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Forensic dentistry: Decoding identity through dental evidence

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Abstract
Forensic odontology is the branch of forensic science that plays a key role in cases of age determination, bite mark analysis, child abuse and DNA identification of deceased individuals in cases of disasters with the help of gathering absolute data, handling, through investigation, interpretation and preservation of evidence of dental use. The groundwork of forensic dentistry is based on the peculiarity of every person's oral structure. Cataclysmic events such as airline accidents, natural disasters, terrorist attacks which involves explosive or nuclear attacks emphasized the importance of forensic odontologists in identification of victims. The main aim of this article is to explain different areas of practice used by forensic dentists in identification of found human remains, mass fatalities, cases of abuses and age estimation.

Keywords: Forensic odontology, age estimation, bite mark analysis

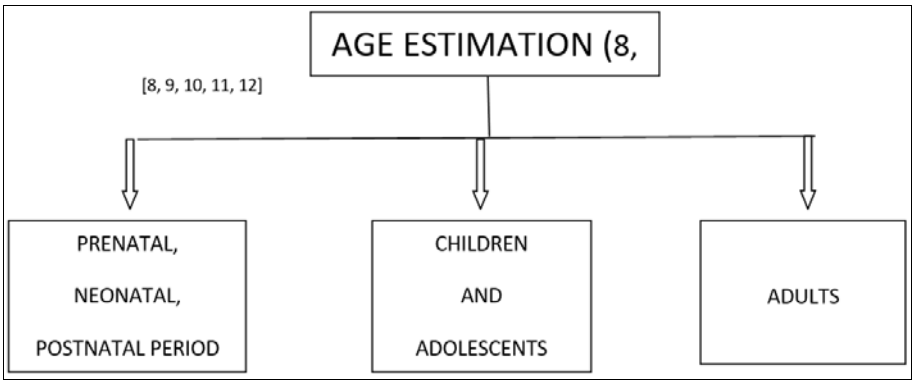
Introduction
The word forensic odontology in itself explains the meaning in which term "forensic" originates from the latin word "forensic" which means of the forum and odontology is the study of the teeth [1]. Forensic odontology is the branch of dentistry, that in the interest of justice, deals with the proper handling and examination of dental evidence. With thorough evaluation and presentation of dental finding, it is used for crime investigation [2, 3].
Identification of an individual is an intimidating task that relys on DNA, fingerprint scanning. Forensic dentists are accountable for different areas of practice in recognisation of individuals which involves identification of found human remains in mass fatalities, evaluation of bite mark injuries, determination of cases of abuse, age and sex estimation, civil cases involving malpractise [2, 4, 5].
This article will describe a collaborative assessment on various methods used in forensic odontolgy that plays a pivotal role in managing through dental records that will help in crime investigations.

Dental identification
Events of death give appropriate information of the identification of a deceased person. Dental records of the decendent plays a crucial role in identification and it is only achievable because the hard tissue can withstand high temperature without substantial loss of microstructure [3].
The American Board of Forensic Odontology 1986, classified dental identification into four types based on the comparison of ante-mortem and post-mortem data [4, 6, 7].

Conclusion	Reasoning
Positive Identification	Ante-mortem and post- mortem data match each other, no major differences scrutinized
Possible Identification	Similarities exist between ante-mortem and post-mortem data, but explainable differences exist due to missing information.
Insufficient Identification	Available ante-mortem and post-mortem data is minimal due to which identification is indeterminate
Excludes Identification	The data contains unexplainable differences that indicates a mismatch.

Age Estimation

Dental age estimation is a crucial part of forensic dentistry that uses morphological, radiographic, histological and biochemical methods to examine age changes in teeth [3, 4, 7].



Age estimation in prenatal, neonatal, postnatal period

- Observation of Tooth Mineralization.
- Neonatal Line
- If present, indicate a live birth
- Measurement of dry weight mineralized tooth cusps
- 6 month child IU - 60gms
- Newborn- 0.5gms
- 6 month after birth- 1.8gms

Age estimation in children and adolescents

- **By Tooth Eruption:** Restricted to deciduous teeth as their eruption is under genetic control. Eruption of permanent teeth depends on oral environment, arch space etc.
- **By Calcification:** Observed for several years using radiographs in permanent teeth
- **Schour and Massler's Method:** 20 chronological stages of tooth development are described from 5 months IU until 21 years of age and age is assessed by comparing stages to radiographs
- **Demirjan's Method:** Assessment of mandibular left side teeth. Demirjan provided different maturity scores for each tooth for different development stages. The score of all teeth are added to obtain total maturity score with the help of formula given by Demirjan, score is converted to obtain age.

Age estimation in adults

Gustafson's method

- Based on histological and morphological changes of teeth
- The age changes assessed are:
- Attrition- A
- Loss of periodontal attachment- P
- Secondary dentin deposition- S
- Cementum deposition at Root apex- C
- Root resorption at apex- R
- Dentin Translucency- T

Each regressive changes are assigned different grades from 0-3 and adding these scores 'X' is obtained.

$A_n + P_n + S_n + C_n + R_n + T_n = X$

Formula for age estimation= 11.43+(4.56 x X)

Dentin Translucency

- Bang and Ramm measured translucency of different age groups
- Root translucency increases as age advances
- Major disadvantage involves the irregularity of translucent and non translucent zones that makes it difficult to measure the length

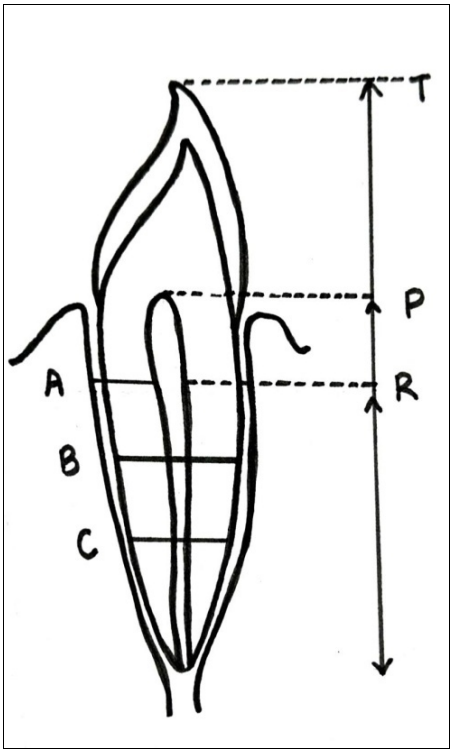
Incremental lines of cementum

- Kagerer and Grupe used acellular cementum incremental lines to estimate age.
- Hypomineralised bands give indication of certain events of life such as pregnancy, skeletal trauma etc. which facilitates identification.

Radiographic method of Kvaals

Kvaal used panoramic radiograph of six teeth to include the length- width ratio of the following [11].

- Pulp-root length (P)
- Pulp-tooth length (R)
- Tooth- root length (T)
- Pulp- root width at CEJ (A)
- Pulp-root width at mid root level (C)
- Pulp-root width at mid point between level C and A (B)
- Mean value of all ratios excluding T (M)
- Mean value of width ratio B and C (W)
- Mean value of length ratio P and R (L)



Age Estimation Formula = 129.8- (316.4* M) - [66.8*(W-L)].

Biochemical indicators of age

- Aspartic Acid racemization, mitochondrial DNA, collagen crosslinks are the reliable methods of biochemical age estimation. The partial conversion of L-form into D- form until equilibrium is achieved is known as racemization.
- D/L ratio in aspartic acid from enamel and coronal dentin can be applied to calculate age [12].

Bite marks

Bite mark is considered as a primitive type of assault. Mac Donald in 1974, defined it as "A mark caused by the teeth either alone or in combination with other mouth parts." [13]. Bite marks are caused by humans, animals and it is often associated with sex crime, violent fights, child abuse [14]. Size, Shape, Pattern of biting edges of teeth depict unique pattern of biter [2, 7].

Classification of bite marks

1. **Cameron & Sims Classification:** Based on the type of agent producing mark and material exhibiting it. Agent is either Human or Animal and materials may include skin, foodstuff etc.
2. **Mac Donald's / Etiological Classification**

- Tooth pressure marks- direct application of Occlusal or incisal surface of teeth.
- Tongue Pressure marks- marks on tissue when tongue presses against rigid areas- 'Suckling'
- Toothscrape marks- caused due to scraping of teeth across the material.

3. **Webster's Classification -** Based on marks of foodstuff

- Type 1 - food item fracture readily with limited tooth penetration
- Type 2 - Fracture of food item with considerable penetration of teeth
- Type 3 - Complete penetration of food item

Characteristics of Bite Marks

- Circular/ elliptical mark with central area of ecchymosis are caused due to upper and lower arches.
- Individual features such as rotation, spacing etc. make the bite marks distinct [15].

Evidence collection for investigation of Bite mark [16, 17]

1. Case demographics
2. Extra-oral and intra-oral photographs, UV light photographs are taken as they helps to analyze deep damage and capture particular characteristics of teeth like size, shape etc.
3. Visual examination to know the type of injury
4. Saliva swab with the help of cotton swab moistened with distilled water to obtain epithelial cells as this proves to be the excellent source of DNA
5. Impressions to record the Occlusal relationships
6. Study casts

Conclusion	Inference
Definite Biter	Concordance of sufficient distinctive, individual characterstics to confer uniqueness within population under consideration
Probable Biter	Bite mark show some degree of specific suspect's teeth, similarity of some characteristics, absence of any unexplainable indiscrepancies
Possible Biter	Few matching points, non-specific similarities
Not the Biter	Bite mark and suspect's dentition not consistent

[18, 19]

Lip prints

Lip Prints are the characteristic pattern of the individual and these imprints are produced by grooves. The study of it is referred to as Cheiloscopy. These grooves/lip prints are supposed to be individualistic and remain uniform throughout life [20].

Classification of lip prints

1. **By Tsuchihashi and Suzuki in 1970**

- Type 1 - Vertical grooves that run across entire lip
- Type 1' - Vertical grooves but do not cover entire lip
- Type 2 - Branched grooves
- Type 3 - Intersected grooves
- Type 4 - Reticular grooves
- Type 5 - Grooves that cannot be morphologically differentiated [21].

2. **Clauco Martin Santos [22].**

a) Simple Type

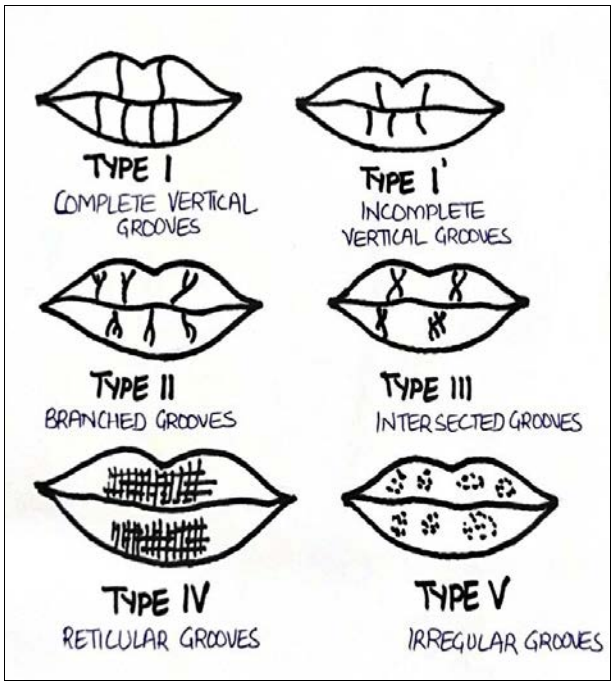
- Straight lines
- Curved lines
- Angled lines
- Sine Shaped lines

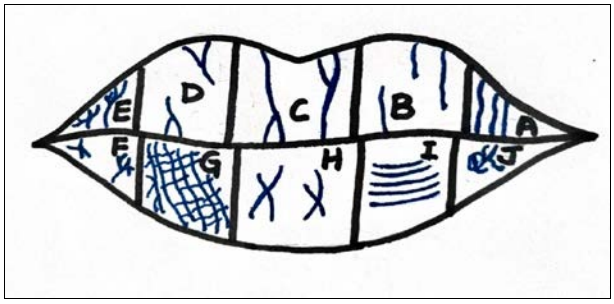
b) Composite Type

- Bifurcated
- Trifurcated
- Irregular

3. **Renaud in 1973**

A. Complete Vertical
B. Incomplete Vertical
C. Complete Bifurcated
D. Incomplete Bifurcated
E. Complete Branched
F. Incomplete Branched
G. Reticular Pattern
H. X or comma type
I. Horizontal
J. Other forms (ellipse, triangle) [23].





Collection of lip prints

- Traditionally, lipstick applications leave behind colored traces of lip prints.
- Collection from the surface like glass, clothing, cutlery may not leave visible marks sometimes but they can be visualized using aluminium powder or silver metallic powder etc.
- Direct photography of prints [24].

Method Of Recording

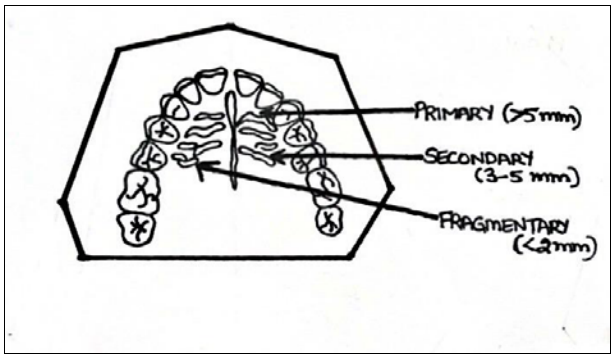
- Lips are divided into quadrants and a horizontal line is used to divide upper and lower arch and a vertical line divides right and left sides.
- In each quadrant, the grooves are assessed and the lip print is recorded using the classification [24, 25].

Palatal rugae identification

Palatal rugae are the relevant source for human identification due to its uniqueness to an individual. The rugae pattern seldom changes with age. The study is referred to as Palate Rugoscopy [26]. Palatal rugae are the ridges present on the anterior part of the palate, on each side of the mid-palatal raphe behind incisive papilla [26, 27].

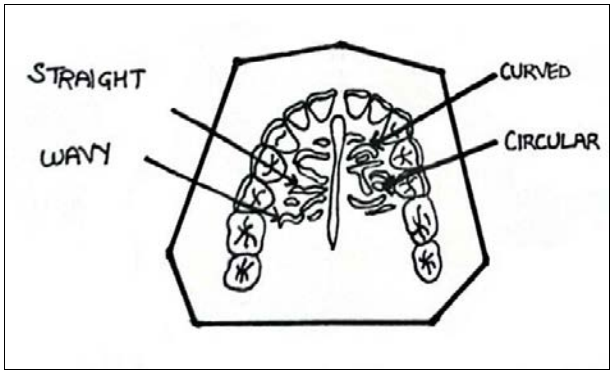
Rugae are divided into three categories, classified by Lysell. They are measured in straight line from mid-palatine raphe to terminals laterally [28].

1. Primary rugae (>5mm)
2. Secondary rugae (3-5mm)
3. Fragmentary rugae (2-3mm)



Kapali's classification was based on the shape of rugae [29].

- Straight
- Curved
- Wavy
- Circular



Palatal rugae are the most stable anatomic landmark which plays a significant role in assessing the tooth movement during orthodontic treatment. It can also be used for identification purposes in cases of mutilation due to its stability [30].

Identification from dental DNA

Teeth are an excellent source of DNA. A routinely applied technique used in forensic identification is PCR that allows amplification of even degraded DNA. DNA from teeth facilitates comparison with ante-mortem samples of descendent such as hair from a comb, epithelial cells to be matched with parent or siblings for positive identification [4, 17].

Best source of dental DNA are the tooth pulp, dentin and cementum. A fine drill is used to access pulp from crown and with the help of endodontic file, biological material is collected and cementum is scraped using sterile blade. Thus, retaining morphology of the tooth [31].

Conflict of Interest

Not available.

Financial Support

Not available.

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