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**Teeth as Testimony: Advances and
Controversies in Bite Mark Analysis and
Forensic Odontology**

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Abstract

Forensic odontology has emerged as an important discipline in forensic science by utilizing dental evidence for human identification, age estimation, disaster victim identification, and medico-legal investigations. Bite mark analysis has been used in the past to help identify possible suspects of violent crimes by matching patterned wounds with those of specific bite marks. This review outlines the scientific principles of bite mark analysis such as human dentition, bite mark formation, evidence collection and characteristics. New technologies like digital imaging, 3-D imaging, computer-assisted comparison, DNA profiling and microbiome testing have enhanced the documentation of evidence and analysis. The review also explores key limitations of bite mark analysis, such as distortion of the skin, examiner bias, inadequate scientific validation, and the potential for false convictions. Moreover, it outlines the legal admissibility and ethical obligations of bite mark evidence in the Indian judicial system highlighting the importance of multi-disciplinary and scientifically accepted forensic practices.

Keywords; Forensic odontology; Bite mark analysis; Dental evidence; DNA profiling; Forensic identification.

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1 Introduction

Forensic odontology is a specialized field of forensic Science which deals with the use of dental knowledge and expertise in the investigation and resolution of legal issues. It involves the examination, preservation, interpretation and presentation of dental evidence for human identification, age estimation, disaster victim identification, bite mark evaluation, and oral injury analysis. Given the longevity of teeth and dental structures, forensic odontology has become an essential aspect of contemporary forensic science practice, especially when other modes of identification are precluded by decomposition, destruction by fire, and/or serious bodily trauma.²

The unique anatomical features, durability and preservation of biological materials such as pulp tissue and saliva, make teeth valuable forensic evidence. The morphology of the teeth, their restorations, occlusal relationships and dental history make it possible for the forensic odontologist to make accurate identifications with individual variation. As a result, dental examination is often used in conjunction with fingerprint and DNA evidence to support medico-legal investigations and disaster victim identification procedures.³

Bite mark analysis has become a subject of great interest to scientists and the legal community as one of the many forensic odontology applications. Bite mark analysis is the process of recognizing, recording, and interpreting patterned injuries that are made with human teeth in skin, food, or other items. These injuries have traditionally been scrutinised in order to ascertain if they are consistent with human dentition and to give investigative information about the circumstances of an assault. In modern forensic work, however, bite mark analysis is not necessarily a suspect identification technique, since there are some inherent limitations with skin distortion and examiner subjectivity associated with bite mark comparison.⁴

Bite marks are commonly found in violent interpersonal crimes such as homicide, sexual crimes, domestic violence, child abuse and other crimes in which teeth are utilized as weapons of offense or defense. Bite marks can also contain saliva, which can be useful for conventional forensic examinations, and document injury patterns. While there is still debate about the reliability of

² R. A. Gawali, "Forensic Odontology in India: Present Scenario, Hurdles & the Way Forward," *Indian J. Forensic Med. Toxicol.*, vol. 14, no. 4, pp. 450–456, 2020, doi: 10.37506/ijfmt.v14i4.11519.

³ N. Jeddy, S. Ravi, and T. Radhika, "Current trends in forensic odontology," *J. Forensic Dent. Sci.*, pp. 115–119, 2018, doi: 10.4103/jfo.jfds_85_16.

⁴ K. P. Kaur, S. Kundu, S. Bagchi, S. Gayen, and M. Pal, "Bite Mark Analysis- A Crucial Forensic Evidence," *Oral MaxillofacPathol J*, vol. 13, no. 2, pp. 0–4, 2022.

this type of evidence, bite mark evidence has been used to aid investigations when used in conjunction with other evidence and in scientifically established protocols.⁵

2 Scientific Principles of Bite Mark Analysis in Forensic Odontology

The basis of bite mark analysis is that the teeth of a human can leave identifiable patterns on skin and other biteable substrates. The scientific assessment of these patterns will need knowledge of dental anatomy, the biomechanics of the creation of a bite, and standardised techniques of evidence collection. The ability to compare bite marks is controversial due to differences in skin elasticity and healing, but the first recognition, documentation, and interpretation of bite marks remain important investigative information if corroborated with other forensic evidence. The examination of injuries requires knowledge of dentition, characteristics of the injuries, and proper evidence preservation.⁶

A. Anatomy of Human Dentition Relevant to Bite Marks

Human dentition is composed of incisors, canines, premolars and molars with different morphological characteristics that provide different contributions to bite patterns. Identifiable bite marks are most commonly found on the anterior teeth, especially on the incisors and canines, which form an arch-shaped mark. The size, spacing, rotation, wear, fracture, restorations, and missing teeth may vary in individuals and affect the pattern of the bite as well as help to make forensic interpretations.⁷

B. Formation and Classification of Bite Marks

Bite marks are produced by mechanical interaction between the teeth, oral tissues, and the bitten surface. They are commonly classified into:

- i. **Tooth Pressure Marks:** Injuries produced when the teeth compress tissue, leaving circular, oval, or rectangular bruises or abrasions.
- ii. **Tooth Scrape Marks:** Linear abrasions created as teeth slide across the skin during biting.

⁵ C. Shebah, A. Sheethal, H. Br, P. Preethi, and P. RK, "A Review on Bite Marks in Forensic Dentistry Shebah," *Austin J. Dent.*, vol. 9, no. 1, pp. 1–7, 2022.

⁶ A. Cardoza, "Forensic Odontology and Bite Mark Analysis: Understanding the Debate," *J. Calif. Dent. Assoc.*, vol. 51, no. 1, pp. 1–4, 2023, doi: <https://doi.org/10.1080/19424396.2023.2210332>.

⁷ D. Acharya and D. Nilendu, "From Anatomy to Analysis: Current Trends and Future Directions in Bite Mark Forensics," *Indian J. Forensic Med. Toxicol.*, vol. 19, no. 2, 2025, doi: 0.37506/vqc8hr16.

- iii. **Tongue Pressure Marks:** Bruising caused by suction or pressure generated by the tongue within the closed dental arches during biting.

C. Characteristics of Human Bite Marks

Bite marks have class and individual characteristics. The characteristics of the dental arch (overall size, shape and placement) are typical of human bite. Unique dental characteristics like rotated, fractured, restored, missing teeth, abnormal spacing, and irregular occlusion contribute to the uniqueness of individual characteristics. These features can help investigators rule out a suspect or confirm a suspect identification, but should not be used as the sole evidence of identification without corroborating forensic evidence.⁸

D. Basic Evidence Collection and Documentation

A quick and accurate record of bite marks is essential to the forensic value. These include high resolution photography with an ABFO No. 2 scale, photographs with multiple angles and lighting conditions, impression taking with elastomeric dental materials where appropriate and sterile swabbing of the bite site to obtain saliva for DNA analysis. Bite marks on skin can change rapidly and it is imperative that comprehensive documentation is provided that includes the location of the bite, dimensions, color changes and sequential photos over time.⁹

3 Advances in Bite Mark Examination and Identification

Advances in technology have greatly facilitated the examination and documentation of bite mark evidence, increasing the accuracy, reproducibility and objectivity of forensic odontology. The use of digital imaging, 3D reconstruction, computational analysis and molecular methods is increasingly complementing traditional visual and manual comparisons. While these innovations might not eliminate the biological and human variation that is inherent in human skin markings, they offer valuable resources for preservation of bite mark evidence, pattern analysis, and corroborative identification in combination with traditional forensic techniques.¹⁰

⁸ D. R. S. Bds, "Assessment and classification of the forensic significance of human bite marks in skin," *Eur. Soc. Med.*, vol. 13, no. 11, 2025, doi: <https://doi.org/10.18103/mra.v13i11.7035>.

⁹ P. Rebello, M. Patidar, S. Purohit, S. Pareek, S. Mohapatra, and S. Murmu, "Bite Marks as Forensic Evidence: A Comprehensive Review of Identification Methods and Reliability," *J. Clin. Insights Res. Dent.*, vol. 1, no. 3, pp. 132–137, 2025, doi: 10.5005/jcird-11034-0031.

¹⁰ P. A. Menon and N. A. Kumar, "Recent Advances in Forensic Odontology: An Overview," *J. Forensic Sci. Med.*, pp. 105–108, 2021, doi: 10.4103/jfsm.jfsm_41_20.

A. Digital Photography and Image Enhancement

The digital photography of bite mark evidence has become the norm for high resolution evidence. Forensic scales and controlled lighting provide standardized photographic protocols, which are able to preserve fine morphological details with minimum distortion. Image enhancement software also enhances the contrast, sharpness and color balance, making it easier to see the patterns of faint injury and to make consistent comparisons when considering forensics.¹¹

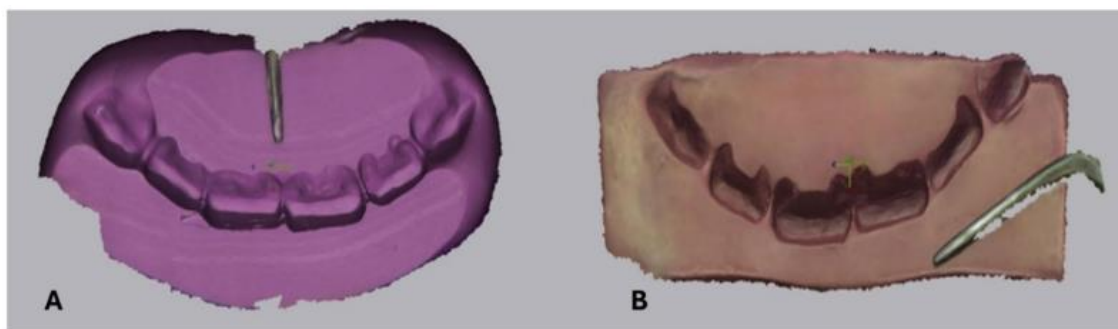


Figure 12: Digital PLY files of bite marks (A: dental silicone, B: dental wax)¹²

B. Three-Dimensional (3D) Imaging and Scanning

Different imaging technologies such as laser scanners, structured-light scanners, and cone-beam computed tomography (CBCT) can create accurate digital models of bite marks and dental structures. The 3D models show depth, curvature and surface topography, which reduces the error in measurements and provide the ability to virtually reconstruct, quantify and save the evidence digitally for long-term use, unlike two-dimensional photos.¹³

¹¹ M. Rajshekar, E. Kruger, and M. Tennant, "Photographic imaging distortion and its effects on forensic bite mark analysis," *J. Adv. Dent. Res.*, vol. 3, no. 3, 2012, doi: 10.1177/2229411220120301.

¹² U. Kayhan, S. Özden, and M. Ş. Yıldırım, "Distinguishing actual from 3D-printed bite marks in forensic odontology: accuracy and reliability of digital analysis," *Int. J. Legal Med.*, vol. 140, pp. 1775–1783, 2026, doi: <https://doi.org/10.1007/s00414-025-03712-x>.

¹³ S. Martin-de-las-heras, D. Tafur, and M. Bravo, "A quantitative method for comparing human dentition with tooth marks using three-dimensional technology and geometric morphometric analysis," *Acta Odontol. Scand.*, vol. 72, pp. 331–336, 2014, doi: 10.3109/00016357.2013.826383.

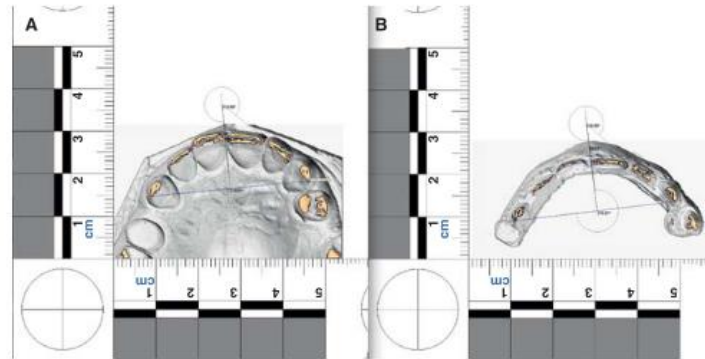


Figure 13: Example of the morphometric analysis (tps Dig v.2.10 software) to measure the rotation of the four incisors and the inter- canine distance of the biting edges previously obtained using DentalPrint? software: (A) from 3-D image of upper dental cast; and (B) from 3-D image of bite impression¹⁴.

C. Computer-Assisted Bite Mark Comparison

The computer-assisted comparison systems use digital overlays to match bite mark patterns with dental records, as well as geometric measurements and image processing algorithms. Such systems minimize subjectivity from the examiner by increasing the uniformity of measurements and allowing for repeatable analyses. In more recent years the use of Artificial Intelligence and Machine Learning algorithms has also been explored to automate pattern recognition and enhance analytical uniformity, with more work needed to confirm in forensic routine.¹⁵

D. DNA Recovery from Saliva Associated with Bite Marks

Epithelial cells are often included in saliva deposited during the biting and offer a great source of DNA. Sterile swabbing of bite marks can allow for testing of short tandem repeat (STR) which can provide more individualizing evidence than bite pattern swabbing alone. As a result, DNA testing has become an integral part of bite mark analysis in the field of forensics.¹⁶

¹⁴ S. Martin-de-las-heras, D. Tafur, and M. Bravo, "A quantitative method for comparing human dentition with tooth marks using three-dimensional technology and geometric morphometric analysis," *Acta Odontol. Scand.*, vol. 72, pp. 331–336, 2014, doi: 10.3109/00016357.2013.826383.

¹⁵ S. Dwivedy, T. M. Kulkarni, N. P. Tayde, and S. V Pillai, "Reliability of Computer Assisted Method for Bite Mark Analysis: A Narrative Review," *Indian J. Forensic Odontol.*, vol. 18, no. 1, 2025, doi: 10.21088/ijfo.0974.505X.18125.3.

¹⁶ A. K. Verma, S. Kumar, and S. Bhattacharya, "Identification of a person with the help of bite mark analysis," *J. oral Biol. craniofacial Res.*, vol. 3, no. 2, pp. 88–91, 2013, doi: <http://dx.doi.org/10.1016/j.jobcr.2013.05.002>.

E. Emerging Role of Microbiome and Molecular Forensic Methods

The oral microbiome has been the topic of recent research, and it has been determined that there are unique microbial communities present in the oral cavity of each person, even if they are the same gender and age. These microbial signatures can be characterized by high throughput sequencing and other molecular methods, providing another source of associative evidence in the absence of or in the context of limited or degraded human DNA. Microbiome-based identification is a new, rapidly evolving field, and it shows promising potential for enhancing future bite mark investigations, but there is a great deal more to understand.

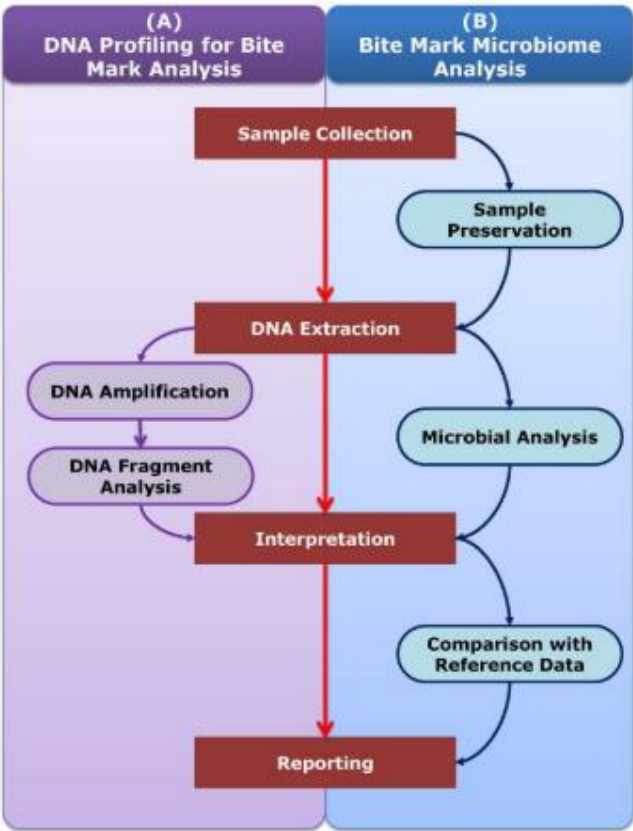


Figure 14: Different Stages of DNA Profiling and Microbiome Analysis in Bite Mark Examination.¹⁷

¹⁷ P. A. Mehar, L. Z. Bhoyar, and A. L. Mahakalkar, “Integration of Bite Mark Microbiome Analysis with Forensic DNA Profiling: Advancements, Challenges, and Synergistic Approaches,” *Rambam Maimonides Med. J.*, vol. 15, no. 3, pp. 1–12, 2024, doi: 10.5041/RMMJ.10528.

4 Limitations and Controversies in Bite Mark Analysis

Although this technique has been used for decades in forensic cases, bite mark analysis is one of the most controversial areas of forensic science. While bite marks can be useful investigative clues, the reliability of their identification of a specific individual has been called into question in recent years due to biological variability, methodological limitations and inadequate scientific validation. Recent scientific reviews suggest caution when interpreting bite mark evidence and that it should not be used as primary evidence but rather as corroborating evidence alongside other forensic methods, especially DNA analysis.¹⁸

- i. **Skin Distortion and Healing Effects:** Human skin is an elastic, anisotropic and dynamic tissue, which deforms during biting, and changes post-biting. Bite marks can significantly change based on body location, age, posture, motion, swelling, bruising, decomposition, and healing. This means that the pattern of injury may be very different from the pattern of the original dentition making it difficult to make accurate comparisons in the future.
- ii. **Subjectivity in Interpretation:** The interpretation of bite marks often depends on expert opinion for the conclusions about whether a bite mark is a human bite mark, and if so, whether the bite mark is similar to a suspect's dentition. Since there are no objective criteria established for many of the comparisons that can be made, varying conclusions may be drawn by different forensic odontologists when the same evidence is evaluated.¹⁹
- iii. **Examiner Variability:** Research has shown that there may be significant inter-examiner and intra-examiner differences in bite mark identification. Training, experience, and analytical approaches and definitions of injury characteristics can affect conclusions, creating inconsistency and the need for uniform examination procedures.
- iv. **Lack of Scientific Validation and Reproducibility:** The major objection to bite mark comparison is the lack of scientific proof that human teeth generate bite marks that are unique and consistent enough on human skin. Definitive conclusions about individualisation require large scale validation studies to confirm known error rate, reproducibility, and statistical reliability, which are currently limited.²⁰

¹⁸ D. A. Sehrawat, "Controversies and Challenges in Bite Mark Analysis: A Comprehensive Review," *Acta Sci. Dent. Sci.*, vol. 7, no. 10, pp. 64–70, 2023, doi: 10.31080/ASDS.2023.07.1718.

¹⁹ P. Gajmer and R. Kumari, "Reliability of Bite Marks in Forensic Investigations: A Review," *J. Med. Acad.*, vol. 8, no. 2, pp. 152–154, 2025, doi: 10.5005/jp-journals-11003-0188.

²⁰ M. J. Saks et al., "Forensic bitemark identification: weak foundations, exaggerated claims," *J. of Law Biosci.*, pp. 538–575, 2016, doi: 10.1093/jlb/lsw045.

- v. **False Convictions and Reliability Concerns:** Bite mark evidence has been used in several criminal cases that have resulted in wrongful convictions and subsequently DNA exoneration. These cases have sparked concerns about over-statement of forensic conclusions and underscored the need to keep the bite mark evidence to scientifically supported opinions.
- vi. **Current Scientific Criticism of Bite Mark Comparison:** Forensic science studies in recent years have determined that existing evidence is insufficient to prove the identity of a particular person based on a bite mark found on the human body. Therefore, many scientists advocate for only documenting patterned injuries, determining if bite marks are consistent with a human bite, recovering biological evidence (saliva for DNA) and incorporating the evidence with other accepted forensic methods. Future studies should focus on scientific and objective analytical methods and standardized methodologies prior to wider acceptance of forensic applications.

5 Legal and Ethical Perspectives of Bite Mark Evidence

The use of bite mark evidence in a medico-legal context is not just a scientific undertaking, but also a legal and professional ethical one. A bite mark in India is considered as corroborative in nature and is looked into in conjunction with DNA evidence, medical evidence and other forensic evidence. The courts are increasingly focused on the scientific validity of opinions, proper evidence handling, and expert competency when accepting such opinions. Therefore, the conclusions drawn by forensic odontologists must be based on evidence, remain objective, and be presented within the accepted scope of forensic odontology.

A. Legal Perspectives

Bite mark evidence can be presented as expert evidence in the Indian criminal justice system under Section 39 of the Bharatiya Sakshya Adhiniyam, 2023, formerly known as Section 45 of the Indian Evidence Act 1872, which permits evidence of the opinion of persons specially skilled in science or technical subjects. But opinions of experts are only opinions and can't stand alone to prove guilt, unless they are corroborated by other evidence. Courts look at the qualifications of the expert, accepted forensic protocols, chain of custody, and scientific reliability of the bite mark examination when evaluating the credibility of bite mark evidence. As modern studies have revealed the shortcomings of bite mark comparison, Indian experts are urged to limit their

opinions to what is scientifically proven, such as documenting injuries or finding biological evidence like saliva for DNA testing.²¹

B. Ethical Perspectives

Ethical practice demands impartiality, scientific integrity and accountability in the entire course of investigation in forensic odontology. A forensic odontologist should refrain from bias, recognize methodological limitations, be thorough in documentation, and not over state the certainty of conclusions. Confidential handling of medical and personal information, informed consent during evidence collection (where applicable) and adherence to professional norms set by the National Medical Commission (NMC) and the Dental Council of India (DCI) are all ethical responsibilities. Ongoing professional development and the use of recognised protocols also help to ensure that forensic opinions are used in a way that helps to achieve a fair outcome in court cases and that wrongful convictions are avoided. Ethical responsibility is still at the heart of maintaining public confidence in forensic science and the administration of justice, as bite mark analysis continues to develop.²²

6 Conclusion

Forensic odontology is still very much relevant in contemporary criminal investigations as it offers enduring and informative dental evidence for medico-legal examination and human identification. Bite mark evidence has been a valuable tool in the investigation of violent crimes for many years, but modern scientific research has revealed significant problems with its accuracy for personal identification. New technologies such as digital imaging, 3D scanning, computer-assisted analysis, DNA fingerprinting, and molecular forensic analysis have significantly improved documentation and interpretation of bite mark evidence, and minimized reliance on subjective examinations. However, bite mark comparison must be used in conjunction with other reliable forensic techniques and DNA should be used as a major corroborating factor. In the Indian context, expert testimony needs to be backed by scientific rigor and standard procedures as well as ethical professionalism. The future of forensic odontology requires continued forensic, validation studies, objective analytical approaches, technological advancements, and multidisciplinary team collaboration in order to ensure that

²¹ N. Madhukrishna, "An Analysis Of Forensic Odontology – Its Application In The Criminal Justice System Introduction: Forensic Odontology," *TIJER – Int. Res. J.*, vol. 13, no. 6, pp. 113–124, 2026.

²² P. A. Mehar, L. Z. Bhoyar, and A. L. Mahakalkar, "Integration of Bite Mark Microbiome Analysis with Forensic DNA Profiling: Advancements, Challenges, and Synergistic Approaches," *Rambam Maimonides Med. J.*, vol. 15, no. 3, pp. 1–12, 2024, doi: 10.5041/RMMJ.10528.

bite mark evidence can meaningfully, ethically, and reliably be used to assist in the administration of justice.

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