Journal of Forensic Research

Gill and Singh, J Forensic Res 2015, S4:5
DOI: 10.4172/2157-7145.1000S4-005

Review Article Open Access

# Reality Bites – Demystifying Crime

**Gurveen Gill*** **and Ranjit Singh**

*Department of Orthodontics, LBDC, Patiala, India*

***Corresponding author:** Gurveen Gill, Department of Orthodontics, Luxmi Bai Institute of Dental Sciences & Hospital, Patiala, India, Tel: 9855467630; E-mail: gurveengill88@yahoo.com

**Rec date:** Nov 18, 2014 **Acc date:** October 15, 2015 **Pub date:** October 19, 2015



**Abstract**

Forensic dentistry is an essential part of Forensic science, mainly involves the identification of an assailant by comparing a record of their dentition (set of teeth) with a record of a bite mark left on a victim. Human bite-mark traditionally provides the forensic dentist with both physical and biological evidence. Bites have been found in cases of homicide, attempted suicide, sexual assault, and child abuse. Bite marks with high evidentiary value that can be used in comparisons with the suspects' teeth will include marks from specific teeth that accurately record distinct traits. The teeth may also be used as weapon and, under certain circumstances may leave information as to the identity of the biter. Analysis of bite marks is the second major responsibility of the forensic dentist. However, the advent of DNA and its recovery from bite-marks has offered an objective method of bite-mark analysis. Despite the strengths of DNA, the physical comparison of a suspect's dentition to bite-mark injuries is still commonplace. The article provides an update on the current context and status of bite-mark analysis.

**Keywords:** Forensic; Bite-marks; Dentition

## Historical Background

Forensic odontology has been with us since the beginning when, according to the Old Testament, Adam was convinced by Eve to put a 'bite mark' in apple [1]. Identification by teeth is not a new technique. It dates back as far as 66 A.D. at the times of Nero. As the story goes, Nero's mother Agrippina had her soldiers kill Lollia Paulina, with instructions to bring back her head as proof that she was dead. Agrippina, unable to positively identify the head, examined the front teeth and on finding the discoloured front tooth confirmed the identity of the victim. During the U.S. Revolutionary War, Paul Revere (a young dentist) helped to identify war casualties by his bridgework [2]. The first bite mark case in Colonial America occurred during the Salem Witch Trials in 1692, where the Rev. George Burroughs was convicted and hanged for witchcraft, including biting his victims [3]. The contemporary history of bite marks is thought to have started with Sorup. In 1924, Sorup used transparent paper upon which biting edges of a suspect's dentition were rendered to compare with life size photographs of a bite-mark [4]. The first case was reported in 1930 in Quebec, Canada where infant was murdered having bite-marks evidence on the skin.

## Introduction

A bite mark has been defined as 'a pattern produced by human or animal dentitions and associated structures in any substance capable of being marked by these mean's [5]. Human bite-marks are one among the most violent crimes tried in the criminal courts. Bites have been found in cases of homicide, attempted suicide, sexual assault, and child abuse. Bites can occur on both the victim and the suspect; teeth are used as weapon by the aggressor and in self-defence by the victim [6,7]. Increasingly though, bite-mark analysis is attracting attention from other quarters; criminal defence lawyers, researchers, national and international regulatory and advisory bodies, and those individuals interested in the prevention and rehabilitation of wrongful convictions [8]. The analysis of bite-marks attracts a vital interest within the judicial system. Forensic dentists are responsible for providing testimony that can have severe consequences for individuals, and this is particularly the case when assessing bite-mark evidence. It is not uncommon for a bite-mark to be the only physical evidence present on a body and the evidence provided by odontologists is compelling and easily understood by juries [9]. A review of the current status of bite-marks in the U.S. legal system revealed cases in which the behavioural aspects of a bite-mark were introduced as evidence. An example of the use of behavioural evidence pertaining to bite-marks can be found in the military legal literature. In United States v. Martin the prosecution offered a link between the appellant's habits of biting objects (such as pens, pencils, toothbrushes, etc.) under stressful situations to a bite-mark on his deceased wife's neck. Their argument was that, in the process of strangling his wife, Martin would have been stressed and therefore prone to biting. The Court ruled against the admission of this evidence In another Court case, a forensic dentist testified that he was able to distinguish lunatic and fighting bite-marks from attacking or sadistic bite-marks and from sexually oriented bite-marks. The Witness claimed that the essence of the distinction is "that fighting bite-marks are less well defined because they are done carelessly and quickly, whereas attacking or sadistic bite-marks are made slowly and produce a clearer pattern." The dentist stated that sadistic bites are well defined, while sexual bite-marks often have a red centre caused by sucking actions. The conclusion drawn in this case was that the bite was sadistic in nature. It must be stated that there is little support in the literature for these views. Indeed, much has been discounted, especially relating to the "suck mark" [10-12].

## Examination of Bite-Marks

A common method of comparing bite marks is to use transparent overlays to record the biting edges of a suspect's teeth and compare them with the crime scene sample [13].

## Clinical History

**Following type of homicides are prone to bite-marks**

- The homicide victim indulged in sexual activity during the time of death.
- The battered-child homicide victim [14].

**Anatomic locations of bite-marks:** Breasts arms, legs, face, head, abdomen, back, shoulder, buttocks, female genitalia, hands/fingers, chest, ears/nose, neck and male genitalia [15]. A history of the bite/assault should be ascertained as follows

- When was the bite inflicted?
- Which part (s) of the body was bitten?
- Which position (s) were the bitten parts in at the time?
- Did the bite take place through clothing? Has this clothing been submitted for examination already?
- Has the skin been washed since the assault?
- Does the person suffer from any condition liable to have influenced the appearance of a bite mark/bruise?

Injuries observed with bite marks include abrasion, lacerations, contusions/bruises, petechial, indentations, erythema and punctures [16-20] (Table 1).

| | |
|---|---|
| **Artefact** | Where a piece of flesh or body part is completely removed or bitten off piece of body |
| **Abrasion** | Undamaging mark on the skin or bruise without damage to the skin |
| **Avulsion** | Removal of the skin |
| **Contusion** | Ruptured or broken blood vessels |
| **Hemorrhage** | A small bleeding spot |
| **Incision** | Neat puncture of the skin |
| **Laceration** | Torn or Punctured skin |

**Table 1:** Bite-marks have been divided into seven classifications.

## Presentation of Bite-mark Injuries

Bite-marks will typically present as a semi-circular injury which comprises two separate arcs (one from the upper teeth, the other from the lower) with either a central area absent of injury, or with a diffuse bruise present. It is not unusual to see only one arch of teeth on an injury and, if this is the case, it is most often the lower teeth that are present which relates to the mechanics of biting, i.e. the maxilla remains stable while the mandible moves until the teeth meet [21]. There are three main factors that influence the severity of a bite-mark injury:

- The force by which the original injury was inflicted;
- The anatomical location bitten; and
- The time elapsed between infliction of the injury and the presentation to the odontologist [22].

### Guidelines for the analysis of the bite-marks

To standardize the analysis of bite marks the American Board of Forensic Odontostomatology (ABFO) [23] established the following guidelines in 1986:

- **History**: Obtain history of any dental treatment subsequent to, or in proximity to, the date of the bite-mark.
- **Photography**: Extra-oral photo-graphs including full face and profile views, intraoral should include frontal views, two lateral views and an occlusal view of each arch. Often it's useful to include a photograph of maximal mouth opening. If inanimate materials, such as food stuffs, are used for test bites the results should be preserved photographically. Place a scale beside the bite mark and make a note of distance at which photograph was taken. UV light photographs can see the damage deeper into the tissue and can capture the spacing, size and shape of teeth. A blood group determination is possible in bite marks in human tissue as well as in food stuffs on account of saliva left in bite mark.
- **Extra-oral examination**: It includes observation and recording of soft and hard tissue factor that may influence biting dynamics. Measurements of maximal opening and any deviations on opening or closing should be made. The presence of facial scars or evidence of surgery should be noted, as well as the presence of facial hair.
- **Intra-oral examination**: Salivary swabs should be taken. The tongue should be examined to assess size and function. The periodontal status should be noted with particular reference to mobility. Prepare a dental chart if possible.
- **Impressions**: Take two impressions of each arch using materials that meet the American Dental Association specifications. The occlusal relationship should be recorded.
- **Sample bites**: Whenever possible, sample bites should be made into an appropriate material, simulating the type of bite under study.
- **Study casts**: Casts should be prepared using Type II stone according to manufacturer's specifications, using accepted dental techniques. Additional casts should be made by duplicating the master casts.

## Methods of Bite-marks Analysis

### Physical comparisons

An essential component of the determination of the validity of bite-mark analysis is that the techniques used in the physical comparison between suspect dentition and physical injury have been assessed and found valid [24]. One of the fundamental problems with this task is the wide variety of techniques that have been described in the literature [25]. Techniques using confocal [26], reflex and scanning electron microscopes [27-29], complex computer systems [30,31], special light sources [32,33], fingerprint dusting powder [34] and overlays have all

been reported [35-41]. Indeed a new technique involving the 3D laser scanning of dental casts has recently been described by two research groups, adding a further technique to the plethora of possible approaches to bite mark analysis [42,43]. Despite this overabundance of methods a recent survey of 72 odontologists found that over 90% used some form of overlay as their sole method of pattern analysis [44].

There are a number of methods for producing bite-mark overlays and, again, these methods have been the subject of numerous research projects [45]. Two studies are described. The first assessed the five main methods of bite-mark overlay production (Figure 1):

- Computer-based
- Two types of radiographic
- Xerographic
- Hand-traced [46]

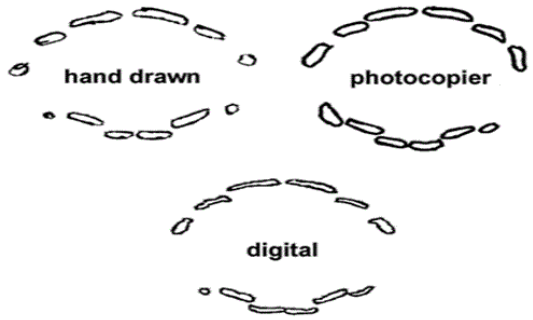


**Figure 1:** Overlay production methods and example of resultant overlay: (a) hand-drawn technique using acetate sheets and marker pen; (b) photocopier technique (note ABFO scale included to check scaling); (c) digitally scanning cast (note ABFO scale included to check scaling); (d) Example of each type of overlay [22] (Table 2).

| Sr.No | Area | Rotation |
|---|---|---|
| 1 | Computer-based | Computer-based |
| 2 | Radiopaque wax | Xerographic |
| 3 | Hand-traced from wax | Hand-traced from wax |
| 4 | Hand-traced from study casts | Hand-traced from study casts |
| 5 | Xerographic | Radiopaque wax |

**Table 2:** various overlay fabrication techniques ranked according to accuracy [46].

For many years, hand-traced overlays were the method of choice and these were slowly replaced by a photocopier technique [22]. Sweet and Bowers determined that computer-generated overlays were by far the most accurate in terms of both tooth area and rotation. Given this, a number of different modifications of the computer generated technique were developed and further research examined which of these was the most effective. Results demonstrated that both of the main techniques were reliable, and the choice of method was down to personal preference [46]. However, while the overlay production method has been shown to be reliable, the application of these to the bite-mark photographs, and the assessment of degree of match has not enjoyed as much scientific support [22]. There have been some efforts to produce a bite-mark severity and significance scale that would enable odontologists to describe a bite-mark using a validated index, and from this determine the required path of action [47]. The proposed index is in two parts; the first is the text based index and the second is an illustrated guide that can be used by those unfamiliar with bite-marks [24], Figure 2 demonstrate the bite-mark severity and significance scale. The scale is designed to demonstrate and simplify the somewhat complex relationship between bite-mark severity and the likely success of a comparative analysis. Bite-marks at the extreme end of the scale, either those presenting as very mild bruises or, conversely, avulsed tissues, are rarely suitable candidates for comparison with a suspect's dentition. The scale has been assessed using odontologists, police officers, social workers, paediatricians and forensic pathologists with good levels of reliability (kappa scores >0.91) [47].

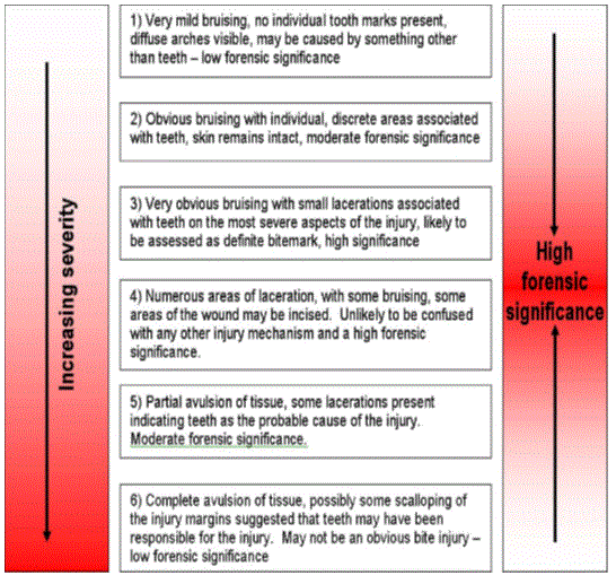


**Figure 2:** Range of bite-mark severity—the bite-mark severity and significance scale [47].

## Biological Techniques for Bite-mark Comparison

The biological basis of bite-mark analysis has centred on the recovery of salivary DNA and much of this work has been pioneered by Sweet who investigated the deposition of saliva during the biting process and its collection over protracted periods of time from cadavers [48,49]. In order to maximize the DNA collected, Sweet recommends that bite-marks should be 'double swabbed', the first swab being moistened with distilled water and the second being dry. It is thought that the wet swab rehydrates the salivary constituents, releasing more epithelial cells from the dried deposit [48]. Sweet has further used these techniques in numerous bite-mark cases, with a good example being provided in the literature where a conventional bite mark comparison was undertaken followed by a DNA analysis [50]. One particular advantage of the use of DNA for the analysis of bite-marks is that there is a vast amount of underlying, peer reviewed publications supporting its use, with data on errorrates and reliability

[51-54]. Such publications are lacking in relation to the physical methods [25] (Figure 3).

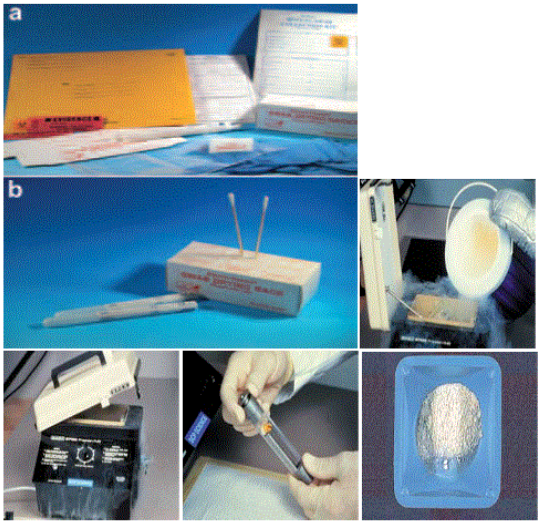


Figure 3: DNA collection from bitemark victims and suspects: (a) kit required for collection from either victim or suspect, including two swabs (for skin only, buccal suspect swabs require only one), gloves, card drying rack, evidence stickers, sealable plastic bag, documentation and evidence envelope; (b) example of a double swab being dried prior to placement in sealed evidence bag. Drying is a crucial stage and can take up to 30 minutes [22].

## Role of DNA in Dental Identification

Because of the resistant nature of dental tissues to environmental assaults, such as incineration, immersion, trauma, mutilation and decomposition, teeth represent an excellent source of DNA material [55]. When conventional dental identification methods fail, this biological material can provide the necessary link to prove identity [56]. With the advent of the polymerase chain reaction (PCR), a technique that allows amplification of DNA at pre-selected, specific sites, this source of evidence is becoming increasingly popular with investigators [57]. Comparison of DNA preserved in and extracted from the teeth of an unidentified individual can be made to a known ante mortem sample (stored blood, hairbrush, clothing, cervical smear, biopsy, etc.) or to a parent or sibling [58].

## Genomic DNA

Genomic DNA is found in the nucleus of each cell and represents the DNA source for most forensic applications, (there are no nuclei, and hence there is no DNA, in red blood cells.) When body tissues have decomposed, the structures of the enamel, dentine and pulp complex persist. It is necessary to extract the DNA from the calcified tissues [57]. In the authors' laboratory, the cryogenic grinding method is employed [56]. Teeth represent an excellent source of genomic DNA [57]. Indeed, the authors have found that even root-filled teeth supply sufficient biological material for PCR analysis [56] (Figure 4).


Figure 4: Cryogenic grinding is used to extract DNA from calcified tissues such as teeth. In a freezer mill a ferromagnetic plunger is oscillated back-and-forth in alternating electric current. Liquid nitrogen is used to cool the sample, which results in making it extremely brittle and also protects DNA from heat degradation. The tooth is reduced to a powder to increase surface area and expose trapped cells to biochemical agents that release DNA into solution [56].

## Mitochondrial DNA

In addition to genomic DNA, cells contain mitochondrial DNA (mt DNA), the sequence of building blocks of which can be determined to assist in identification. The main advantage of mtDNA is that there is a high copy number in each cell caused by the high number of mitochondria present in most cells. This infers that in cases where genomic DNA cannot be analysed, possibly because it is too degraded, mtDNA may be present in sufficient quantity. In addition to its higher copy number, mtDNA is maternally inherited [59]. This maternal inheritance pattern confers the same mtDNA sequence, barring mutations, upon siblings and all their maternal relatives. This has important implications for the identification of individuals for which there is no ante-mortem comparison sample. Although mitochondrial DNA is still in its infancy in forensic casework, it is a powerful technique that is likely to become commonplace in the future [57].

## The Uniqueness of Human Dentition

Bite-mark analysis is based upon two assumptions; the first that the human dentition is unique in terms of the positions of those teeth

commonly involved in biting and secondly that this asserted uniqueness is replicated on the bitten substrate [25]. Dental identification, as opposed to bite-mark identification, utilises the number, shape, type, and placement of dental restorations, root canal therapies, unusual pathoses, root Morphology, trabecular bone pattern, and sinus morphology [60]. Many forensic dentists, appellants, and lawyers have questioned this fact and demand to know from testifying experts the relative frequency of dental features identified in bite-marks. Despite the lack of evidence supporting both of the statements above, it is interesting to note that odontologists nonetheless seem confident about these principles; 91% of respondents believed that the human dentition was unique, and 78% believed that it was replicated on human skin [24]. Ninety-six percentage of Diplomats of the American Board of Forensic Odontology stated that the human dentition was unique and that this uniqueness could be recorded on human skin [61].

## Human Skin as a Bite Registration Material

While bite-marks can occur in objects such as food stuffs it is bites on skin that form the majority of bite-mark cases taken to court [62]. Yet skin is a poor material to record patterned injuries and is highly variable in its response to trauma [63]. This variability can be compounded by poor evidence collection and hence, even if one can accept that physical comparisons of bite injuries were scientifically sound how can the odontologist control for skin and all its vagaries [64]? Skin is highly variable in terms of anatomical location, underlying musculature, or fat, curvature, and looseness or adherence to underlying tissues [65]. Skin is highly viscoelastic, which allows stretching to occur during either the biting process or when evidence is collected [24]. This is due to elastic fibres in the dermis, distorting under pressure and then recoiling back to their original position [24]. The degree to which this occurs depends on a number of factors including age and anatomical location [66]. It has been argued that any bite-mark on skin will have some degree of distortion, due to either oedema, recoil or other factor.

## Conclusion

The field of bite-mark science is expanding, and the need for individuals trained and experienced in the recognition, collection and analysis of this type of evidence is increasing. Analysis of bite mark evidence has been assisting the judiciary to answer crucial questions about interactions between people at the scene of a crime. The shape of the bite-mark can give useful clues about the person who caused it and may lead to the implication or exclusion of an individual under investigation. Some scientist recommends that thorough analysis of the size, position and other features of bite marks be completed before any comparison with a suspect's dentition is made. It is possible to identify specific types of teeth by their class characteristics. The often serious nature of the crimes in which bites are found dictates that the highest level of forensic standards should be applied and that analyses of such injuries should only be undertaken if unique or, in certain circumstance, class characteristics exist. Research into more objective methods of bite-mark analysis has produced techniques such as salivary DNA recovery and bacterial genotyping, although further efforts to reduce subjectivity in standard physical techniques are required.

## References

1. Gustafson G (1996) Forensic odontology, American Elsevier Publishing Co. New York.
2. Anoop K Verma, Sachil Kumar, Sandeep Bhattacharya (2013) Identification of a person with the help of bite mark analysis, journal of oral biology and craniofacial research 3: 88-91.
3. Vale GL (2005) The history of bitemark evidence In: Dorion RBJ (ed): Bitemark Evidence. Marcel Dekker, New York 2.
4. STROM F (1963) Investigation of bite-marks. J Dent Res 42Pt 2: 312-316.
5. Clark MA, Sandusky GE, Hawley DA, Pless JE, Fardal PM, et al. (1991) Fatal and near-fatal animal bite injuries. J Forensic Sci 36: 1256-1261.
6. Vale GL, Noguchi TT (1983) Anatomical distribution of human bite marks in a series of 67 cases. J Forensic Sci 28: 61-69.
7. Furness J (1981) A general review of bite-mark evidence. Am J Forensic Med Pathol 2: 49-52.
8. Pretty IA, Sweet D (2010) A paradigm shift in the analysis of bitemarks. Forensic Sci Int 201: 38-44.
9. Sweet D, Pretty IA (2001) A look at forensic dentistry--Part 2: teeth as weapons of violence--identification of bitemark perpetrators. Br Dent J 190: 415-418.
10. US. v. Martin, United States Court of Military Appeal, 13 M.J. 66 (1982).
11. Commonwealth v. Henry, 524 Pa, 135, 569 A.2d9 929 (Feb. 8, 1990).
12. Sweet D (1995) Human bitemarks: examination, recovery, and analysis. In: Bowers CM and Bell G, editors. Manual of Forensic Odontology, Manticore:Ontario.
13. Dailey JC (1991) A practical technique for the fabrication of transparent bite mark overlays. J Forensic Sci 36: 565-570.
14. Kapil Verma, Bhawana Joshi, Charu H Joshi, Reject Paul MP () Bite Marks as Physical Evidence from the Crime Scene-An Overview, Open Access Scientific Reports.
15. Pretty IA, Sweet D (2000) Anatomical location of bitemarks and associated findings in 101 cases from the United States. J Forensic Sci 45: 812-814.
16. Jones DG (1998) Odontology often is final piece to grim puzzle. J Calif Dent Assoc 26: 650-651.
17. Bell K (2000) Identification and documentation of bite marks. J Emerg Nurs 26: 628-630.
18. ABFO (2000) Guidelines and standards: Bitemark Guidelines and Standards, American Board of Forensic Odontology, Colorado Springs.
19. Webb DA, Pretty IA, Sweet D (2000) Bitemarks: a psychological approach, Proceedings of the American Academy of Forensic Sciences Reno.
20. Bushick RD (2006) Forensic dentistry: an overview for the general dentist. Gen Dent 54: 48-52.
21. Rothwell BR (1995) Bite marks in forensic dentistry: a review of legal, scientific issues. J Am Dent Assoc 126: 223-232.
22. Pretty IA (2008) Forensic dentistry: 2. Bitemarks and bite injuries. Dent Update 35: 48-50, 53-4, 57-8 passim.
23. [No authors listed] (1986) Guidelines for bite mark analysis. American Board of Forensic Odontology, Inc. J Am Dent Assoc 112: 383-386.
24. Pretty IA (2006) The barriers to achieving an evidence base for bitemark analysis. Forensic Sci Int 159 Suppl 1: S110-120.
25. Pretty IA, Sweet D (2001) The scientific basis for human bitemark analyses--a critical review. Sci Justice 41: 85-92.
26. Bang G (1976) Analysis of tooth marks in a homicide case. Observations by means of visual description, stereo-photography, scanning electron microscopy and stereometric graphic plotting, Acta Odontol. Scand. 34: 1-11.
27. Solheim T, Leidal TI (1975) Scanning electron microscopy in the investigation of bite marks in foodstuffs. Forensic Sci 6: 205-215.
28. Jonason CO, Frykholm KO, Frykholm A (1974) Three dimensional measurement of tooth impression of criminological investigation. Int J Forensic Dent 2: 70-78.

29. Jakobsen J, Holmen L, Fredebo L, Sejrsen B (1995) Scanning electron microscopy, a useful tool in forensic dental work. J Forensic Odontostomatol 13: 36-40.
30. Nambiar P, Bridges TE, Brown KA (1995) Quantitative forensic evaluation of bite marks with the aid of a shape analysis computer program. Part 2. SCIP and bite marks in skin and foodstuffs, J. Forensic Odontostomatol 13: 26-32.
31. Barsley RE, West MH, Fair JA (1990) Forensic photography. Ultraviolet imaging of wounds on skin. Am J Forensic Med Pathol 11: 300-308.
32. Lightelm AJ, Coetzee WJ, van Niekerk PJ (1987) The identification of bite marks using the reflex microscope. J Forensic Odontostomatol 5: 1-8.
33. Rao VJ, Souviron RR (1984) Dusting and lifting the bite print: a new technique. J Forensic Sci 29: 326-330.
34. Wood RE, Miller PA, Blenkinsop BR (1994) Image editing and computer assisted bitemark analysis: a case report. J Forensic Odontostomatol 12: 30-36.
35. Sweet D, Bowers CM (1998) Accuracy of bite mark overlays: a comparison of five common methods to produce exemplars from a suspect's dentition. J Forensic Sci 43: 362-367.
36. Sweet D, Parhar M, Wood RE (1998) Computer-based production of bite mark comparison overlays. J Forensic Sci 43: 1050-1055.
37. Dailey JC (1991) A practical technique for the fabrication of transparent bite mark overlays. J Forensic Sci 36: 565-570.
38. West MH, Barsley RE, Frair J, Seal MD (1990) The use of human skin in the fabrication of a bite mark template: two case reports. J Forensic Sci 35: 1477-1485.
39. Naru AS, Dykes E (1996) The use of a digital imaging technique to aid bite mark analysis. Sci Justice 36: 47-50.
40. Pretty IA Sweet D (2001) Digital bite mark overlays--an analysis of effectiveness. J Forensic Sci 46: 1385-1391.
41. Blackwell SA, Taylor RV, Gordon I, Ogleby CL, Tanijiri T, et al. (2007) 3-D imaging and quantitative comparison of human dentitions and simulated bite marks. Int J Legal Med 121: 9-17.
42. Martin-de las, Heras S, Valenzuela A, Ogayar C, Valverde AJ, Torres JC (2005) Computer-based production of comparison overlays from 3D-scanned dental casts for bite mark analysis. J Forensic Sci 50: 127-133.
43. Pretty IA (2003) A web-based survey of odontologist's opinions concerning bitemark analyses. J Forensic Sci 48: 1117-1120.
44. Sweet D, Parhar M, Wood RE (1998) Computer-based production of bite mark comparison overlays. J Forensic Sci 43: 1050-1055.
45. Sweet D, Bowers CM (1998) Accuracy of bite mark overlays: a comparison of five common methods to produce exemplars from a suspect's dentition. J Forensic Sci 43: 362-367.
46. Pretty IA (2006) Development and validation of a human bitemark severity and significance scale, in: Proceedings of the 2006 AAFS Conference, Seattle, WA 32: 209.
47. Sweet D, Lorente M, Lorente JA, Valenzuela A, Villanueva E (1997) An improved method to recover saliva from human skin: the double swab technique. J Forensic Sci 42: 320-322.
48. Sweet D, Lorente JA, Valenzuela A, Lorente M, Villanueva E (1997) PCR-based DNA typing of saliva stains recovered from human skin. J Forensic Sci 42: 447-451.
49. Sweet D, Shutler GG (1999) Analysis of salivary DNA evidence from a bite mark on a body submerged in water. J Forensic Sci 44: 1069-1072.
50. Walsh SJ (2005) Legal perceptions of forensic DNA profiling part I: a review of the legal literature. Forensic Sci Int 155: 51-60.
51. Umetsu K, Yuasa I (2005) Recent progress in mitochondrial DNA analysis. Leg Med (Tokyo) 7: 259-262.
52. Wenk RE (2004) Testing for parentage and kinship. Curr Opin Hematol 11: 357-361.
53. Iwamura ES, Soares-Vieira JA, Muñoz DR (2004) Human identification and analysis of DNA in bones. Rev Hosp Clin Fac Med Sao Paulo 59: 383-388.
54. Schwartz TR, Schwartz EA, Mieszerski L, McNally L, Kobilinsky L (1991) Characterization of deoxyribonucleic acid (DNA) obtained from teeth subjected to various environmental conditions. J Forensic Sci 36: 979-990.
55. Sweet D, Hildebrand D (1998) Recovery of DNA from human teeth by cryogenic grinding. J Forensic Sci 43: 1199-1202.
56. Pretty IA, Sweet D (2001) A look at forensic dentistry--Part 1: The role of teeth in the determination of human identity. Br Dent J 190: 359-366.
57. Sweet D, DiZinno JA (1996) Personal identification through dental evidence--tooth fragments to DNA. J Calif Dent Assoc 24: 35-42.
58. Hutchison CA 3rd, Newbold JE, Potter SS, Edgell MH (1974) Maternal inheritance of mammalian mitochondrial DNA. Nature 251: 536-538.
59. Pretty IA, Sweet D (2001) A look at forensic dentistry--Part 1: The role of teeth in the determination of human identity. Br Dent J 190: 359-366.
60. Pretty IA (2003) A web-based survey of odontologist's opinions concerning bitemark analyses. J Forensic Sci 48: 1117-1120.
61. Atkinson SA (1998) A qualitative and quantitative survey of forensic odontologists in England and Wales, 1994. Med Sci Law 38: 34-41.
62. Barbenel JC, Evans JH (1974) Bite marks in skin--mechanical factors. J Forensic Sci Soc 14: 235-238.
63. West MH, Barsley RE, Frair J, Seal MD (1990) The use of human skin in the fabrication of a bite mark template: two case reports. J Forensic Sci 35: 1477-1485.
64. Zhang Z, Monteiro-Riviere NA (1997) Comparison of integrins in human skin, pig skin, and perfused skin: an in vitro skin toxicology model. J Appl Toxicol 17: 247-253.
65. Sheasby DR, MacDonald DG (2001) A forensic classification of distortion in human bite marks. Forensic Sci Int 122: 75-78.
66. DeVore DT (1971) Bite marks for identification? A preliminary report. Med Sci Law 11: 144-145.

This article was originally published in a special issue, entitled: **"Forensic Science & Technology"**, Edited by Amarnath Mishra, Associate Professor, Department of Forensic Medicine, Tribhuvan University