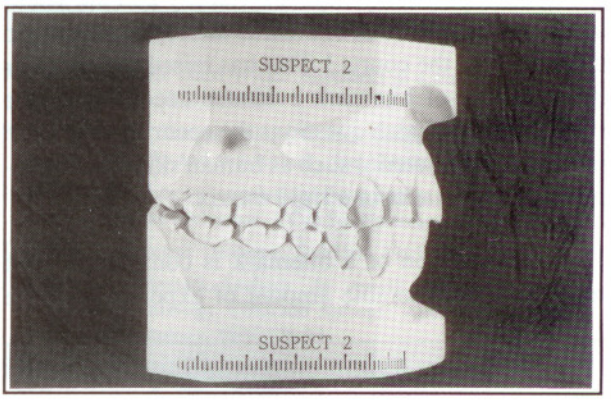

Fig. 6. The right aspect of suspect 2's plaster models

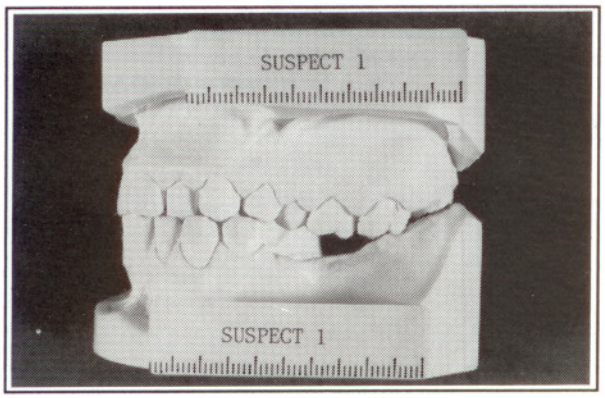

Fig. 4. The left aspect of suspect 1's plaster models.

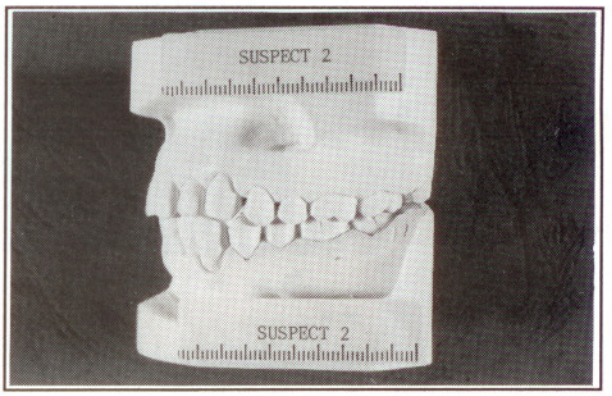

Fig. 7. The left aspect of suspect 2's plaster models.

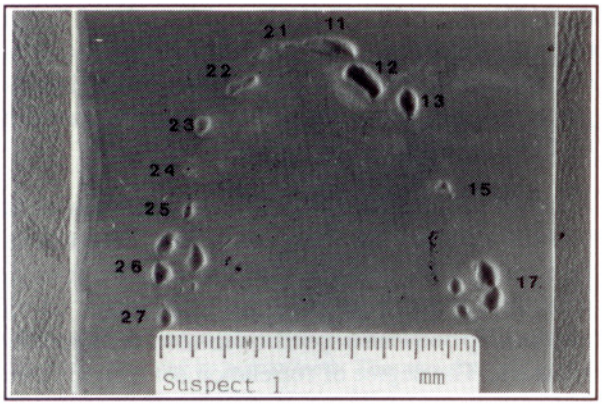

Fig.8. The Aluminex wax impression of the bite of suspect 1's maxillary model. The indentations are labled with the FDI nomenclature.

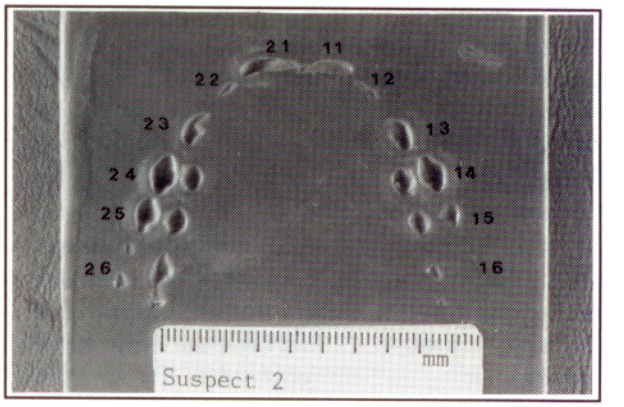

Fig. 9. The Aluminex wax impression of the bite of suspect 2's maxillary model (FDI nomenclature).

COMPARISON BETWEEN BITEMARK AND DENTITION OF SUSPECTS 1 AND 2

SUSPECT 1	SUSPECT2
Bruise A was produced by teeth 24 or 25.	Bruise A was produced by teeth 24 or 25.
The space between A and B corresponds to the less prominent bite of teeth 23 and 24.	
Bruise B was produced by tooth 22.	Bruise B was produced by tooth 23.
Bruise C was produced by tooth 21.	Bruise C was produced by a combination of teeth 21 and 22.
The space between B and C corresponds to the overlap of teeth 21 and 22.	
Bruise D was produced by tooth 11.	Bruise D was produced by a combination of teeth 11 and 12.
Bruise E was produced by tooth 12.	Bruise E was produced by tooth 13.
Bruise D and E are in close proximity due to the overlap of teeth 11 and 12.	
Bruise F was produced by tooth 13.	Bruise F was produced by tooth 14.
The space between E and F corresponds to the space between 12 and 13.	
Bruise G was produced by tooth 15.	Bruise G was produced by tooth 16.
The space between F and G corresponds to the tooth 14 missing.	

RESULTS

The comparisons between the bitemark on the breast and the bite patterns of the suspects are listed in Tables 1 and 2.

Suspect 1's maxillary teeth showed that the lateral incisors were displaced palatally and that the right lateral incisor bit far more prominently into the Aluminex wax than the right central incisor or canine. This corresponded to bruise E and bruise B then corresponded to the left lateral incisor. From Table 1 it can be seen that suspect 1's dentition produced 12 concordant points with the bitemark, whereas suspect 2's dentition only corresponded with 7 features.

DISCUSSION

In the case of a human bite there is usually an element of sucking involved and the resultant bruising in soft tissue, particularly in a breast, will be distorted when compared to an imprint made by the teeth in wax. It is important to recognise this distortion as the bitemark on the breast should be wider because of the sucking action of the tongue which tends to draw the skin inwards. As the suction is released elasticity of the tissue allows it to return to the more spread out original area and it is recommended that, when comparing wax impressions or tracings or casts with the bite rather than viewing the dental arch as a whole, the left and right arches be considered separately.

From the comparison between the bitemark and the wax impressions it is evident that suspect 1 was most likely to have bitten the victim. The bruises and spaces between the bruises correlate far more accurately than those of suspect 2. The bite pattern in the wax of suspect 2 shows that the most prominent features are the canines and 1st premolars (Fig.10) and this relates with difficulty to the spaces between the bruises, and is certainly less accurate than that of suspect 1.

When comparing the bite patterns of the suspects it would appear highly probable that the bite on the breast of the victim was inflicted by suspect 1 in which there were twelve concordant points, the most important being the bruise which corresponded to the upper right lateral incisor which was palatally angulated and more prominent than the adjacent canine. The bite of suspect 2 clearly did not fit because of the spaces between the teeth. The dilemma of this case was the number of concordant points necessary to make a positive identification. If suspect 2 had been the only candidate under suspicion the 5 or 7 concordant points necessary to prove beyond reasonable doubt that a bitemark was inflicted by a person could have condemned him to be found guilty. Fortunately there was another suspect found and as it turned out, it was most likely that he had bitten the deceased. The final ironic twist in the case however, was that suspect 2 was in fact the murderer and it was her lover (suspect 1) who inflicted the bitemark in a fit of passion. If the number of concordant points for a positive identification were set at five or seven points and only suspect 2 had been apprehended, he would probably have been found guilty of inflicting the bite.

The American Board of Forensic Odontologists adopted guidelines for the analysis and evaluation of bitemarks in 1984. Subsequent discussion and review, after re-evaluation of these guidelines,[8] led to the conclusion that much more work and consideration was needed before a stable and accurate index, which could be widely applied, could be developed. Vale[9] recommended that odontologists await the results of further research before relying on precise point counts in evidentiary proceedings. They suggested that investigators continue to use the method of analysis that they find the most helpful.

Although the changes produced in human tissue as the result of a bite are not always an accurate image of the teeth causing the changes, they can enable a forensic scientist to make an accurate assessment of the relationship between a specific dentition and a specific bitemark. The degree of correlation between the teeth and teeth marks can be determined reliably if evaluated in sufficient detail. But because a uniform scoring system that might assist investigators in reaching conclusions in every instance is not available, the authors endorse the precaution suggested,[10] that it is advisable for a positive identification to be confirmed by at least two dentally qualified forensic experts and that the evidence may only be interpreted as highly probable at best. A further lesson learned from this case was that bitemark evidence is equally, but sometimes more reliable and useful, in eliminating suspects rather than identifying them.

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COMPARISON OF BITEMARKS IN FOODSTUFFS BY COMPUTER IMAGING: A CASE REPORT

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ABSTRACT

Police called to investigate a fire in a snackbar in Mount Gambier, South Australia, discovered four cakes with characteristic marks apparently produced by human teeth. These marks were examined and compared with the teeth of a suspect arsonist. The comparison was made by computer imaging analysis and a remarkable similarity in arch shape was observed. **(J Forensic Odontostomatol 1994; 12:2, 41-44)**

INTRODUCTION

The use of bitemark injuries on skin to aid in the identification of offenders has been well documented in the forensic literature[1-5,9]. Similar analyses have been reported using bitemarks in foodstuffs[3-8]. It is usually noted that certain foods make poor media for bitemark impressions, particularly baked materials including soft cakes[5,9]. This case highlights that this is not necessarily always true, and introduces a technique for bitemark analysis which contributed to the conviction of the offender.

Sequence of Events:

On the morning of 6th September 1991 a fire occurred in a snackbar located in the commercial area of Mount Gambier, a city in South Australia. Considerable damage was caused to the premises, and upon investigation police discovered numerous items of food at the scene, a number of which appeared to have been partially eaten (Fig.1). These were recovered and sent in sealed plastic containers to the Forensic Odontology Unit for laboratory examination.

A suspect was quickly located, and the police sought confirmation of identity of the hungry arsonist.

MATERIALS AND METHODS

Four items of food were received.

These were (1) a pink iced lamington*, (2) a chocolate fruit slice, (3) an apricot/lemon coconut slice and (4) a strawberry coconut slice. All were hard and dry with some areas of scorching.

Fig. 1 The cakes as discovered after the fire.

* *A lamington is an Australian cake. It consists of a small block of sponge cake coated in chocolate or other flavoured icing sugar and dessicated coconut. It is named after Baron Lamington, Governor of Queensland from 1896-1901.*

A part of each cake was missing with the remainder displaying evidence indicative of human tooth marks. A semicircular segment had been avulsed from the lamington and the shape of the remaining surface appeared to have been produced by upper and lower anterior teeth acting together (Fig.2). An irregularity in the bitten surface in a position corresponding to the upper right central incisor suggested this tooth was missing in the arch producing the bite. A similar irregularity, although not so clearly defined, could be observed in the other cakes. Shrinkage resulting from the heat of the fire was apparent in each cake, but was especially significant in the lamington in the areas adjacent to the bite. Of all the items received, the bitten surfaces of the lamington offered the most promising definition for further investigation.

Arrangements were made by the police for impressions of the teeth of the offender† to be taken by a dental practitioner in Mount Gambier and the casts made from these impressions were forwarded to the Forensic Odontology Unit for laboratory comparison. The casts of the upper teeth revealed that the upper right central incisor was missing, leaving a space in the arch at the position of that tooth (Fig.3).

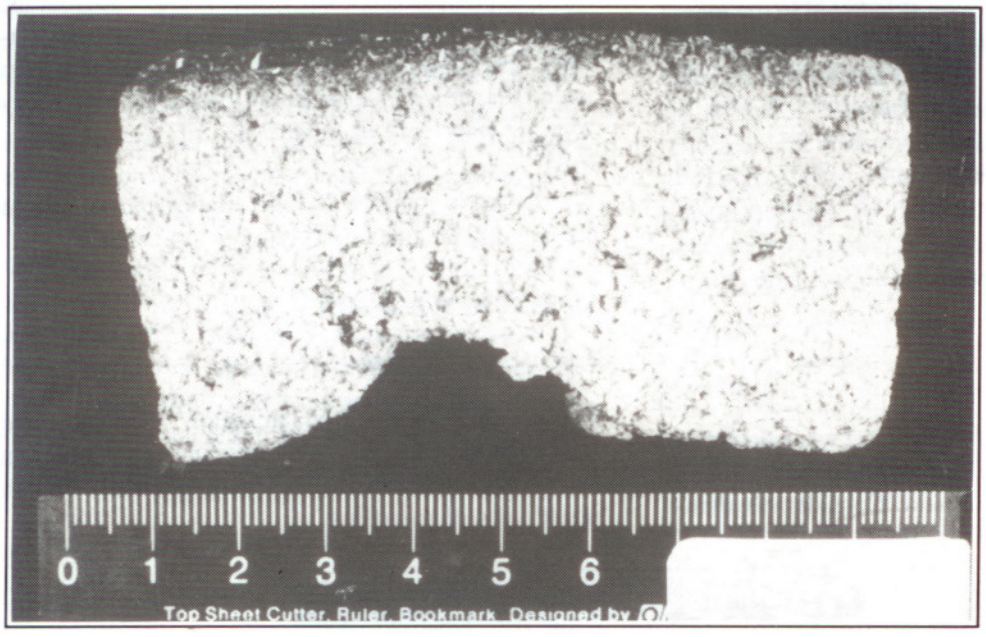

Fig. 2 Outline of the bite produced by upper teeth in the lamington.

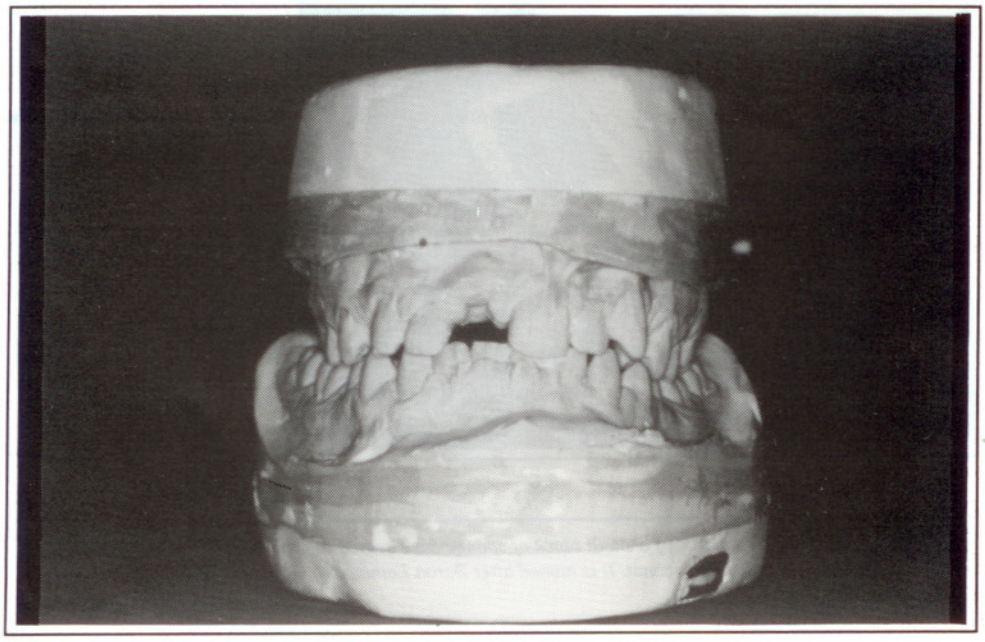

Fig. 3. Dental casts of the suspected arsonist.

Six similar fresh lamingtons from the same manufacturer were provided as controls. The linear dimensions of the control lamingtons were averaged and the averages compared with the damaged lamington to calculate the amount of shrinkage that had occurred in that item.

Dark green casting wax§ was then moulded along the vestibular gingival margins of the teeth on the casts to provide a contrasting background to the teeth when viewed from the occlusal aspect.

An image analyser was used to generate profile outlines of the vestibular surfaces of the teeth on the upper and lower casts and also the margins of the bitten surfaces of the cake. The profile image of the lamington bite was enlarged by a factor calculated from the differences in dimensions of the fresh controls and the exhibit to compensate for the shrinkage produced by the heat of the fire and subsequent drying. These outlines were then simultaneously displayed on the computer screen, and when superimposed their contours could be compared visually (Fig.4).

RESULT

This computer-generated comparison indicated remarkable similarity between the profiles of the bitten surfaces of the cake and the profiles of the corresponding segments of the dental arches of the casts, particularly in the area of the missing right central incisor. Some minor irregularities in the profile image of the bitten margins of the lamington were observed.

DISCUSSION

The probability, in an Australian population, for an upper right central incisor to be missing in a dentition with upper right lateral incisor, upper right canine, upper left central incisor, upper left lateral incisor and upper left canine standing is given in Table 1. It will be seen that the probability increases with age from 1.3 persons per thousand below the age of 20 to 6.4 per thousand at the age of 30. These figures do not take into account the form of a bridge or removable partial denture. It is reasonable to assume that this factor would reduce the probabilities shown by approximately 50%.

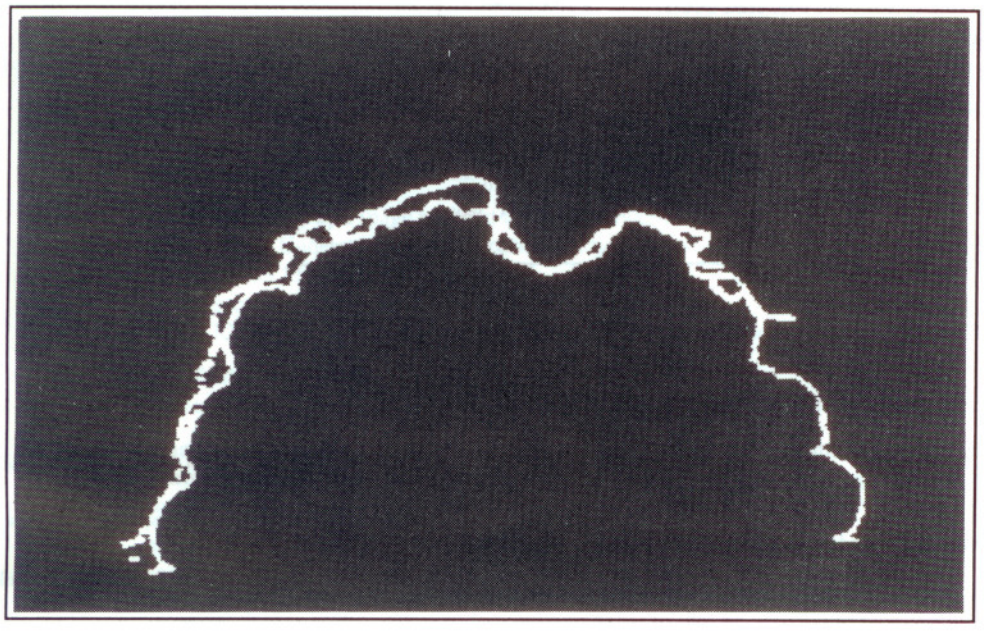

Fig. 4. Comparison of images at enlarged size.

† *Summary Offences Act 1953-85 (South Australia) Section 81(4) Where a person is in lawful custody on a charge of committing an offence, a member of the police force may, if he believes on reasonable grounds that it is necessary to do so for the purpose of identifying that person or identifying that person as the person who committed an offence (b) cause impressions of the teeth of that person to be taken by a registered dentist.*

§ *Bremer Goldschlägerei Wilh Herbst*

Age in Years	Percentage with missing upper right central incisor with all other anterior incisors standing
<20	0.13
20-30	0.4
>30	0.64

(Ref: National Oral Health Survey 1987-88)

Table 1: Frequency of missing upper right central incisors in an Australian population.

In this case the outline of the bitten margins of the four items of food recovered from the scene indicated a missing upper right central incisor in the dentition of the offender.

The minor irregularities observed in the computer-generated profile image of the bitten margin of the lamington could be attributed to the presence of coconut particles adhering to the icing on the surfaces in this area.

Despite these irregularities, a high level of concordance was achieved in the superimposition comparison of this image against the profile outline of the suspect's dentition; in regard to both the arch shape and the width of the area representing the missing tooth. This indicated a strong possibility that the bite had been produced by the teeth represented on the casts. This evidence strengthened the police case against the suspect who subsequently pleaded guilty to the charge of arson.

CONCLUSION

This technique has been shown to be a useful tool for comparison of bitemarks occurring in foodstuffs. It enables the profiles of both the bitemark and the dental arch of a suspect to be generated by computer imaging and then simultaneously superimposed on a screen to achieve a direct comparison

ACKNOWLEDGEMENTS

This paper was prepared under a grant from the South Australian Government, to whom grateful acknowledgement is made. Special thanks is due to the Commissioner of Police for South Australia, Detective Sen. Const. 1st class A Rodda, Sen. Const. 1st class P Argy, Professor AJ Spencer and Mrs E Formenti.

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