ROLE OF DENTIST IN FORENSIC ODONTOLOGY

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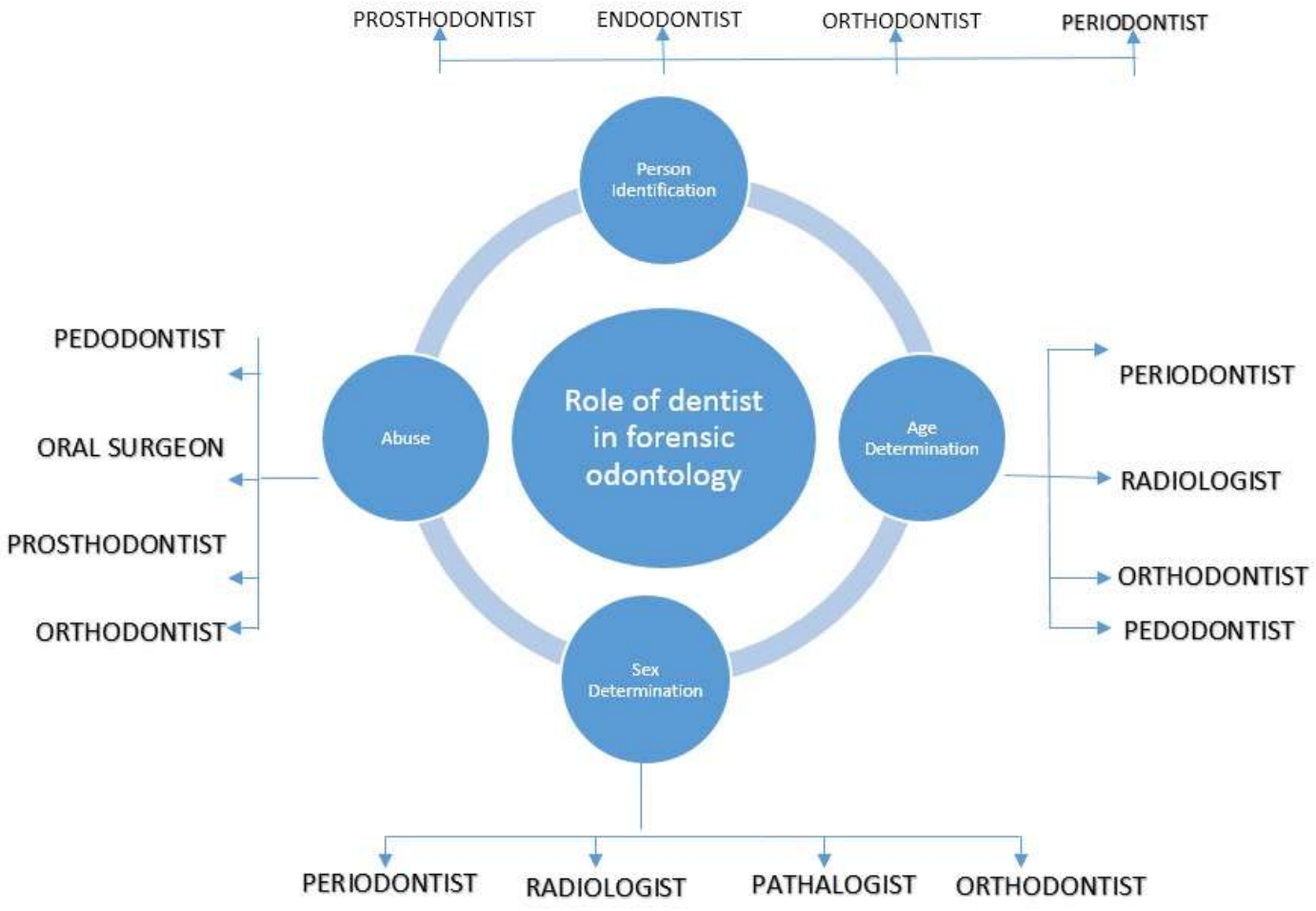
***Abstract*: Forensic odontology applies dental principles to legal issues that analyses dental evidence for human identification. They can aid in identifying the person by using previous dental records and present dental findings. For personal identification Denture labelling has been a useful aid in the identification of the Victims of fatal disasters, misplaced dentures in hospitals, nursing homes, and institutions, The pattern of palatal rugae is considered unique to an individual and can be used as reliable method in postmortem cases. Even if the individual's previous records are not available, dentists can identify the sex and age by using the current postmortem findings. Age estimation is done by 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 and Histologically by cemental lines, noenatal line and quantification of aspartic acid for a positive identification.Measuring maxillary canine arch width and mandibular crown arch of mandibular canine.Sex determination using DNA in dental calculus will be quite useful for forensic application. Oral pathologist and Pedodontist helps physician to evaluate the bite marks due to abuse. Dental professionals have a major role to play in keeping accurate dental records and providing all necessary information so that legal authorities may recognize malpractice, negligence, fraud or abuse, and identify unknown humans.**

***Keywords*: Forensic, Odontology, Age estimation, Gender Identification**

Introduction

The roles of Dentist in Forensic Odontology is to deal with the management, examination, evaluation and presentation of dental evidence in criminal or civil proceedings, all in the interest of justice.



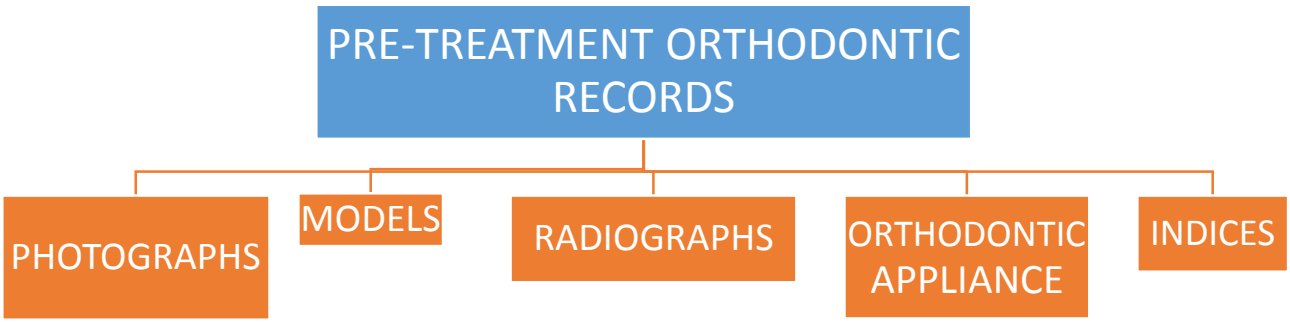
Flow chart -1 shows how a dentist contributes in Forensics

The identification of dental remains is of primary importance when the deceased person is skeletonized, decomposed, burned or dismembered. The principal advantage of dental evidence is that, like other hard tissues, it is often preserved after death.(1)
Reasons of identification (2) –

1. Criminal cases: An investigation to a criminal death truly begins after positive identification of the victim
2. Monetary: Life insurance claims in murder victims solely depends on positive person identification.
3. Closure: In cases of a missing person correct identification of the body helps in sorrowful relief to the family.
4. Burial: In many religions burial in certain geographical sites are allowed only when the person identity is known.

1. PERSON IDENTIFICATION

The central dogma of dental identification is that postmortem dental remains can be compared with the antemortem dental records for which Orthodontist (Flow chart 2), Prosthodontist, Periodontist, Endodontist and plays an important role in forensic odontology.



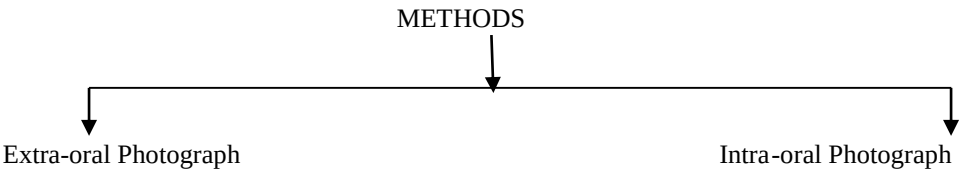
FLOW CHART 2: Orthodontic records used in Forensic Odontology

PHOTOGRAPHS

The Antemortem data is compared with postmortem findings. In the absence of dental documentation, photographs of the smile play an important role in this comparison.

Thus photographs can be used for the following:

a. Direct Visual Identification



The extra oral photographs can be used to directly identify the face in recognizable faces.
While 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. [1(3)]

b. Smile photograph analysis:
The identification of unknown human by smile photographs that show specific characteristics of each individual has found wide acceptance all over the world. During the autopsy the photographs of the smile were used by comparison of the ante and postmortem images gave accurate and useful information not only about dental state but also the anatomical features surrounding the upper and lower anterior dental arches.[3(4)] FIG.1 shows ante-mortem & postmortem comparison of smile photographs

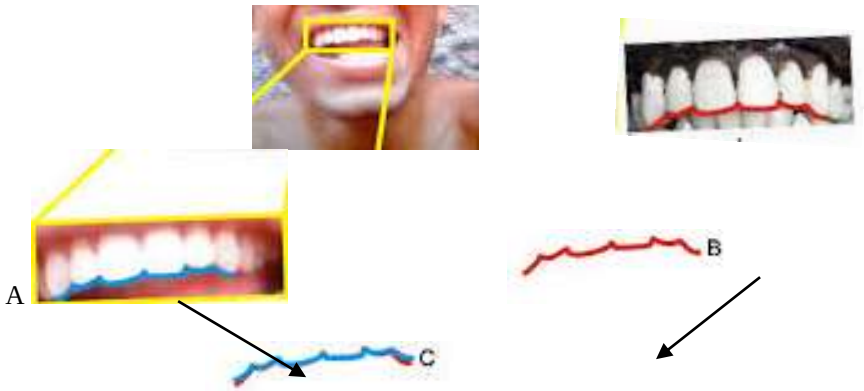


Fig. 1-A(antemortem smile);B(postmortem intraoral photograph);C(superimposition of A and B)

MODELS

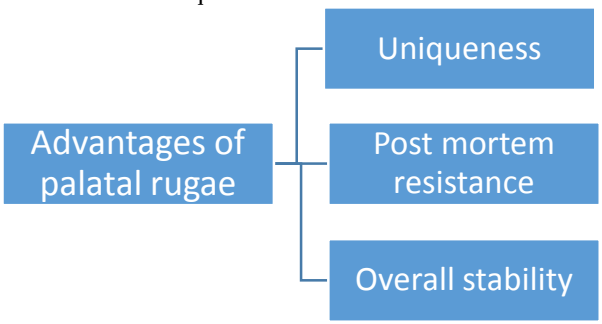
A 3-dimensional view of the maxillary and mandibular arches through models, help us assess certain features of the malocclusions, morphology and anatomy of teeth such as enamel abrasions, attrition and fractures. Palatal rugae pattern analysis & shape and size of the tooth can be used as a tool for person identification through models

PALATAL RUGAE

Palatal rugae comprise about three to seven ridges radiating out tangentially from the incisive papilla. Venegas et al determined the shape, size, number and position of the palatal rugae. (5)

In males, wavy pattern is the most prominent type (62%) ,while in females ,it was curvy rugae pattern(54%).The pattern of these rugae is considered unique to an individual and can be used as reliable method in postmortem cases. Percentage accuracy in male was 48% and female was 24% wth total accuracy of 36% (6).

The pattern of these rugae is considered unique to an individual and can be used as reliable method in postmortem cases. (7)



FLOW CHART 3: Advantages of palatal rugae

The anatomical position of the rugae inside the mouth—surrounded by cheeks, lips, tongue, buccal pad of fat, teeth and bone—keeps them well-protected from trauma and high temperatures.

RADIOGRAPHS

Sassouni has suggested use of measurements in postero‑anterior and lateral radiographs of the skull to match the ante and postmortem radiographs, which includes-

- Bigonial width
- Cranial height (from mastoid to vertex)
- Bimaxillary breadth
- Height from bigonial width to temporalcrest
- Maximum cranial breadth
- Frontal sinus breadth
- Incisor height
- Facial height.

Currently, there are three main comparison methods of personal identification used in Hungarian forensic practice:

- Examination of dental records
- Superimposition of photographs
- Comparison of radiographs

Person Identification by Dental Implants

In incidents where a victim has been incinerated, there may be loss of fingerprint detail and denaturing of DNA. Although extremely durable, tooth loss will also occur with extreme temperatures and the characteristics of recovered dental implants, if any, may be the only physical identifying data available.[8]

The physical properties of high corrosion resistance, high structural strength, and high melting point, suggest the retention of intact implants following most physical assaults.[9]

Berketa et al.[9] did a study to ascertain if the batch number was still identifiable following intense heat exposure in a furnace.

Denture labelling

Marking dentures has been well documented as a useful aid in the identification of the following: Victims of fatal disasters, misplaced dentures in hospitals, nursing homes, and institutions, as well as patients who suffer from unconsciousness or psychiatric problems such as traumatic or senile loss of memory.(10-14)

SURFACE MARKING (A)
• Personal identification details are printed on paper with a laser printer & is placed into the designated space in palatal aspect, and then covered with an auto polymerizing acrylic resin.
ENGRAVED FIXED RESTORATIONS(B)
• The incorporation of an identification mark on a cast partial denture framework would ensure identification even in more extreme situations, such as fires and traffic accidents.(15-16)
LENTICULAR CARDS(C)
• It is a technology in which the lenticular lens is used to produce images with an illusion of depth, morphology or the ability to change or move as the image is viewed from different angles
BAR CODING(D)
• Automatic identification using barcodes incorporated into dentures has been developed and can contain large amounts of data. Use of clear acrylic is recommended for the same.(17-18)
MICROCHIPS(E)

TABLE 1 Shows Different Methods of Denture Labelling

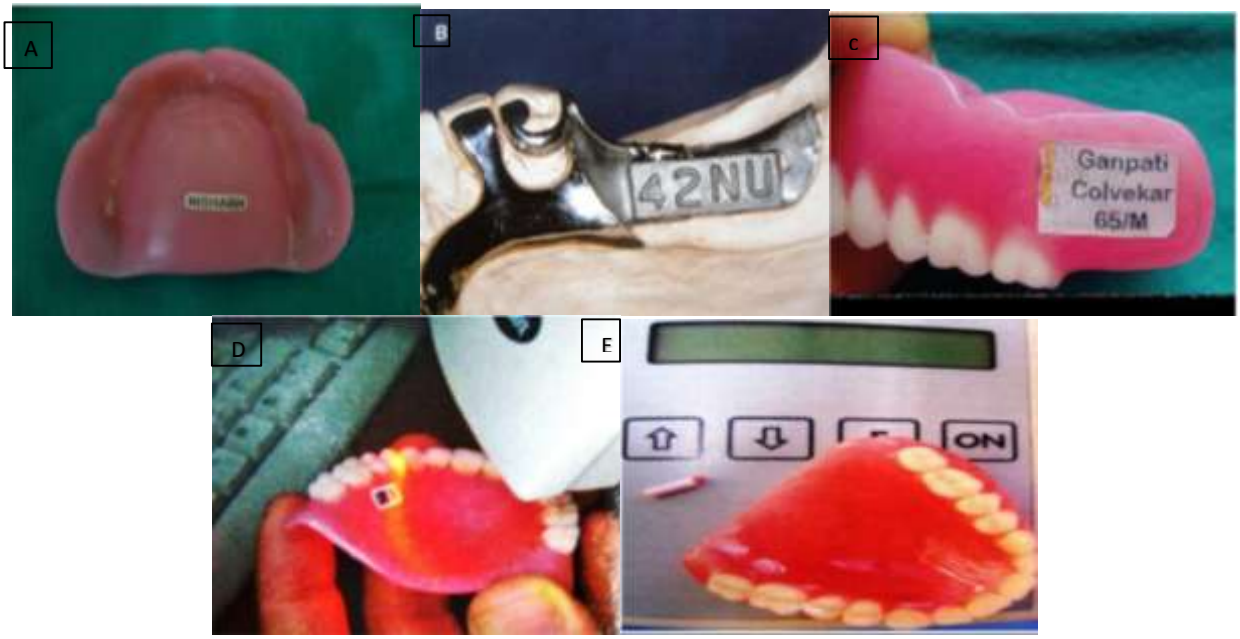


FIG 2 Showing denture labelling by different techniques

In Australia, the Nursing Home Standards require that dentures of residents be "discreetly labeled" and marking of all dentures is recommended by the Australian Dental Association.[19] Denture marking is regulated by law only in Sweden and Iceland.[20] Unlabeled dentures have been recovered from patients and then fitted to casts retained by the treating dentist or laboratory, and this has been an accepted method of identification.[21)

It has been observed in numerous incinerated bodies the lower lingual posterior, and the upper palatal posterior portions of the dentures are usually spared. These sites become the choice of areas for the marking.[22-24]

If the ante mortem records of the condition like aggressive periodontitis or other pathological diseases are well preserved, Periodontist can definitely see the post mortem record of the condition that would serve as an important tool in forensic evidence.

AGE ESTIMATION

According to the technique of investigation: (25)

- Clinical or visual
- Radiographic
- Histological

i. **Clinical or visual method**: Visual observation of the stage of eruption of the teeth.

a. Schour and Massler method

Schour and Massler in 1941 introduced a chart explaining the development and eruption of human dentition.[14] They studied the development of deciduous and permanent teeth in seven stages, i.e., prenatal (4.5–5 months utero), neonatal (at birth), infancy (birth to 6 months), childhood (2–6 years), early grade school (6–10 years), prepubertal period (10–12 years), and adulthood (12–21 years) using histological and radiographical

stages, i.e., prenatal (4.5–5 months utero), neonatal (at birth), infancy (birth to 6 months), childhood (2–6 years), early grade school (6–10 years), pre-pubertal period (10–12 years), and adulthood (12–21 years) using histological and radiographical method.[26] They also compared the calcification stages of teeth
on radiographs with the standards. The proposed numerical chart describes 21 chronological steps of teeth development ranging from 5 months in utero to 21 years of age. The American Dental Association (ADA) has periodically updated these charts and published them in 1982.[27)

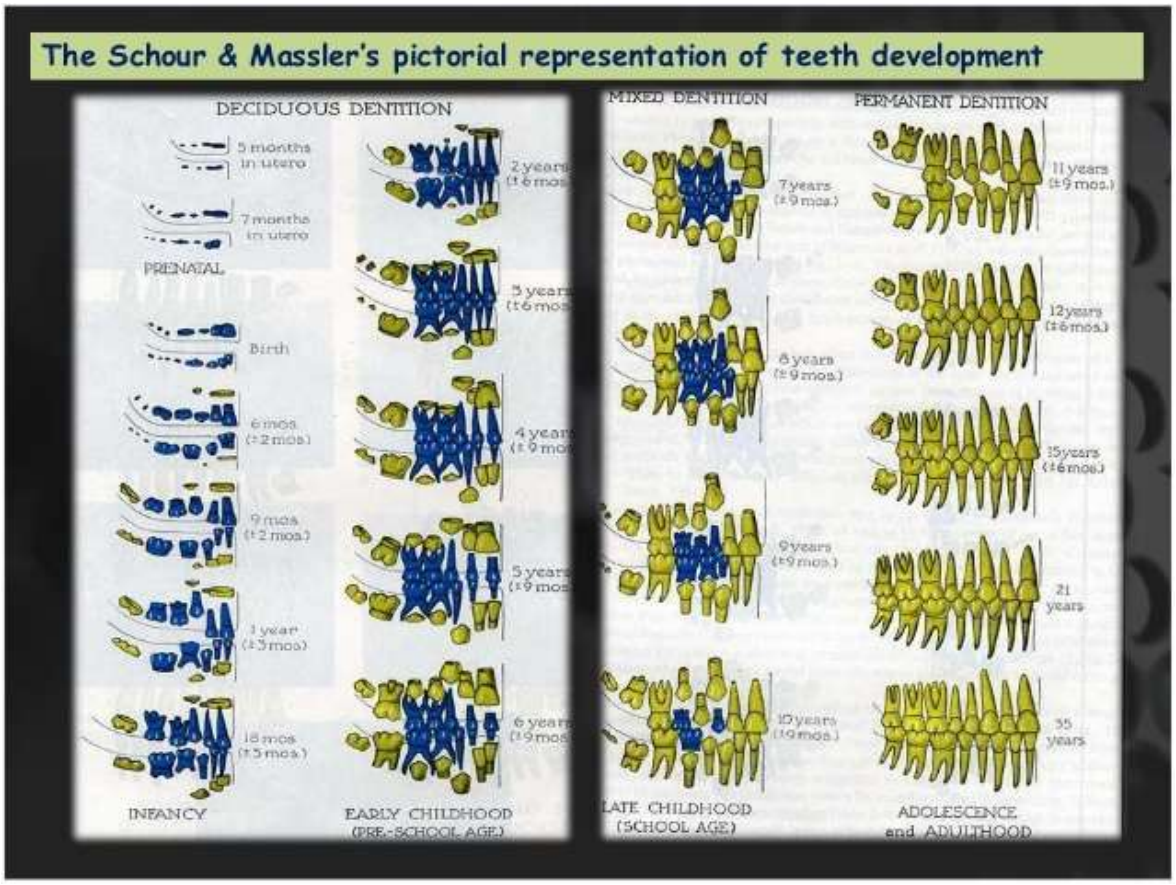


Figure 3: Schour & <assler chart explaining development & eruption of human dentition

The development of deciduous and permanent teeth in seven

b. Inter-canine width

Inter-canine distance method is usually recorded for recognition of a child's dentition to an adult dentition as the distances <30 mm belong to a child and a distance above that to an adult.[28]

ii. RADIOGRAPHS

Various radiographic dental records like OPG's, IOPA, Lateral cephalograms, Hand-wrist radiograph, CBCT are used as essential and supplemental diagnostic aids.

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.

The evaluation criteria for the OPGs for both of dentists were compiled from the literature.[29,30]

- Presence of primary teeth in mouth
- Mixed dentition period
- Presence of third molar teeth in mouth
- Apexogenesis and maturation stage of third molar teeth
- Enamel attrition level of teeth
- Width of root canal and pulp cavity
- Level of alveolar bone resorbtions were considered during age estimation

The size of dental pulp cavity gets reduced as a result of secondary dentin deposition, and measurement of this reduction could be used as an indicator of age. Kvaal et al.(31) proposed a method based on indirect measurement of secondary dentin deposition by measuring pulp radiolucency on periapical radiographs. This method is very useful in ascertaining whether a person in question is under 18 years of age or above. , it cannot be applied if the teeth are rotated, attrited, carious, or associated with any periapical pathosis.

The estimation of age using pulp and tooth area ratio (PTR) on maxillary and mandibular canines

Indian formula was: age = 64.413 – 195.265 × PTR

(Given by- Babshet et. al)(32)

HANDWRIST RADIOGRAPH

Age estimation by handwrist radiograph can be done by(33) –

1. Greulich–Pyle

Greulich-pyle method uses an atlas containing ideal photographs of hand-wrist radiographs of children of various age groups (till 18years for female & 19years for male), separate sets for male & female exists in this atlas. Comparing atlas photographs with the left wrist radiographs of the victims help defining the age.

2. Tanner–Whitehouse

Tanner-Whitehouse method uses developmental level of each bone which is categorized into stages A to I to determine age. A numerical score is given to each stage of development for each bone individually & total maturity score is then calculated by summing up. Separate comparison for male & female score is done to determine age.

3. Singers method

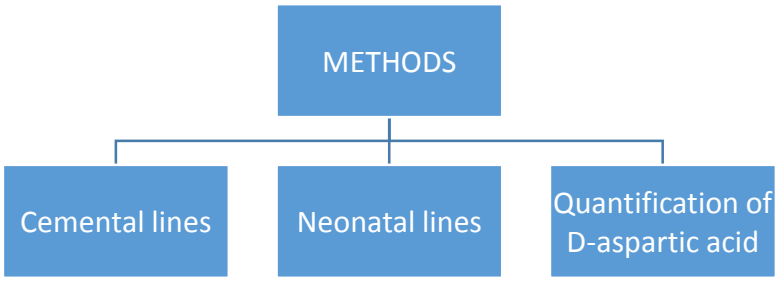
Singers on the other hand asses calcification stages of carpal bones to determine the age characterized as early, pre-pubertal, pubertal onset, pubertal, pubertal deceleration & growth completion.

4. Fishman

Fishman method uses 4 anatomical sites located on thumb, third finger, fifth finger& radius to propose 11 discrete adolescent skeletal maturity indicator which cover entire period of adolescence.

iii. HISTOLOGICAL METHODS

Histological method technique is more appropriate for post mortem situations. It is also significant in estimation of age of early development of dentition.



FLOW CHART 4

a) BY EXAMINATION OF THE NEONATAL LINES : (34)

A method described by Boyde (1963)**.** The method involves a microscopic examination of the incremental markings found in longitudinal ground sections of the teeth, and relies on the identification of the neonatal line in teeth forming at birth.

b) BY EXAMINATION OF THE CEMENTAL LINES(35)

Tooth Cementum Annulations (TCA) may be be used more reliably than any other morphological or histological traits of the adult skeleton, for age estimation.

Number of incremental lines (n) = X / Y.

Where X is the total width of cementum (from dentinocemental junction to cementum surface) and Y is the width of cementum between the two incremental lines

c) BY QUANTIFICATION OF D-ASPARTIC ACID(35)

Amino acid racemization is used as biochemical indicator of age. Aspartic acid has a rapid rate of racemization (high in root dentin). It gets spontaneously converted from one type (L-aspartic acid) to another (D-aspartic acid) with increasing age. Thus, there is a constant change in the ratio of L- and D-aspartic acid at different ages. This D/L ratio may be used for age estimation. This method estimates age within ± 3 years of actual age.

Age estimation using the dentition can be grouped into 3 phases:
1. Age estimation in prenatal, neonatal and early postnatal child
2. Age estimation in children and adolescents
3. Age estimation in adults

In prenatal, neonatal/early postnatal period	In children & adolescents	In adults	Biochemical indicators
• Histologic techniques • Neonatal lines • Dry weight • Measurements	• Tooth emergence • Tooth calcification • Modified Demeirjian's method	• Gustafson's method • Root transparency • Third molar formation • Cementum annulations	• Aspartic acid racemization • Radioactive carbon14 estimation

Various methods are utilized for determination of age from dentition.

1. AGE ESTIMATION IN PRENATAL, NEONATAL AND EARLY POSTNATAL CHILD (36)

Determination of age during the development of dentition can be obtained with an accuracy of "plus or minus one year" and during the early part of this period, microscopic examination of teeth may provide the age with an accuracy of "plus or minus few days".

Age Assessment from the Neonatal line:
Neonatal lines are present in both enamel and dentine of deciduous teeth and permanent first molars which indicate the development during the transitional period between intrauterine and extra uterine environments.

Age assessment based on thickness of enamel and dentin from the neonatal line:

Miles (1958)(25)determined age at death by measuring the thickness; of enamel and dentine from the neonatal line and divided it by appropriate daily rate of formation. To give the age at time of death, the measured distance is divided by the appropriate daily rate of formation taken from tables published by Massler and Schour (1941).

2. AGE ESTIMATION OF CHILDREN AND ADOLESCENTS:((37)

1. Odontological age estimation of children and adolescents depends on the eruption of teeth which can be either visual or through radiographic methods.

RADIOLOGICALLY DETERMINED DMF INDEX VARIATIONS FOR FORENSIC AGE ESTIMATION OF YOUNG ADULTS

Olze.A et al (2006) (38)radiologically determined DMF index variations for forensic age estimation in young adults. The variables examined include the DMFT index of all permanent teeth, the DMFT index of all permanent teeth excluding third molars and the DFT index of third molars projecting beyond the occlusal plane.

3. ESTIMATION OF AGE IN ADULTS (ABOVE 20 YEARS): (39)

GUSTAFSON'S METHOD (1950):
Gustafson's method

The first technique for age estimation based on the assessment of certain regressive alterations in teeth was given by Gosta Gustafson in 1947 and 1950. This method is a morphohistological method and is applicable on single-rooted teeth. The age changes are:

- Attrition of the enamel (A)
- Secondary dentin deposit (S)
- Alteration/recession of periodontal ligament (P)

- Cementum apposition (C)
- Root resorption (R)
- Transparency/translucency of dentin (T).

In the method proposed, each of these criteria was scored (n) ranging from 0, 1, 2, and 3 . The grade value of each of the age change is then added which gives a total score (Y). The error of estimation in this method was ±3.6 years as calculated by Gustafson (1947)

FORMULA :
An+ Pn+ Sn+ Cn+ Rn+ Tn= total score (Y) (n = score of individual criteria)
An increase in total score (Y) corresponded linearly with increase in age. Age was estimated using the following equation:[40)

Age = 11.43 + 4.56 × Y (total score)

MALWA POPULATION STUDY (41)

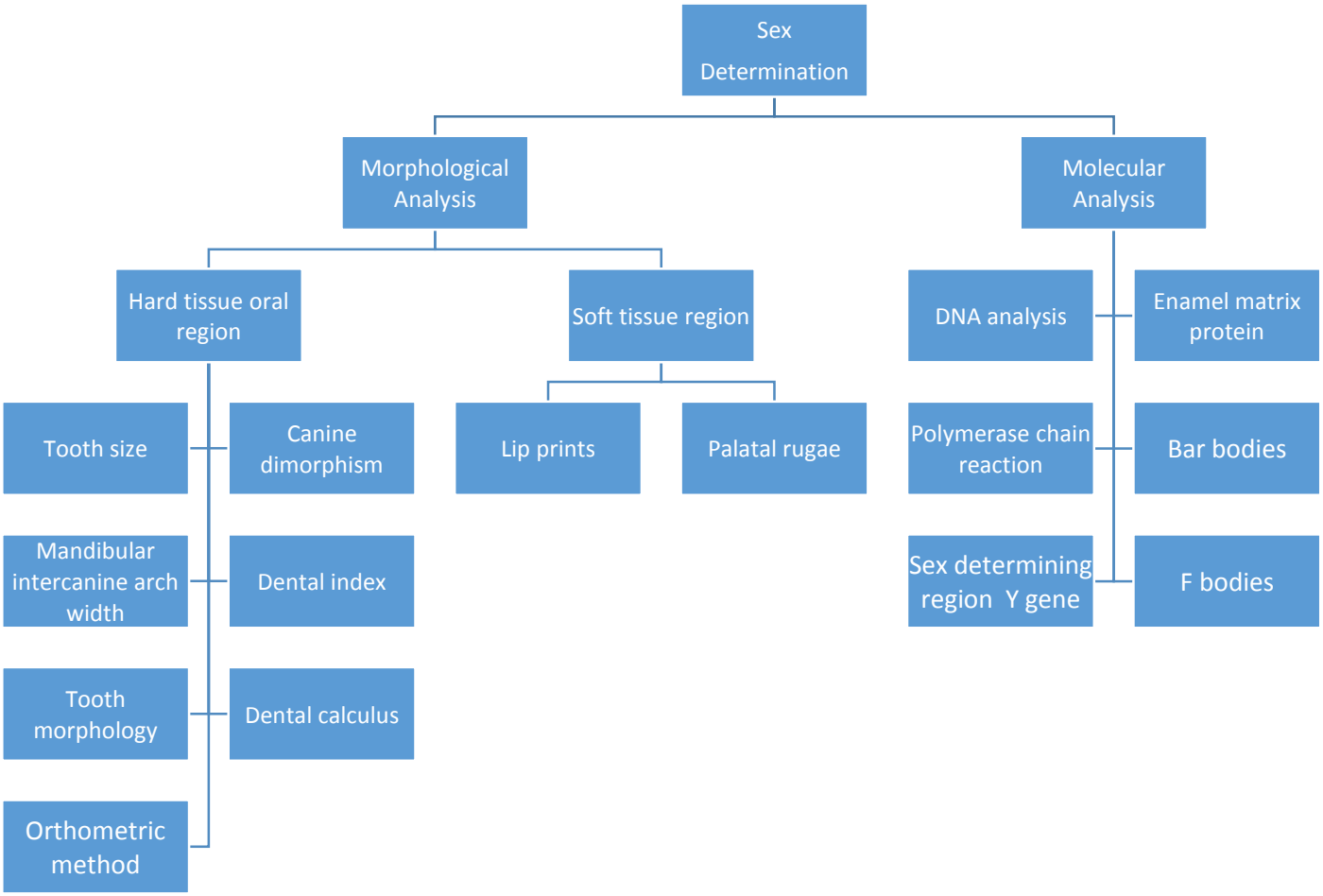
A study is conducted to check the applicability and accuracy of Demirjian's and Acharya's formulas for age estimation on Malwa population
. Acharya's method is more reliable than Demirjian's method in Malwa population and underestimates the age by 0.04 year in male and over estimates the age by 0.74 year in female population.

Method 1: Chaillet and Demirjian's regression formulas based on tooth development of French children (original method)
1. For males, age = (0.000055 × S3) − (0.0095 × S2) + (0.6479 × S) − 8.4583
2. For females, age = (0.0000615 × S3) − (0.0106 × S2) + (0.6997 × S) − 9.3178

Method 2: Acharya's Indian formulas for age estimation (Indian Method)
1. For males, age = 27.4351 − (0.0097 × S2) + (0.000089 × S3)
2. For females, age = 23.7288 − (0.0088 × S2)+ (0.000085 × S3)
Acharya's method is more reliable than Demirjian's method in Malwa population and underestimates the age by 0.04 year in male and over estimates the age by 0.74 year in female population.

SEX DETERMINATION

The determination of sex and ancestry can be assessed from skull shape and form. Radiologist, Pathologist, Periodontist, Pedodontist and Orthodontist contributes to individual characteristics identification



FLOW CHART 5: Various methods of gender identification

HARD TISSUE EXAMINATION

1. Odontometric method

In hard tissue analysis odontometric method involves (a) mesiodistal (MD) dimensions and buccolingual (BL) dimension of teeth (b) mean canine index (MCI) (dental index), and (c) distinct tooth morphology.
Sexual dimorphism exists in the shape and size of the tooth. Tooth size can be measured best during early permanent dentition because it's the stage when the tooth is subject to less external and internal stimuli.[42]
Though studies have concluded that MD dimension to be a better predictor of sex than BL dimension, certain discrepancies occur while measuring the MD dimension due to close proximal contacts. Therefore, both MD and BL dimensions aid in as a more reliable tool in determining sex[43] [Table 2].

Tooth number	MD and BL			
	Male	Female	Male	Female
11	8.9	8.5	7.1	7.0
12	7.0	6.65	6.5	6.2
13	8.3	7.6	8.4	7.9
14	6.9	6.8	9.3	8.9
15	6.7	6.65	9.8	9.3
16	11.0	10.6	11.0	10.9
17	10.4	9.9	11.0	10.7
41	5.5	5.3	6.2	6.1
42	6.1	5.9	6.5	6.5
43	7.2	6.6	7.55	7.4
44	7.1	7.0	7.9	7.6
45	7.4	6.9	8.6	8.2
46	11.1	10.8	10.4	10.2
47	10.5	10.2	10.3	9.9

MD: Mesiodistal, BL: Buccolingual

Table 2. Difference in MD & BL dimension of tooth among Male & Female

Since canine exhibit the greater sexual dimorphism and are also highly resistant to disease and postmortem insults, Rao et al. developed the MCI which was derived as follows:

Mean canine index = Mesiodistal crown width of mandibular canine.
Mandibular inter-canine arch width.

The cut-off point, or standard MCI value, obtained by Rao et al. was 0.274. If the MCI value of a skull specimen is less than or equal to the standard MCI, the individual is categorized as female; a value more than the standard MCI would group the person as male.[44]

Rao et al., (1989) suggested another index, the "mandibular canine index" which gave an accurate indication of sex in the Indian population with an accuracy of 89%.

Dental index

Tooth proportions have been recommended for gender assessment apart from complete tooth size. Hence, Aitchison(1964) put forth the "incisor index" (Ii), calculated by the formula:

Ii = [MDI2/MDI1] ×100,

where MDI2 is the maximum mesiodistal diameter of the maxillary lateral incisor and MDI1 is the maximum mesiodistal diameter of the central incisor. Aitchison found out that this index tends to be higher in males.[45]

Distinct tooth morphology Nonmetric features like – distal accessory ridge number of cusp in mandibular first molar can be used in sex determination. Distal accessory ridge in canine is more pronounced in male compared to female.[46] Female exhibit lesser number of cusp in the mandibular first molar compared to male (distobuccal or distal cusp).[47] This feature can be attributed to the evolutionary reduction in the size of the lower jaw in females.[48]

2. Orthometric method

Orthometric method involves morphology of skull and mandible with a constellation of six traits and frontal sinus dimensions. Williams and Rogers found sex could be predicted correctly in 96% of cases using different features of skull and mandible.[49] Morphology of skull and mandible[44] Constellation of six traits are-

TRAITS USED FOR GENDER IDENTIFICATION			
1.	Mastoid	2.	Supra-orbital ridge
3.	Zygomatic extensions	4.	Nasal aperture
5.	Size & architecture of skull	6.	Mandible gonial angle

TABLE 3: traits used for gender identification

Determination of sex using only these six traits shows accuracy of 94%[44] [Table 3].

	Male	Female
Size/architecture of skull	Big/rugged	Small/smooth
Cranial mass	More blocky and massive	Rounder and tapers at the top
Temporal ridge	More prominent	Less prominent
Supraorbital margin	Round and dull	Sharper
Zygomatic bone	More pronounced	Less pronounced
Mandible	Squared	Rounded
Forehead	Rounded and sloping	Terminates at brow
Cranial mass	Deeper	Less deeper
Superciliary arch	Large and pronounced	Smaller
Gonion	Flared and sharply angled	Less flared
Teeth	Larger	Smaller
Mastoid	Medium - large	Small - medium
Nasal aperture	High, thin sharp margins	Lower, wider rounded margins
Mandible gonial angle	Less obtuse, flared	More obtuse, does not flare

Table 4: Depicts the difference in skull morphology among Male & Female

A digital radiographic study carried out in 2012 on the mandibular ramus indicated that the ramus breadth is the best parameter for sex determination.[50]

Thakur et al., (2013) conducted an anthropological study on the mandibular angle and height of the ramus to test their role in sexual dimorphism, and results showed both these parameters are greater in males than in females.[51]

Sharma et al.,(2016) recently conducted a study on an Indian population and used parameters such as the length of body of the mandible, angle of the mandible and minimum ramus breadth as chief parameters for sex determination.

Mongoloid	**Caucasoid**	**Australoid**	**Negroid**
1. Shovel shaped incisors 2. Greater curvature of incisors 3. Dens evaginatus 4. Five cusp forms of upper molars 5. Extra distolingual root in lower molars 6. Taurodontism 7. Enamel extensions to the furcation area 8. Parabolic archform	1. Narrow arch and crowded teeth 2. Chisel shaped anterior teeth Cusp of carabelli	1. Large arch size 2. Large molar teeth 3. (Megadont) 4. Severe attrition 5. Edge to edge bite 6. Mesial drift of teeth 6. Enamel pearls between roots	1. 1. Small teeth with spacing and midline diastema 2. Supernumerary teeth 2. Rarely impacted third molars 3. Class III malocclusion 4. Open bite 5. Bimaxillary protrusion

Table 5 Showing distinguishing features of various races 52

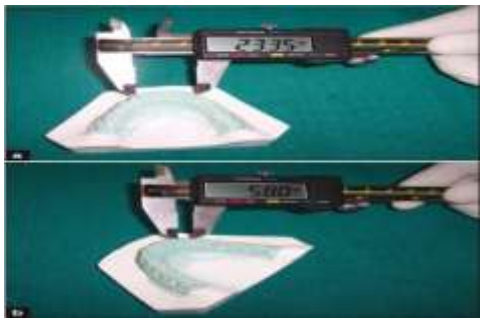
3. Frontal sinus

Frontal sinuses are important parameters in the determination of sex as it presents a distinctive differences in shape, measurements, and symmetry.[53]

Belaldavar et al.,(2016) conducted a study on an Indian population to assess frontal sinus as an aid for sexing and found that the mean values of the frontal sinus height, width and area are greater in males. Moreover, the right frontal sinus was larger than the left sinus in both male and female. The logistic regression analysis indicates that sex was accurately determined up to 64.6%.[54]

4. Canine dimorphism

➢ A study by Anderson and Thompson[55]showed that mandibular canine width and inter-canine distance was greater in males than in females and permitted a 59.7%-66.7% correct classification of sex.



Measuring maxillary canine arch width and mandibular crown arch of mandibular canine

Fig.4

The study In 300 samples (mandibular casts) of people residing in Malwa which included 137 males and 163 female participants.The mean inter canine width in males was 27.41±2.42mm and in females 26.69±1.90mm.(56)
Table 7

	Mean value of	*Mandibular canine*
	Right	Left
Male	7.328±0.470mm	7.381±0.496mm
Female	7.02±0.444mm	6.990±.389mm

6. In studies done between the age group of 12-14 years, the Inter First Molar arch width was more in males as compared to females and the difference was statistically significant.(57)

Arch	*Male*	*female*	*P-value*
Maxillary	50.35mm	48.99mm	<0.001
mandibular	44..75mm	41.90mm	<0.001

7. Pulp samples collected from exfoliated teeth by PCR amplification helps Pedodontist in sex determination.
8. Dental Calculus-

Recognition of DYZ3 region of Y chromosome and DXZ1 region of X chromosome can be done by PCR method. The minimum amount of DNA for sex determination was 3 pg. Sex determination using DNA in dental calculus will be quite useful for forensic application because it can be done without destruction of morphological characteristics of the teeth.(58)

SOFT TISSUE EXAMINATION

1. Lip printing

These lip prints are classified by Suzuki and Tsuchihashi[59]as follows:
• Type I: Clear-cut grooves running vertically across the lip
• Type I′: The grooves are straight but disappear half-way instead of covering the entire breadth of the lip
• Type II: The grooves are branched
• Type III: The grooves intersect
• Type IV: The grooves are reticulate
• Type V: Undetermined.
Vahanwala *et al.* [60]in their study concluded that sex of the individual can be identified by lip prints as follows:

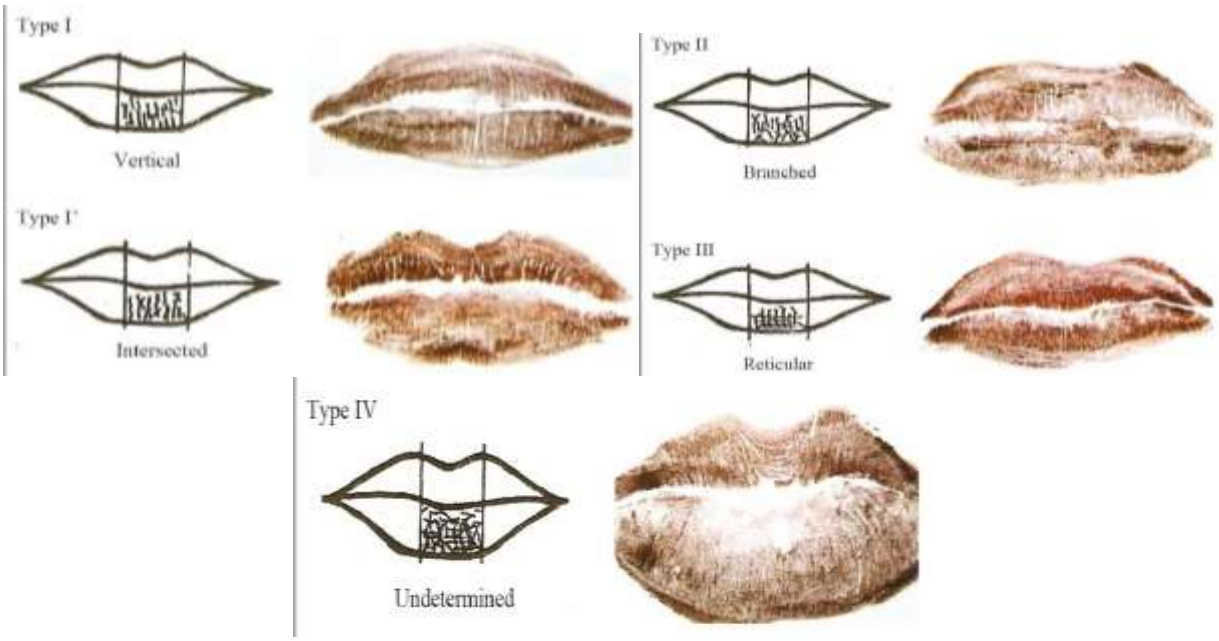


Figure 5: Vahanwala *et al*. classification of lip print

• Type I, I′ pattern dominant: Female
• Type I and II patterns are dominant: Female
• Type III pattern dominant: Male
• Type IV patterns: Male
• Type V varied patterns: Male.

MOLECULAR ANALYSIS

1. DNA Analysis

In a study by Tsuchimochi *et al*. [61] used Chelex method to extract DNA from the dental pulp and amplified it with PCR and typing at Y-chromosomal loci to determine the effects of temperature on the sex determination of the teeth.

Hanaoka and Minaguchi[62] conducted a study to determine sex from blood and teeth by PCR amplification of the alphoid satellite family using amplification of X (131 bp) and Y (172 bp) specific sequences in males and Y-specific sequences in females. It was showed to be a useful method in determining the sex of an individual.

Sivagami *et al*. [63] prepared DNA from teeth by ultrasonication, and subsequent PCR amplification, they obtained 100% success in determining the sex of the individual.

2. Sex determination by Enamel matrix protein

The AMEL gene that encodes for female AMEL is located on the X chromosome and AMEL gene that encodes for male AMEL is located on the Y chromosome. The female has two Identical AMEL genes or alleles, whereas the male has two different AMEL genes. This can be used to determine the sex of the remains with very small samples of DNA.[64]

3. Sex determination using Bar bodies

Presence or absence of X chromosome can be studied from buccal smears, skin biopsy, blood, cartilage, hair root sheath, and tooth pulp. After death it persists for variable periods depending on the humidity and temperature in which tissue has remained.

4. Sex determining region ‘Y’ region

These gene codes for the sex-determining region Y protein, which is responsible for further development as male. Females have 2X chromosomes (46XX), and males have 1X and 1Y chromosome (46XY).

5.F -bodies

Y chromosome contains F-bodies. These F-bodies can be used to identify sex.

Seno and Ishizu[65] carried out the detection of Y chromosome in the nuclei of dental pulp. Their study result was that over 30% of the male pulpal tissue showed positivity for F-bodies.

ABUSE

Comparison of Bite marks represent Dentistry’s vital contribution to forensic science. Oral pathologist and Pedodontist helps physician to evaluate the bite marks due to abuse.

1. BITE MARKS

Bite marks can be found on injured tissue or an inanimate material such as foodstuffs. These may accurately depict the unique pattern of biter's teeth.

Pedodontist should meticulously observe and document bite marks and are encouraged to be knowledgeable about such findings and their significance.[66]

A deciduous dentition bite mark consists of smaller, rounded, bow-like arches with smaller teeth, and spacing between them.[28] Grossly bite marks appear circular/elliptical with central ecchymosis.

Fig 6: HUMAN BITE MARK

The following classes that are of proven significance in practical application regarding bite marks are-(67)

- Class I: It includes diffused bite marks, which is having limited class characteristics and lacks individual characteristics. Such as bruise, diffused bite mark, a smoking ring or, a faint bite mark.
- Class II: This pattern of injury referred to as a single arch bite or the partial bite mark as it has some individual and some class characteristics.
- Class III: This classification includes both individual as well as class characteristics. This bite has great evidentiary value and used mostly for the comparison purposes. The main sites for this type of bite on the body are buttocks, shoulder, an upper arm or the chest. The pressure and deep penetration of tissue is held to record the lingual surface of anterior teeth.
- Class IV: Mainly, avulsion or laceration of the tissues is caused by the bite.

2. CHILD ABUSE

◆ Physical abuse

- The injuries of child abuse occurs in craniofacial, head, face, and neck
  Thorough intraoral and perioral examination is necessary in all cases of suspected abuse and neglect.
  According to some authors the oral cavity may be a central focus for physical abuse

. The lips were the most common site for inflicted oral injuries (54%), followed by the oral mucosa, teeth, gingiva, and tongue.

- There is discoloration of teeth, indicating pulpal necrosis, may result from previous trauma. The gags applied to the mouth can cause bruises, lichenification, or scarring at the corners of the mouth.

◆ Sexual abuse

- The frequent site of sexual abuse is oral cavity in children, oral injuries.

- Oral and perioral gonorrhea may be seen in pre-pubertal children, diagnosed with appropriate culture techniques and confirmatory testing, is pathognomonic of sexual abuse, but not common among pre-pubertal girls who are evaluated for sexual abuse.
- Pharyngeal gonorrhea is frequently asymptomatic.

4. DOMESTIC VIOLENCE

An orthodontist can also help in identification of domestic violence, a few common signs like fracture of teeth, nose , mandible, maxilla and signs of healing fractures seen on radiographs.

A few more signs like:

-Abscessed or non-vital tooth, missing tooth caused by blows to certain areas of the face,

-soft and hard palate abrasions caused by penetration indicating forced sexual act,

-Torn frenum

CASE REPORTS (68)

FIG 7 Postmortem photograph of the mandible

FIG 8 comparision between Postmortem(a) & Antemortem (b) periapical radiograph

A decomposed body found near a river in 2009 was suspected to be of a 30 year old man missing for 15days. Autopsy revealed a nonmetallic restoration in the mandibular left first premolar (#34), a decayed mandibular left second premolar (#35), a metallic restoration in the mandibular right first premolar (#44), and missing molars, PM radiographic examination revealed root canal treatment in the tooth #34. Antemortem radiograph (2008) were collected from the dentist & when compared with Postmortem radiograph radiographs showed the same morphology of the mandibular left first and second premolars, as well as missing molars. Additional similarities were detected when analyzing alveolar bone loss in the region of the mandibular left molars.[Fig.8]

Case report 2

Fig.9 Postmortem radiograph of maxilla of victim

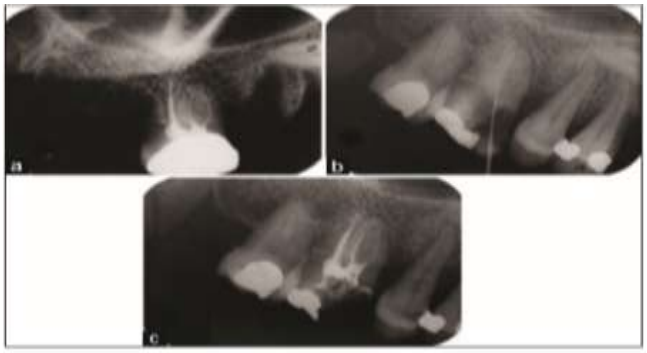


Fig. 10 comparision betwee (a) post-mortem & (b and c) antemortem endodontic radiograph

A body found in the countryside in 2012 showed initial compatibility with a 45-year-old male missing for 60 days. On dental autopsy, only a maxillary right first molar (#16) with a metallic crown was detected [Figure 9]. Radiographically, endodontic treatment of the tooth #16 was detected, as well as an impacted maxillary canine (#13) transversely positioned [Figure 10]. Antemortem periapical radiographs and a clinical file containing details of endodontic interventions performed in 2008 were provided by relatives. AM radiograph positively matched PM findings during comparative procedure leading to positive identification of the victim.

Recently, Silva et al.,[69] 2014, reported a positive human identification based on the combination of unique morphological features of the maxillary sinus; root canal treatment; and missing teeth detected in periapical endodontic radiographs, confirming the forensic potential within this source of evidence.

Limitation for the success of dental identification using endodontic radiographs is the absence of these records or when they are present, they were produced in low quality, or with inadequate technique or the archiving was incorrect.[70] Therefore, the professional has an ethical and legal obligation to produce the dental radiographs (conventional or digital) and stores them properly, especially for use in forensic purposes.[71]

In Brazil, the Dental Code of Ethics requires that dentists archive the dental records of their patients indefinitely,[72]

CONCLUSION

Teeth being the hardest structure in body is usually preserved even after being exposed to extreme condition, with the help of ante-mortem dental records one can compare the anatomy of tooth, root canals present, any restoration if present with the post-mortem reports to see for positive findings for identification.
Oral radiologist has a significant role in age, gender & person identification as well as in identifying the cause of death. Analysis of ante-mortem & post-mortem radiograph to compare anatomical structures & dental restoration plays crucial role in person identification. A pedodontist and an oral surgeon plays an important role in child abuse & neglect, bite mark analysis, criminal & natural death & injuries. Pedodontist is concerned with correct management, examination, evaluation & preservation of child dental evidence.
Periodontists By comparing ante-mortem & post-mortem records of periodontal remains, a periodontist aids in age,gender & person identification. Gingival morphology & pathology along with periodontal ligament morphology plays a key role in person identification.

An oral pathologist analyses dental evidence in interest of justices. Sex determination by exfoliative cytology & age by natal line, thickness of cementum , racemisation of collagen in dentin is also done by pathologist.
An orthodontist can provide vital information majorly in by maintenance of record . The study from models of palatal rugae, canine and molars can help in determination of sex.
Oral & maxillofacial surgeon: an oral surgeon can be presented as a legal witness in legal hearing to provide expert advice in differentiating between accidental trauma & abuse related trauma. Role of Prosthodontist in forensic science is mainly by person identification. Prosthesis provided by the dentist if labelled can be of utmost importance in identification
Thus,a dental professional plays a major role in keeping accurate dental records and providing all necessary information so that legal authorities may identify unknown humans, negligence, fraud or abuse and recognize malpractice.

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