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Forensic Odontology: A Review

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Abstract

Forensic odontology, derived from the Latin "forensis," is a dental specialty that addresses legal and identification issues related to teeth. This field became prominent in the 1930s and is essential in forensic medicine, particularly for identifying human remains due to the resilience of teeth. Key roles include identifying unrecognizable bodies, addressing dental malpractice, and analyzing bite marks in criminal cases. While not as precise as DNA analysis, forensic dentistry is valued for its cost-effectiveness and speed, often aiding initial identifications.

Orthodontists play a crucial role by maintaining comprehensive diagnostic records, using software and superimposition techniques to reconstruct faces in disaster situations. Their expertise in dental positioning and age assessment is vital for profiling skeletal remains when soft tissue identification is not possible. Additionally, orthodontists are encouraged to include lip prints in their records to enhance forensic identification. Overall, meticulous documentation by orthodontists is crucial for assisting legal authorities in identifying victims and suspects effectively.

Keywords: Forensic Odontology, Antemortem, Postmortem, Orthodontist

Introduction

The term "forensic," derived from the Latin "forensis" meaning "before the forum," relates to forensics as a

branch of dentistry focused on legal and identification issues involving teeth. Forensic odontology applies dental knowledge to civil and criminal cases, aiding in identifying remains, estimating age, and analyzing bite marks, among other functions.

Forensic odontology gained prominence in the 1930s with the establishment of formal training and the American Board of Forensic Odontology in 1976. Over the years, it has become essential in forensic medicine, particularly for identifying human remains due to the resilience of teeth in various conditions.

Key areas of forensic dentistry include identifying unrecognizable bodies (e.g., in disasters), addressing dental malpractice, and supporting criminal cases involving bite marks and abuse. Dental records, such as radiographs and photographs, play a crucial role in these processes.

Though not as precise as DNA analysis, forensic dentistry is valuable for its cost-effectiveness and speed, often aiding in initial identifications that can be later confirmed through more scientific methods. The integration of orthodontic records has also been highlighted as significant in identifying victims, emphasizing the importance of meticulous documentation by orthodontists. [3,4,6]

Forensic Odontology

- **Historical Perspective**

Forensic odontology emerged as a distinct discipline in the 19th century, credited to Dr. Oscar Amoedo, who identified fire victims in Paris in 1898 and authored the first book on the subject. Key milestones in the history of forensic odontology include:

- 66 AD: The first recorded use of dental identification in the case of Agrippina and Lollia Pauline.
- 1193: Identification of Jai Chand in India by his false teeth.
- 1453: The Earl of Shrewsbury identified after falling in battle.
- 1758-1776: Notable cases, including identification by Dr. Paul Revere using prosthetic teeth.
- 1849-1850: The first convictions based on dental evidence in murder cases.
- 1884-1898: Advocacy for dental science in crime detection and Dr. Amoedo's contributions following a tragic fire that claimed many lives.

The discipline continued to develop through the 20th century with advancements like bite mark analysis, computerized dental records, and improved forensic techniques. Key publications and research established the role of orthodontic records in victim identification, emphasizing meticulous record-keeping as essential for forensic purposes. Over time, the intersection of orthodontics and forensic odontology has gained recognition, reinforcing the importance of detailed patient documentation in legal contexts.

- **Scope of Forensic Odontology**

Forensic dentistry often evokes mixed reactions, with many associating it primarily with identifying the deceased. While a significant portion of cases involves post-mortem identification, the field also encompasses work related to living individuals. Forensic odontologists find personal fulfillment in applying their skills through ongoing education and experience.

The discipline is defined as the intersection of dental science and the legal system, addressing various aspects beyond just identification. Key areas include age estimation, sex determination, bite mark analysis, and issues related to human abuse, dental malpractice, and dental anthropology. Dentists interested in forensic work can engage in "dry fingered" forensic dentistry by

meticulously recording patients' oral health information in their practices.

- Dental Identification
- Dental Record as a Legal Document
- Mass Disaster Identification
- Age Assessment
- Bite Mark Evidence
- Child Abuse
- Facial Reconstruction and Superimposition
- Sex Determination
- Cheiloscopy and Palatoscopy
- DNA Profiling

- **Limitations of Forensic Odontology**

Forensic odontology faces several limitations that affect its accuracy and reliability. Key shortcomings include:

1) Palatal Rugae: Not useful in edentulous mouths, when antemortem records are unavailable, in cases of palatal pathology, or when damaged by fire, decomposition, or skeletonization.
2) Lip Prints: Ineffective if more than 20 hours have passed since death, or if there are lip pathologies, surgical alterations, or scars.
3) Bite Marks: Not reliable if more than three days have elapsed post-mortem or in decomposed or burned bodies.
4) Radiographs and Photographs: Errors can occur during capture, leading to poor-quality evidence, while contamination and cross-sampling can further complicate DNA interpretation.

These inconsistencies highlight the need for careful consideration to improve the methods used in forensic odontology. [4,6,7,16,43]

General Dental Professional in Forensic Odontology

General dentists play a crucial role in the identification process during both the antemortem and post-mortem phases by maintaining patient records. While dentists are responsible for keeping these records, they must eventually transfer them to another custodian, such as a medical examiner or law enforcement, to protect themselves from potential malpractice claims and to assist in patient identification.

For unidentified individuals, the medical examiner or coroner typically requests dental records, while law enforcement agencies seek records for missing persons to enter into the NCIC database. Families of missing persons should submit these records promptly to aid in potential identifications. After identification or legal proceedings, original records may be returned to the dentist or the family. It is often recommended that forensic odontologists or medical examiners retain these records indefinitely, particularly in unresolved cases or when trials are anticipated. Failure to provide records may result in legal consequences, such as a subpoena. [34]

Records may be gathered from dentist, especially in the event that there were multiple procedures performed and specialty referral was made to an endodontist, oral surgeon, or orthodontist. A complete set of records would consist of:

i. Periapical and bitewing radiographs and, if available, panographic and cephalometric radiographs
ii. Models, laboratory, or diagnostic
iii. Photographs, face and/or dentition
iv. Dental charts and/or narrative reports locating all restorations, position, and material.

Role of Orthodontics in Forensic Odontology

Orthodontics is a dental specialty focused on the prevention, guidance, and correction of masticatory system development and dentofacial structures, aiming to achieve aesthetic harmony in facial features. Due to the complexity and duration of orthodontic treatments, orthodontists create extensive dental records essential for planning and executing these treatments.

These records typically include dental charts that document patient identification, health history, physical examinations, treatment plans, and outcomes, along with supplementary tests such as radiographs, impressions, and photographs.

Forensic odontology (FO) intersects with orthodontics, utilizing expertise from various dental disciplines to ensure proper handling and investigation of dental evidence for legal purposes. Orthodontics is particularly recognized for its standardized approach to patient data collection and record management over time.

Orthodontics has found its use in all the three major FO applications: a) Civil field: Concerned with mass disasters including earthquakes, airline or train accidents which require antemortem records of the deceased or injured for identification. Malpractice or age frauds, which may require age assessments based on teeth or radiographs. b) Criminal field: Identification of deceased or accused in the cases of rapes, homicides, etc. by bitemark analysis or adjuncts like rugae and lip print analysis. c) Research field: Many research avenues related to age estimation or reconstructive profiling are initiated in dental/ orthodontic under-graduate (UG) and post-graduate (PG) levels.

The importance of orthodontic records in playing a major role in identifying disfigured victims was further emphasized by Wahl. Meticulous maintenance of diagnostic and treatment records by orthodontists may help in identification of victims or suspects after death. At times a single feature may be so extraordinary or unique that, it alone may be sufficient to make a positive identification. Imperative of whichever the employed method that is being used in order to identify a disfigured face (person), the results of the comparison of antemortem and postmortem data would lead to any one of these four situations: 1. Positive identification: The items that are compared are sufficiently distinct in both antemortem and postmortem databases, hence, observations show no major difference between the two. 2. Possible identification: A few common findings exist among the comparable items in the antemortem and postmortem databases, but not sufficient enough to prevent the establishment of a positive identification. For example, one restoration among many postmortem radiographs. 3. Insufficient evidence for identification: Insufficient evidence to support the comparison (antemortem and postmortem findings) for definitive identification, but the identity of the deceased cannot be fully ruled out and is deemed inconclusive. 4. Exclusion: Unexplainable discrepancies exist among comparable items in the antemortem and postmortem databases. The role of an orthodontist may be discussed under the following headings: I. Pre-treatment records II. Mid-treatment III. Post-treatment records

I. Pre-treatment records

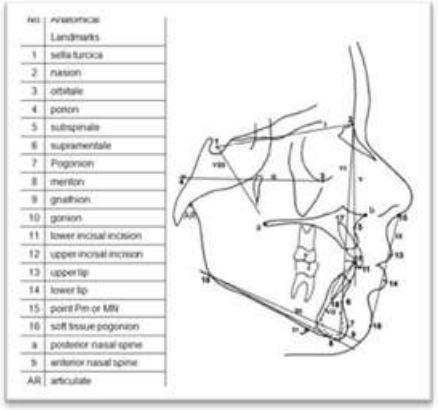
A. Photographs: One of the best and easiest diagnostic aids used in identifying the deceased are the facial and intraoral photographs. While the extra oral photographs can be used to directly identify the face in recognizable faces, the intraoral photographs are of more value in completely disfigured faces, as there may be certain classical hard tissue findings such as fluorosis, enamel decalcification, enamel

cracks and fractures, tooth attrition, abrasion, lower canine anatomy, to name a few.

B. Models: A 3-dimensional view of the maxillary and mandibular arches through models, help us assess certain features of the malocclusions, morphology and anatomy of teeth such as enamel abrasions, attrition and fractures. In particular, the rugae area, inter-canine width, lower canine size and shape can be better assessed on a model which are of great help in age and sex determination of the victim

C. Radiographs: Radiographs such as the OPG, lateral cephalogram, IOPA, occlusal radiographs etc., are routinely used as essential and supplemental diagnostic aid in orthodontic patients. Comparison of such antemortem radiographs with the post-mortem radiographs is the most accurate and reliable method of identifying remains. Classical radiographic findings such as tooth restorations, Root Canal Treatment, bases under restorations, tooth and root morphology, the shape of various sinuses and jawbone patterns, TMJ etc., may be all that is required for a positive identification. Hence, original antemortem dental radiographs of all kinds are of immense value for comparison.

Therefore, it is essential that all routine radiographs exposed during the course of a dental practice be adequately fixed, washed and stored so that they remain viewable for a long time. However, the best postmortem radiographs for comparison are obtained by maintaining the same angulation of the film to the x-ray tube as that of the original films. Lateral cephalogram in particular, can aid in reconstruction of facial soft tissues as it compiles and gives an accurate picture of the soft and hard tissue analysis of lateral view of the face.



The use of computer software in forensic odontology allows for flexible manipulation of facial structures, particularly in facial superimposition, which helps visualize underlying skeletal features beneath soft tissue. The McNamara technique is commonly used, alongside various cephalometric analysis methods such as Steiner's, Down's, and Tweed's. Popular cephalometric software includes NEMO CEPH and DOLPHIN.

The American Association of Orthodontists recommends lateral cephalometric radiographs for evaluating craniofacial structures and identifying skeletal anomalies. Despite their utility in assessing skeletal malocclusions and other parameters, there is limited evidence supporting their effectiveness in reducing treatment time or predicting outcomes, suggesting cautious use as a routine diagnostic tool.

Craniofacial superimposition is a forensic method comparing images of missing individuals with found skulls to determine identity based on morphological similarities. This process can involve photographs or video frames of the missing person and aims to assess anatomical consistency between the skull and face. The term "craniofacial superimposition" is preferred for its widespread recognition and to distinguish the technique from the technical devices used in identification.

D. Clinical examination: While radiographic findings are often more conclusive than clinical examination

results, clinical assessments can provide valuable supplementary information. Key aspects of a comprehensive clinical examination include:

1. Extraoral Facial Assessment: Evaluating facial form, symmetry, soft-tissue harmony, and the condition of perioral musculature to identify deviations in maxillofacial relationships and how the dentition relates to facial structures.
2. Intraoral Examination: Assessing the condition of hard and soft tissues in the mouth, including the periodontium, as well as evaluating the patient's occlusion.
3. Temporomandibular Joint Evaluation: Examining the joint and associated muscles for function and signs of disease.
4. Assessment of Oral Parafunctional Habits: Checking for any habits that may affect oral health.

All findings should be meticulously recorded in the patient's records for future reference.

I. Mid-Treatment

Patients undergoing treatment at that point in time can be certainly identified, as the appliance is a hard-core proof in itself. It is especially useful in cases of mass destruction identification where a lot of time is required due to the number of victims involved.

II. Post-Treatment

A. Photographs

In cases where patients die after orthodontic treatment, post-treatment records take precedence over pre-treatment records. It's important to note that some intraoral findings, such as enamel decalcification, cracks, and tooth wear, may still be present post-treatment. Conversely, conditions like enamel fractures and malocclusion may have been addressed during treatment, potentially altering the overall clinical picture. Additionally, photographs may reveal issues like enamel decalcification or white spot lesions that developed after orthodontic treatment.

B. Models

Post-treatment models may show differences in the alignment, symmetry and number of teeth present. Also, the linear measurements related to inter-canine width, rugae area, depth of the sulcus may change depending on the type of malocclusion treated.

C. Radiographs

One of the most conspicuous finding that may be observed on a post treatment radiograph Orthopantomograph is the generalized root resorption due to orthodontic treatment. At times, since orthodontic treatment warrants extraction of a few teeth for correction, the post treatment radiograph can form a very important tool in identifying the victim. Assessment and recording the post treatment findings is very important.

D. Orthodontic treatment:

Has the potential risk of causing significant damage to hard and soft tissues and are called Orthodontic scars which can be of great help in identification process. A few of them of relevance to forensic odontology include:

1. Lesions of Enamel – a) Enamel decalcification/White spot lesions. b) Physical damages on enamel (Enamel Wear / Enamel Fractures)

2. Periodontal tissues – a) Gingival recession, b) Dark Triangles

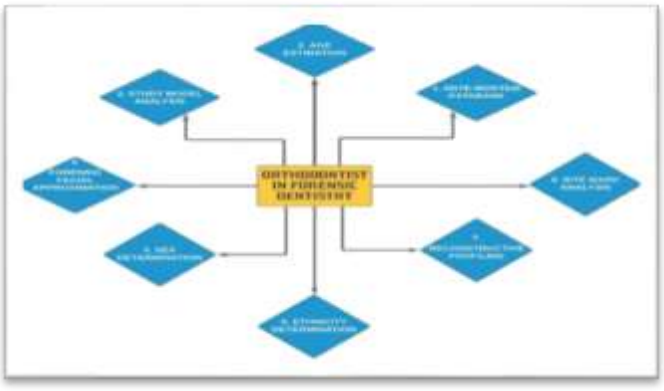
3. Soft tissue damage – a) Direct damage by appliances and their component parts: i. Impingements (E.g. Lingual arch, TPA (Trans Palatal Arch), Loops, Archwires, brackets, bands etc.) ii. Lacerations (E.g.: brackets, molar tubes, ligature ties etc.) iii. Ulcerations (E.g.: brackets, molar tubes, ligature ties etc.) iv. Injury to eyes (E.g.: Headgears, Face-bow injury)

Mind maps, have primarily three main components: a) Central theme: In this case: “Role of Orthodontist in

Forensic Dentistry" b) Branching theme: In this case, all eight major subheads which are descriptive of the role of the orthodontists are explained in the branching themes (branches) which are further sub-branched (twigs) for giving explanations in subsequent mind-maps. c) Visual representation: In this case, the central theme is represented by a similar diagram, font, and color characterization in all the mind maps to give a visual sequence to the readers. The branching concepts are also provided with the same color scheme for the ease of being self-explanatory. The arrows explain the inter-branching of ideas and concepts.

Eight areas have been identified: 1. Ante-Mortem Records 2. Age Estimation 3. Study Model Analysis 4. Forensic Facial Approximation 5. Sex determination 6. Ethnicity determination 7. Reconstructive profiling 8. Bite Mark Analysis

Color coding represented in the current mind maps – The following color coding has been applied in the mind maps: a) Yellow with black large text font: Central theme "Role of the orthodontist" b) Dark blue with white bold text font: "Branching themes": identified eight areas of orthodontic expertise c) Pink with black regular text font: Sub-heads representing major subheads, which give way to twigs (Green and Blue colors) of related concepts or ideas which are varied in different mind maps.



Forensic odontology in 21st century

Over the past 20 years, advancements in forensic odontology have been limited, primarily focused on integrating IT developments, particularly in bite mark analysis using software like Adobe Photoshop. Research in this field faces challenges, including ethical issues in studies related to bite marks and child protection, as well as difficulties in securing funding, which often favors traditional medical fields.

Despite these obstacles, there has been a gradual strengthening of forensic odontology through dedicated research and the application of advanced technologies. Examples of recent research include:

1. Portable X-ray units for efficient identification in mass fatalities.
2. Mobile multi-slice computed tomography (MSCT) for virtual autopsies and dental identification.
3. Three-dimensional imaging for bite mark analysis to reduce photographic distortion.
4. Computer-generated modeling to ethically study bite mark effects.

Future progress in forensic dentistry depends on rigorous research, particularly in bite mark analysis. It is crucial to establish the uniqueness of biting surfaces, create a searchable database for comparison, and develop reliable imaging methods. To improve the accuracy and reliability of bite mark evidence, forensic odontologists must prioritize scientific methods, peer review, and collaboration. By addressing these issues, the field of forensic odontology can enhance its credibility and effectiveness. [9,10,36,37]

Conclusion

Orthodontists play a crucial role in victim and suspect identification through the maintenance of comprehensive diagnostic records. Past disasters have highlighted the importance of forensic dentistry, particularly as incidents

of terrorism and natural disasters are expected to rise. Utilizing software and superimposition techniques on lateral cephalograms, orthodontists can reconstruct victims' faces, emphasizing their responsibility to store dental documents for such critical situations.

Orthodontists are trained from early in their postgraduate education to take routine pre-treatment diagnostic records, which are vital for anthropometric data collection. Their expertise in dental positioning, head shape, age assessment, and radiographic interpretation positions them well within forensic odontology. In cases where soft tissue identification is impossible due to decomposition, orthodontists can work with skeletal and dental remains.

They can assist forensic teams in profiling based on age, sex, and ethnicity using their knowledge of skull orientation and facial proportions. The growth assessment skills of orthodontists are also beneficial in determining mandibular plane orientation and soft tissue thickness.

Maintained records, including photographic, study casts, and radiographs, provide valuable comparative data for future research and victim identification. Their experience with 3D imaging and morphometric analysis enhances the accuracy of virtual reconstructions.

Orthodontists are encouraged to include lip prints in their records, which can aid forensic identification. Overall, the integration of forensic principles in orthodontics underscores the necessity for clinicians to maintain accurate records and assist legal authorities in identifying victims and suspects effectively. [7]

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