**FORENSIC ODONTOLOGY**: THE NEW DIMENSION IN DENTAL

ANALYSIS

Dr Shikha Gupta , reader , BBD University

Dr Indu Yadav , senior lecturer, BBD University

Dr Nidhi , senior lecturer , BBD University

Dr Shailesh Gupta , consultant , Medanta Hospital

**Abstract :** Forensic odontology a branch of Forensic sciences uses the skill of the dentist in identification during mass calamities ,sexual assault and child abuse .

Identification of human remains is essential for various section as including legal, criminal, humanitarian and social grounds. Dental remains used for identification as it is cost effective, reliable and fast. Forensic odontology is a branch of dentistry that analyses dental evidence to overlap the dental and legal profession. Forensic information from soft tissues of the oral cavity, forensic methods of age estimation, therapeutic and molecular aspects of Forensic odontology have been elaborated.

**INTRODUCTION**

 Along with development in science and technology in modern world, natural calamities and crimes continue to persist in human life . . Forensic Odontology, or forensic dentistry was defined by Keiser-Neilson in 19702 as “that branch of forensic medicine which, in the interest of justice deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of the dental findings”.

**HISTORY**

The earliest case recorded of forensic concerns was a female Emperor Nero, who was identified after her death through the unique arrangement of her teeth1. Another case was recorded in 1775, Paul Revere identified victims of a revolutionary war by their teeth and dental work. The body of Joseph Warren was identified by a Walrus tusk used as a pontic for his missing maxillary canine.4 .

In 1977, the interesting case was discovered about identification of the body of Hitler and his wife Eva Brauma. They were identified using their dental records with radiographs and prostheses 9.

 The tragic incident was happened in the U.S.A on September 11, 2001, and the thousand of people lost their lives in the world trade centre. The victims were identified by Deoxyribo Nucleic Acid (DNA) . The extracts from tooth brushes of the victims were used in identification of some victims through the DNA samples 7..

**TOOTH AS A TOOL FOR FORENSIC EVIDENCE :**

**Use of teeth in identification of person:** For every individual the morphology and arrangement of teeth is unique pattern so it is useful in identification of individual. In dental identification procedure the dental evidence are used such as dental caries, missing teeth, restored teeth, prosthesis, alterations in shape of teeth such as taurodontism, talons cusp, and developmental defects such as amelogenesis imperfecta, dentinogenesis imperfecta, changes in colour of teeth like dental flurosis collected from human remains is compared with previous records for establishing identity of the decedent. This necessitates the importance of every dentist to maintain records of their patients 1

The availability, sufficiency, and accuracy of antemortem dental records are important factors in forensic dental identification. Comparative dental analysis, like fingerprints and DNA analysis, plays a vital role in identifying people 10.

**According to the American Board of Forensic Odontology, dental identification methods can be divided into:11**

• **Positive identification:** The antemortem and postmortem data match and thus it can be established that it is from the same individual.

 **• Possible identification:** Although there are similarities between the equivalent items in the antemortem and postmortem databases, neither source contains enough information to allow for definitive identification.

**• Insufficient identification evidence**: Although there is insufficient supporting evidence for comparison and definite identification, the decedent’s presumed identity cannot be ruled out. After then, the identification is judged inconclusive.

**• Exclusion:** In the antemortem and postmortem databases, there are unexplained variations between comparable items. Sometimes there are explainable differences, like alterations in restorations over a while, tooth avulsion owing to trauma at death, or subsequent treatment by a second party that is not recorded in the antemortem record. The differences in all of these examples can be explained and identification can still be established .

**Use of teeth in crime investigation: Bite mark**

A bite mark is defined as ‘a mark caused by teeth either alone or in combination with other mouth parts’ and serves as a good source of forensic evidence in crime investigation1.

 Like fingerprints, the teeth marks made by human teeth can be a helpful for identification . As the teeth mark is unique in every individual.12 .

Bite marks are usually associated with sex crimes, violence fights, and child abuse.12

**CLASSIFICATION OF BITE MARKS :**

Human bites may be classified in different ways, for example, defensive or offensive**15.**

**MacDonald suggested an etiologic classification.**

It is pertinent to human bite marks but equally applicable to marks on other materials.

 **1. Tooth pressure marks:** These are caused by incisal edges of the anterior teeth. They are stable and subjected to minimal distortion

**2. Tongue pressure marks**: Because of tongue pressure, impressions of the palatal surfaces of the teeth, cingulum, or palatal rugae may be produced. This causes distortion of marks

**3. Tooth scrape marks:** These are produced because of irregularities in the teeth due to fractures, restorations, etc.

**4. Complex marks:** These are a combination of the above types of marks. The shape depends on amount of tissue taken into a mouth .

**COLLECTION OF BITE MARK EVIDENCE -**

Following information should be recorded both in living and deceased victim.

1. Demographics: Patients name, age, and gender along with case number, date of examination, and name of examiners should be recorded

 2. Location of the bite mark: Anatomic location, contour of the surface (flat, curved, or irregular) underlying tissue such as bone, cartilage, muscle, or fat should be recorded
3. Shape of the bite mark: Shape of the bite mark such as round, ovoid, crescent, or irregular should be noted

 4. Color and size of the mark: Both vertical and horizontal dimensions should be recorded

5. Type of injury: Petechiae, contusion, abrasions, and laceration caused by bite mark should be noted

6. Nature of the human bite mark: Human bite marks are usually semicircular or crescentic, with gap on either side. The teeth may cause clear, separate marks, or form a continuous or intermittently broken line. Bite marks may be abrasions, contusions or lacerations, or a combination of above any.

**GUIDELINES FOR THE ANALYSIS OF BITE MARKS**

The American Board of Forensic Odontostomatology (ABFO) established the guidelines in 1986 to standardize the analysis of bite marks.12

The basic steps and tools used in the recording of bite marks are as follows.14

**Photography**

 The photography evidence is considered the most important evidence from the victim .

All photographs should be taken with the camera perpendicular to injury. Photographs of injury should be taken immediately.

1. In color and black and white
2. With and without the ABFO number 2 scale
3. On and off camera flash
4. Close‑ups that can easily be scaled 1:1
5. Ultraviolet (UV) photography if injury is fading
6. An overall body shot showing the location of injury
7. If the bite is on a movable anatomic location, then several body positions should be adopted to assess the effect of movement.

**Collection of swabs**
Swabbing of bite mark injury is important to recover trace evidence. Stains of saliva or human cells for a DNA analysis should be collected whenever possible.14

**Ultraviolet illumination**

Bite marks which are not visible by naked eyes may become visible when examined under UV light in a dark room. This technique will demonstrate invisible bite marks up to 6 months after infliction.12

**Impression and models**

Depending on constitution of the skin, the bite marks can be distorted, this can be problem when analyzing the bite marks. To prevent mistakes by the pattern associated comparison, it is recommended to simulate bites at similar body parts using the study casts of the suspect14 or using digital technique for a stepwise dynamic comparison.16,17.

**Sample bites**

 In case of dead victims, bite marks can be excised along with underlying tissue after fixing acrylic stent around bite mark to avoid shrinkage of tissue. The specimen is then stored in 4% formalin.

**METHODS OF ANALYSIS OF BITE MARKS**

**Odontometric triangle method18,19** – It is an objective method, in which triangle is made by joining three points A,B,C mark on the along the bite mark and tracing is done. Point A and B is plotted on the outermost convex points on the canine teeth. Point C is mark on the center of two central incisors and then these 3 points are joined to form the triangle ABC. This done on both upper and lower jaw. Results are obtained by statistical analysis.

**Comparison technique**

 It has two types (1) direct and (2) indirect.20

 **Direct method** – in this method suspect models can be directly placed over the photograph of the bite mark. Bite mark and study casts can be compared using three‑dimensional (3D) pictures.

 **Indirect method -**  involves preparation of transparent overlay which is then placed over the scaled 1:1 photographs and comparison is made.

**Image perception software procedure21**

This is the recent software developed for comparing and analyzing the photographs of bite mark dentition with overlays of suspected dentition . With image perception software, it is possible to depict a 2D picture as a 3D object.

**Other special methods in bite mark analysis are:**

**Vectron** - This is used to measure distance between fixed points and angles.

 **Stereometric graphic analysis** -

This is used to produce counter map of the suspect’s dentition.

**Scanning electron microscopic analysis of bite mark wound.**

**The ABFO provides a range of conclusions to describe results of bite mark comparison**:21

1. **Excluded**: Discrepancies in bite marks and suspect’s dentition
2. **Inconclusive**: Insufficient forensic detail to draw any conclusion
3. **Possible biter:** Teeth like the suspects could be expected to create a mask like the one examined but so could other dentition
4. **Probable biter**: Suspect most likely made the bite; most people in population would not leave such bite
5. **Reasonable medical certainty:** Suspect is identified for all practical and reasonable purposes by the bite mark.

 **Difficulties in bite mark analysis**21

 1. Subjective element in fabrication

 2. Subjective element in comparison

 3. Distortion through skin elasticity, anatomical location, and body positioning is recurring problem

 4. Loss of data, contamination.

**FORENSIC INFORMATION FROM OTHER ORAL TISSUES:**

 **Palatal Rugae:**

Similar to finger print , the palatal rugae pattern is unique for every individual and hence it is useful for forensic information.

Thomas et al has classified rugae pattern as diverge, converge, curve, wavy, straight and circular .22

V S K Shetti et al (2011) proposed that palatal rugae is accurate tools for indian population identification.23

 M Ohtani et al (2008) 1 analysed the limitations of using palatal rugae for person identification in edentulous patients.

**Lip prints: ( Cheiloscopy )**

lip prints are for forensic evidence similar to finger prints.

Tsuchihashi et al have proposed six different types of groove patterns in the lip1.

Type 1- clear-cut vertical grooves that run across entire lip;

Type I’ similar to type I but not covering entire lip;

Type II - branched grooves;

Type III - intersected grooves;

 Type IV - reticular grooves and

 Type V - grooves not morphologically differentiated.

**Tongue Prints** -

The tongue is the organ which is supplied by blood vessel and nerve supply. Like any other organ has its share of skeletal muscles, blood vessels, and nerve supply.3  The form and surface textures of the tongue are unique to each individual.

**FORENSIC METHODS OF AGE ESTIMATION –**

Dentition help in age estimation by eruption sequence, radiographic features like tooth germs, commencement of mineralisation ,degree of mineralisation of various teeth, degree of crown and root completion, degree of root resorption of deciduous teeth, open apices, pulp to tooth ratio, volume of pulp chambers and root canals, third molar eruption, digitization of available radiographs; histologic features like neonatal line, incremental lines of cementum, dentin translucency, dentin predentin interface using scanning electron microscopy and biochemical characteristics like C14 levels and racemication of dentin. Dentition is used to estimate age in three groups namely prenatal, natal and post natal period; children and adolescents and adults. 1

Third molar eruption is of great importance to distinguish juveniles and adults.

A radiograph can reveal information about the age of a person and is vital in forensic odontology as the teeth and the bony complex of the face are structures amenable to radiographic examination.

**The four methods were developed for the age estimation as mentioned below-**

1. **Schoulr and Masslers method**.

In 1941 Shoulr and Massler has studied the development of deciduous dentition and have evolved 21 chronological steps from 4 months to 21 year.

1. **Moorer, Fanning and Hunt method:**

 In this technique 14 stages of mineralisation for developing single and multirooted teeth are used for age estimation.

1. **Demirijian,** Goldstein and Tanners method : studied about seven mandibular permanent teeth in an orderly manner -

 second molar (M2), first molar(M1), Second premolar (PM2), first premolar (PM1), Canine(C), Lateral incisor(I2), Central incisor (I1) .

1. **Nollas technique**: This technique evaluated the mineralization of permanent teeth in ten stages in the maxilla and mandible.

**RECENT ADVANCES IN AGE ESTIMATION** –

Helfman P.M. et al have shown that racemisation of L aspartic acid to D aspartic acid in dentin takes place as aging occurs. This can be used as a basis for age estimation.

The basis for age estimation is that Carbon 14 levels in atmosphere have increased over the years after the cold war between 1955 and 1963 due to ground test of nuclear weapons. This is referred to as bomb pulse.1

**Recent Trends In Forensic Odontology**

**Facial Reconstruction:**

 Forensic facial reconstruction is a quick, non-invasive, and effective approach for identifying people from skeletal remains. There are two sorts of reconstruction techniques: two-dimensional (2D) and three-dimensional (3D).26

Various methods for manual 3D reconstruction include :

• Tissue Depth Method: This technique was developed by Krogman in 1946.

• Anatomical Russian Method.

• Manchester/British Procedure

• Computerized 3D Forensic Facial Reconstruction

**Denture Identification Methods-**

Denture marking can be divided two categories - surface marking and inclusion methods.

Surface marking simply means scratching or engraving an identity mark onto the surface of the denture.

Inclusion methods involve the use of paper, onion skin or label which are included into the denture base prior to polymerisation.

**LIMITATIONS OF RESEARCH IN FORENSIC ODONTOLOGY**

 Ethical issues in sample collection in crime investigation.

The application of molecular and biochemical techniques in Forensic Odontology are expensive.

**CONCLUSION**

 Forensic dentistry has always been a part of forensic science. The use of teeth, biopsy samples, saliva, dentures and other aids have shown epic changes in forensic science.

 DNA recovery from dental samples has become easy with advancements in PCR techniques. Ameloglyphics and age estimation using biochemical markers are some of the recent advances in this field . Even dentures and bridges marked with identity numbers and initials can be used in person identification in mass disasters. Forensic odontology is the most important areas of forensic science as far as “person identification” is concerned.

**REFERENCES-**

1. .Saranya V, Malathi. N , FORENSIC ODONTOLOGY: A BRIEF REVIEW , Sri Ramchandra Journal Of Medicine, July- Dec 2014.
2. . Keiser-Neilsen S. Bristol: John Wright and Sons; 1980. Person Identification by means of Teeth.
3. Rony t RJDS 2022
4. Smitha T, Sheethal HS, Hema KN, Franklin R. Forensic odontology as a humanitarian tool. J Oral Maxillofac Pathol 2019;23(1):164.
5. Ranganathan K, Thavarajah R, Lakshminarayanan, V. Forensic odontology: A review. J Forensic Odontol. 2008;1:4-12
6. . Bhakhri S, Kaur A, Singh K, Puri MS, Puri N, Anandani C. Perception of forensic odontology and its practice among the local dentists of an institution. J Forensic Res 2017;8:377
7. Sansare K. Forensic odontology, historical perspective. Indian J Dent Res. 1995;6:55–7.
8. Devore DT. Radiology and photography in forensic dentistry. Dent Clin North Am 1977;21:69-84.
9. Bagi BS. Role of forensic odontology in medicine. J Indian Dent Assoc1977;49:359-63
10. Rai B., Kaur J. (2013) Forensic Odontology: History, Scope, and Limitations. In: Evidence-Based Forensic Dentistry. Springer, Berlin, Heidelberg
11. Body identification guidelines. American Board of Forensic Odontology (ABFO). J Am Dent Assoc.1994; 125 (9): 1244-1246.
12. Bite mark analysis
13. MacDonald DG. Bite mark recognition and interpretation. J Forensic Sci Soc 1974;14:229‑33.
14. Lessig R, Benthaus S. Forensische odonto‑stomatologie. Rechtsmedizin 2003;13:161‑8.
15. Rötzscher K, Pilz W, Solheim T. Bissspur – Zahnspur. In: Madea B, Brinkmann B, editors. Handbuch Gerichtliche Meddizin. Vol. 2. Berlin, Heidelberg, New York: Springer; 2003. p. 1699‑728.
16. Sakoda S, Fujita MQ, Zhu BL, Oritani S, Ishida K, Taniguchi M, et al. Wounding dynamics in distorted bitemarks: Two case reports. J Forensic Odontostomatol 2000;18:46‑51.
17. Thali MJ, Braun M, Markwalder TH, Brueschweiler W, Zollinger U, Malik NJ, et al. Bite mark documentation and analysis: The forensic 3D/CAD supported photogrammetry approach. Forensic Sci Int 2003;135:115‑21.
18. Chhatpar S, Sabane VS. Role of bite mark analysis in identification of a person in forensic odontology. J Indian Dent Assoc 1989;60:173‑9.
19. Singh M, Das R, Rao KT. Bite marks an index for identification in crime (An experimental clinico‑anthropological study). J Indian Acad Forensic Med 1988;10:21‑5
20. West MH, Frair J. The use of videotape to demonstrate the dynamics of bite marks. J Forensic Sci 1989;34:88‑95.
21. Bhargava K, Bhargava D, Rastogi P, Paul M, Paul R, Jagadeesh HG, et al. An overview of bites mark analysis. J Indian Acad Forensic Med 2012;34:61-3.
22. Thomas CJ. Kotze TJ. The palatal rugae pattern: A new classification. J Dent Assoc S Afr 1983; 38: 153- 7.
23. . V. S. Kotra shetti, K. Hollikatti, M. D. Mallapur, S. R. Hallikeremath, A. D. Kale, “Determination of palatal rugae patterns among two ethnic populations of India by logistic regression analysis,” Journal of Forensic and Legal Med 2011;18:360-5.
24. Silva RH, Musse JD, Melani RF, Oliveira RN. Human bite mark identification and DNA technology in forensic dentistry. Braz J Oral Sci 2006;5:1193-7.
25. Mayall SS, Agarwal P, Vashisth P. Dental DNA finger‑printing in identification of human remains. Ann Dent Spec 2013;1:16-9
26. Lee WJ, Wilkinson CM, Hwang H. An Accuracy assessment of forensic computerized facial reconstruction employing cone-beam computed tomography from live subjects. J Forensic Sci 2012;57(2):318-27