

Orthodontics pertaining to forensic odontology – Narrative Literature Review

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Abstract— Forensic science is the application of a broad spectrum of sciences used to answer questions of interest to a legal system related to crime or civil action. Teeth can withstand trauma better than other tissues in body and can withstand the temperature of 1100 degree Celsius without the loss of microstructure. Teeth is a source of DNA and can provide nuclear or mitochondrial DNA which helps in identification of a person. diagnostic aids used in identifying the deceased are the facial and intraoral photographs. Comparison of such antemortem radiographs with the post-mortem radiographs is the most accurate and reliable method of identifying remains. Even photos of cast and rugae patterns can be superimposed. Palatal rugae, bite marks and lip prints are also useful tool for identification. All practitioners of various fields must understand the forensic implication associated with his/her profession. Thus, the importance of the forensic field should give the dental clinician yet another reason to maintain proper records in accordance with law and assist legal authorities in the identification of victims and suspects.

I. INTRODUCTION

Interest in forensic dentistry was sparked in 1930's by the first formal instructional program on the same was given in the United States at the Armed Forces Institute of Pathology. The American Academy of Forensic Sciences established the American Board of Forensic Odontology in the year 1976 [1]. Forensic science is the application of a broad spectrum of sciences used to answer questions of interest to a legal system related to crime or civil action. Forensic dentistry or forensic odontology deals with proper handling, examination, and evaluation of dental records, which are then presented in the interest of law

for Justice. The new millennium has brought many good things to our lives along with new challenges of terrorism, natural disasters, and high rate of crime. Dental identification of humans is required in different situations for different reasons such as in violent crime, fire, drowning, road accidents etc., wherein the body could be fully disfigured to the extent of being unrecognizable. "Tooth for truth" has a multidisciplinary role to play in such cases [2]. The specialty of forensic odontology generally covers three basic areas, which include-

1. Identification of the deceased where the body is unidentifiable. E.g.: Multiple fatality incidents such as accidents, plane crash etc.
2. Legal help related to malpractice.
3. Criminal proceedings, primarily in the areas of bite-mark evaluation and abuse cases especially child abuse.

Orthodontic reconstruction in a victim of murder was one of the finest articles of the late nineties. The importance of orthodontic records in playing a major role in identifying disfigured victims was further emphasized by Wahl [3]. 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 post-mortem 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 post-mortem 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 post-mortem databases, but not sufficient enough to prevent the establishment of a positive identification. For example, one restoration among many post-mortem radiographs.
3. Insufficient evidence for identification: Insufficient evidence to support the comparison (antemortem and post-mortem 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 post-mortem databases.

2. ROLE OF ORTHODONTIC DENTAL RECORDS [4]

1. Case history form
2. Usage of dental casts for
 - A. Bite marks in personal identification
 - B. Palatal rugae in personal identification, racial, age and gender analysis
 - C. Mandibular Canine Index (MCI) in sex determination
3. Superimposition Using Computer Software
 - Craniofacial superimposition
 - Superimposition of photographs
 - Superimposition of cast
 - Superimposition of rugae patternSuperimposition of post mortem radiographs and photographs over ante mortem radiographs and photographs aids in easy identification of person.

Even photos of cast and rugae patterns can be superimposed. The role of an orthodontist may be discussed under the following headings-

- 1 Pre-treatment records
2. Mid treatment
3. Post treatment records

3. RECORDS

Photographs

One of the best and easiest diagnostic aids used in identifying the deceased are the facial and intraoral photographs. While the extraoral 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 canines anatomy, to name a few.

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 intercanine 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.

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 a dental practice be adequately fixed, washed and stored so that they remain viewable for a long time.

However, the best post-mortem 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, 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.

With the use of these measurements at specific points on the face it is possible to digitize and reconstruct a face on a computer screen [5].

However, use of photographs and superimposition of the lateral cephalometric findings on it help in maximizing the accuracy levels. The anatomical landmarks that can be taken into consideration during reconstruction include Sella turcica, Nasion, Porion, Orbitale, Subspinale, Infradentale, Pogonion, Gonion, ANS, PNS etc.

The use of computer software's permits the addition and deletion of components to mix and match. They have been extremely useful for facial superimposition. The underlying structures can thus be viewed below the soft tissue, providing a means to check the accuracy and try out various permutations and combinations. The superimposition technique by Mc Namara [6] commonly followed and practiced. The various other cephalometric analysis methods include Steiner's, Down's and Tweed's analysis. Some of the cephalometric software pertaining commonly used include NEMO CEPH and DOLPHIN.

CLINICAL EXAMINATION

Though the findings of the clinical examination may not be as important and conclusive as the radiographic findings, nevertheless, it may be useful as an adjunct at times. For example, the shape of the head (Dolichocephaly, Mesocephaly or Brachycephaly), Facial form (euryprosopic, mesoprosopic, leptoprosopic,) or a very deep scar on the face, etc. may be of help at times.

MID-TREATMENT

Patients undergoing treatment at that point in time can be certainly identified, as the appliance is a hard-core proof.

It is especially useful in cases of mass destruction identification where a lot of time is required due to the number of victims involved.

POST-TREATMENT

Apart from the available data discussed under pre-treatment diagnostic records, several other post treatment data may be equally useful.

It should be kept in mind that depending on when the disaster occurred, pre and/or post treatment records may be used accordingly.

Also, it is important to know that certain findings of pre- and post-treatment records may remain the same as in the case of teeth that have undergone restorative fillings, RCT's, missing teeth, to name a few.

Photographs:

In patients who died after the treatment, the post treatment records become more relevant as they supersede the previous findings of pre-treatment records. Hence, it should be kept in mind that certain relevant intraoral findings such as enamel decalcification, enamel cracks, tooth attrition, abrasion may have still been present at the end of the treatment. On the other hand, certain findings such as enamel fractures and malocclusion (e.g.: crowding, spacing between teeth etc.) may have been treated and hence may give a completely different picture following treatment. Photographs may show enamel decalcification/white spot lesions following orthodontic treatment.

Models:

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

Radiographs

One of the most conspicuous findings 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.

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).

Periodontal tissues a) Gingival recession

b) Dark Triangles

Soft tissue damage

a) Direct damage by appliances and their component parts: i.e. 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)

While soft tissue damage by impingements of bands, brackets and arch wires heals quickly and may not be of great help, injuries caused to enamel and periodontal tissues may result in permanent damage if untreated following orthodontic treatment.

4 BITE MARKS

MacDonald defined 'Bite mark' as a mark made by the teeth either alone or in combination with other mouth parts. In forensic odontology, the part that deals with Indexing and identification of bite marks has very high importance in terms of evidentiary value. In the Indian context the number of populations seeking orthodontic treatment is comparatively low as compared to western population. It could be considered as a limitation of orthodontics in Indian Orthodontic Forensic odontology, but the good indication is that the number is currently increasing in India. Bite marks are produced mainly through two aspects.

- As a result of sexual or physical assault by an adult on a child, rape or attempted rape, quarrels, and fights among people.

- May occur during self-defense when defending against aggressive animal or self-inflicted as tongue bite in epileptic fits or fall from heights



Fig 1- Bite Mark identification

Mac Donald's [7] etiological classification of bite marks-

- Pressure marks of tooth caused by incisal edge of anterior teeth.
- Pressure marks of tongue seen as impression of the palatal surface.

Scratches and abrasions that can indicate irregularities in shape of teeth such as tooth fractures, restorations or attrition during scrapping.

Gustafson's clinical classification

- Well defined bite mark may be due to sadistic or sexual bite as these are made slowly
- Aggressive bite where bite is made quickly with force caused by scribing across the tissue.
- Most aggressive bite results in tissue being bitten off usually and involves ears, nose, and nipples.

American Board of Forensic Odontology (ABFO) guidelines shows various classifications of bite marks -

According to the relationship of the jaws

- The form and size of arches
- Missing teeth
- Spacing between teeth
- Presence of supernumerary teeth
- Observed rotations of teeth
- The width of teeth
- Presence of special features such as fractures and ridges.
- Presentation of Bite Mark Injuries

Typical cases are presented as a semi-circular injury which comprises of 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.

Factors to be considered during bite mark examination are –

- The force by which the original injury was inflicted
 - The anatomical location bitten
 - The time elapsed between infliction and record
- ABFO guideline says there may be four types of conclusions regarding bite mark examination. These are:

- Exclusion - The injury is not a bite mark.
- Possible bite mark - An injury showing a pattern that may or may not be caused by teeth could be caused by other factors but biting cannot be ruled out.
- Probable bite mark - The pattern strongly suggests or supports origin from teeth but could conceivably be caused by something else.
- Definite bite mark - There is no reasonable doubt that teeth created the pattern.

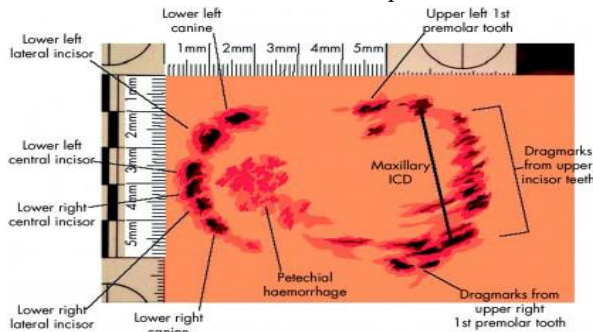


Fig 2 – Example of a bite mark identification

Study of Palatal Rugae (Rugoscopy)

Palatal rugae, the ridges in the anterior part of palate behind incisive papilla, are recognized as a forensic tool in the year 1889 by Harrison Allen. These have different pattern namely curved, straight, wavy, and branched. In the instances, where post-mortem dental identification is not possible, as in edentulous mouths, palatal rugae can be used as supplement. This can be

slightly altered during orthodontic treatment. According to Kapali et al. denture wear, tooth malposition, and palatal pathology can alter the patterns; reliability of these rugae pattern identification is questioned. No two palates are alike in their configuration, there is no bilateral symmetry, and the palatal prints will not change. They serve as an important tool in forensic as they remain consistent in shape, direction, pattern, and unification. Even in third degree pan facial burns 93% palatal rugae patterns are normal.

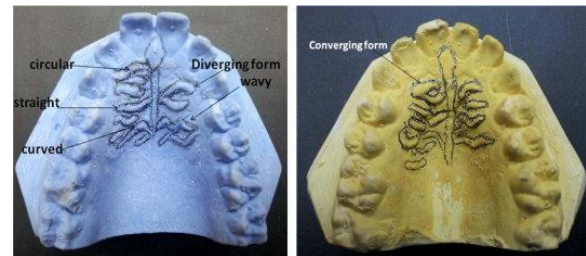


Fig 3 – Different patterns of rugae

The internal position of rugae helps it from getting damaged from heat due to the insulating effect of tongue and buccal pad fat. If surgically altered or removed, they can grow back in the same position in a period of 6 months. While water can alter the usability of fingerprints, the palatal rugae can resist longer, due to their fibrous origin. The events which may contribute to change in rugae are digit sucking, orthodontic persisting pressure, tooth extraction (lateral part only).

Rugoscopy is an effective and reliable tool in identification of individuals, gender determination and ethnicity identification [8]. According to Lysell rugae can be classified based on their size as –

- Primary rugae (>5mm)
- Secondary rugae (3–5mm)
- Fragmentary rugae (2<3 mm).
- Rugae <2 mm is not taken into consideration.

Kapali et al. classified based on shape as straight, curved, circular, wavy, convergent and divergent.

Examination of Lip Prints (Chieloscopy)

The genetically determined elevation, depression pattern in the external surface of the lip is the characteristic of a particular person and is known as

lip prints. It does not change in pattern since birth, and can give significance, in number of people involved, cosmetics used, so socioeconomic status, ethnicity. The exposed part of lip is usually chosen for impression taking. As the lip is vulnerable for change after death, it is better to record the impression within 24 hours.



Fig 4 – Lip Print Identification

Examination of Tooth Prints (Amelogyphics)

It is the study of enamel rod end pattern. The intertwining path of Ameloblast during deposition of enamel, leads to a unique feature. This is reflected on the outer surface of the enamel as patterns of the ends of a series of adjacent enamel rods. This term is coined as Amelogyphics by Manjunath et al. and could aid as an identification tool in decomposed or burned bodies as enamel can resist decomposition. Although the limitations with these above-named methods are less, the discrepancies associated with them ought to be weighed cautiously to make forensic odontology a more accurate, reliable, and reproducible investigatory science.

Mandibular Canine Index (MCI)

Odontometric sex assessment is possible with the help of canine index. Mandibular canine index is found to be more reliable than maxillary. It can be used only as a supplemental tool as the accuracy of sex determination never exceeded 87.5%. This index involves maxillary and mandibular canine width and the inter canine widths and calculation of Canine index (CI) and Standard Canine Index (SCI) using formula. The formulas for calculating CI and SCI are -
 $CI = \text{mesiodistal crown width of canine} / \text{intercanine distance}$
 $SCI = (\text{mean male CI} - SD) + (\text{mean female CI} + SD) / 2$.
 If observed CI is greater than SCI it indicates a male and if less than or equal to the SCI- female.

The measurement of canine index can be made in two ways.

1. Direct technique
2. Indirect – a carbon bite mark is made on a paper and inter canine bite mark width is measured.

CONCLUSION

The orthodontist can play a major role in identification of victims or suspects by maintaining proper diagnostic records. The tragic incidences of past and present have given an insight into the increased importance of forensic dentistry in identification of the deceased or victims of disaster in general [9]. Also, with the expected future increase in disasters due to terrorism and natural disasters such as earthquakes and other causes, the orthodontists with the help of the available software's can use superimposition techniques on lateral cephalograms to mostly rebuild the victims face. It is the duty of all orthodontists to store dental documents as they may help in such unexpected/critical circumstances [10]. All practitioners of various fields must understand the forensic implication associated with his/her profession. Thus, the importance of the forensic field should give the dental clinician yet another reason to maintain proper records in accordance to law and assist legal authorities in the identification of victims and suspects.

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