FORENSIC ODONTOLOGY

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Definition

- FDI defined it as *"that branch of forensic medicine which in the interest of justice, deals with the proper handling and examination of dental evidence and also with proper evaluation and presentation of the dental findings".*

HISTORY

- Dr. Oscar Amoedo, Paris, is considered as "Father of Forensic Odontology".
- Dental evidence played a vital role in historical case of identification of Adolf Hitler. His dental findings were compared with antemortem dental records and radiographs .

AIMS

- Management and maintenance of dental records that comply with legal requirements
- Identification of human remains by comparing antemortem and postmortem dental information.
- Collection and analysis of patterned marks (bite marks) on inanimate material or injured tissues.
- Recognition of the signs and symptoms of human abuse.
- Assessment of the age of the person
- Determination of sex of a person

Personal Identification

- Identification is the establishment of a person's individuality
- Defined as 'the characteristics by which a person may be recognized'.
- Methods

Traditional methods

- visually recognizing body
- personal property such as clothing ,jewels etc
- Burned or decomposed can be very difficult for friends and relatives

Physical features:

- Physical features- inherited and acquired
- Inherited feature include ethnic characteristics
- Acquired features- surgical scars, previous fractures, dental restorations.
- Physical features –prone to change over time
- Finger prints - undergo postmortem change
- Dental hard tissues and Dental materials - resistant to post mortem decomposition
- Dental evidence is the method of choice in establishing identity of badly burned, decomposed and skeletal remains

Basis for Dental Identification

- Human Dentition is never same in any two Individuals
- The morphology and arrangement of teeth vary from person to person
- Dental identity -"total of all characteristics of the teeth and their associated structures which, while not individually unique, when considered together provide a unique totality"
- Teeth are relatively resistant to environmental insults after death.

Dental Identification Procedures

- 1)COMPARATIVE DENTAL IDENTIFICATION: attempts conclusive identification by comparing the dead individuals teeth with presumed dental records of the individual.
- ORAL AUTOPSY
- OBTAINING DENTAL RECORDS
- COMPARING POST AND ANTEMORTEM DENTAL DATA
- WRITING A REPORT AND DRAWING CONCLUSIONS

2) RECONSTRUCTIVE GROUPS:

- Attempts are made to elicit age, sex, race, occupation etc leading to a probable identification

3) DNA PROFILING:

This method is used when dental record is not available for comparison. The technique uses modern forensic DNA profiling methods to oral tissues to establish identity

Oral Autopsy

- Autopsy is a highly specialized surgical procedure that consists of a thorough examination of a corpse to determine the cause and manner of death and to evaluate any disease or injury that may be present.
- Performed for either legal or medical purposes

- **TYPES:**

1. Forensic
2. Clinical or pathological
3. Anatomical
4. Virtual

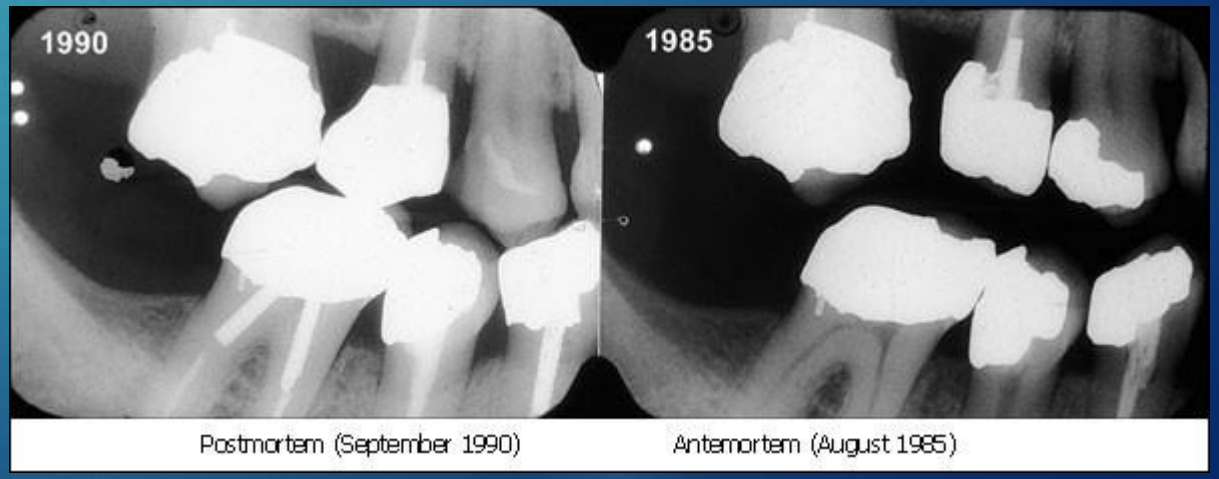
- Critical examination –gender, ethnicity, build, wounds, scars, tatoos
- Photographs, radiographs, fingerprints, finger nail scraping and hair sample may be obtained according to the requirements.
- Oral examination is an essential part of post mortem procedures
- Rigor mortis - use of mouth gags or intra oral myotomy is essential for jaw seperation.
- Thorough examination of soft tissues injuries, fractures, each tooth (carious, restored, missing) should be noticed.

Obtaining Dental Records

- Dental records contain information of treatment undergone and dental status of a person during his/her life time and constitute the antemortem dental data.
- Content of all available records should be transcribed on to the standard ‘interpol antemortem form’ which is colour coded in yellow

Comparing Post and Ante-Mortem Dental Data

- Features compared include tooth morphology and associated bony structures, pathology and restorations
- An individual with multiple dental treatment and unusual features has a better likelihood of being identified than someone with no extraordinary dental characteristics

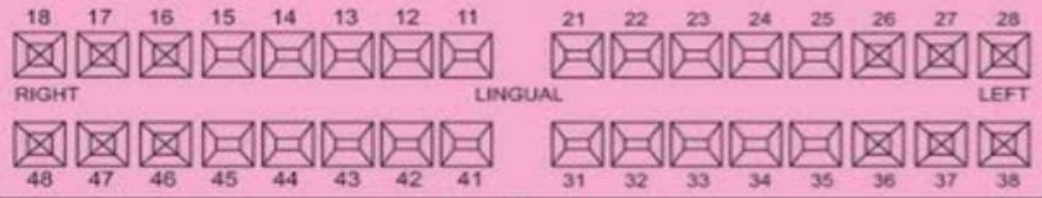


Post-mortem

DENTAL STATUS OF HUMAN REMAINS

Site of discovery :	Date :
Condition of remains :	Body no :
Cause of death :	Ref. F/O :
	Sex

11			21
12			22
13			23
14			24
15			25
16			26
17			27
18			28



48			38
47			37
46			36
45			35
44			34
43			33
42			32
41			31

Occlusion :		Crowns :		Bridges :		Smoker
DENTURES :	P/U F/U P/L F/L	Material : Marks :	TEETH :	Type : Mould : Shade : Type :		
MAXILLOFACIAL PROSTHESIS : IMPLANTS :			CLASPS :			
RADIOGRAPHS : PHOTOGRAPHS :	Bw Clinical	Pa :	Occ.	Lat. Portrait	AP	OPG
SPECIAL TREATMENT	Endo.	Perio	Ortho.	Oral Surgery		C. & B.

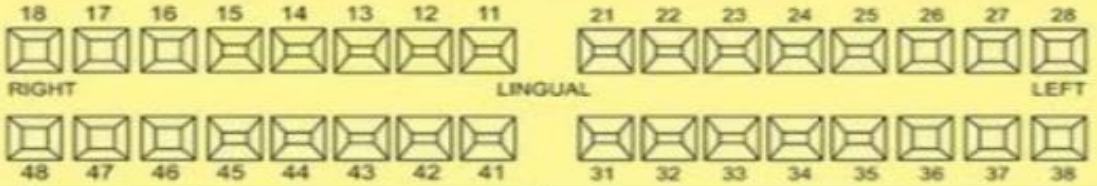
Anti-mortem

DENTAL STATUS OF MISSING PERSON

Date :

Name :	Age :	D.O.B.	M/F
Address : Previous Address :		Dentist School Clinic Hospital	
Occupation :			
Police Reference :		Reference F/O :	

11			21
12			22
13			23
14			24
15			25
16			26
17			27
18			28



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SPECIAL TREATMENT	Endo.	Perio	Ortho.	Oral Surgery		C. & B.

(Sonni. 1)

Writing a Report and Drawing Conclusions

- Positive identification: sufficient uniqueness among the comparable items.
- Probable identification: high level of concordance among datas, may lack radiograph support.
- Presumptive (possible) identification: enough information may be missing from either source.
- Insufficient identification: insufficient supportive evidence.
- Exclusion of identification: clearly inconsistent.

Identification In Disasters

- The term "mass disaster" evokes images of a chaotic event.
- The process of dental identification is same except the magnitude of event is far greater.
- Mass disasters can be classified in one of three ways:

i. Natural
ii. Accidental
iii. Criminal

- Large number of human remains
- Fragmented and
- Incinerated or commingled

- Natural mass disasters include earthquakes, tornadoes, volcanic eruptions, fire storms and floods.
- Principal problem for the dental identification team → environmental infrastructure is often compromised. Dental offices containing antemortem records may be destroyed.
- Accidental mass disasters are most often associated with transportation accidents, fires, industrial and mining accidents, and military accidents.
- Occur over short periods, closed populations

Dental Section

- According to clark, 50% of identification are from dental evidence. So odontology is a part of team.
- Clarke states- 'dental examination is usually done after most other procedures such as photography, fingerprinting, and autopsy'.
- Postmortem unit is responsible for processing the radiograph and also need to arrange photography of teeth.
- Antemortem unit is most difficult. Dentist need to collect as mush information as possible in the shortest period of time.
- Comparison by- IDENTIFY, ODONTID, CAPMI, IDIS softwares.

Interpol has facilitated access to an free use of a software program called 'Plass Data DVI System International'

Reconstructive post mortem (dental profiling)

- Dental profiling includes extracting a triad of information- race, gender, occupation & age.
- According to Sweet and pretty- "The information from this process will enable a more focused search for ante mortem records".

Identification from Dental DNA

- Teeth can resist extreme condition.
- Pretty and Sweet state that teeth are an excellent source of DNA
- Applied technique → polymerase chain reaction- allows amplification of highly degraded DNA.
- This facilitates comparison with a known biological antemortem sample of the decedent such as hair from a comb, epithelial cells from a toothbrush or biopsy specimen.
- Advantage: - DNA pattern can be compared to the parents or siblings, thus facilitating positive identification

Palatal Rugae in Identification

- Palatal rugae are ridges on the anterior part of the palatal mucosa on each side of the mid-palatal raphe behind the incisive papilla
- A useful method of identification in edentate individuals.
- The rugae pattern on the deceased's maxilla or maxillary denture may be compared to old dentures
- Well protected by lips, check, tongue, buccal pad of fat and teeth in incident of fire and high impact trauma.
- Can resist decomposition to an extent
- Unique to an individual.
- Seldom change shape with age and reappear after trauma or surgical procedures.

Classification of palatal rugae:

Acc to lysell,

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

(Rugae <2mm is not taken into consideration)

Analysis of Rugae Pattern

Ohtani and coworkers suggests - high accuracy can be obtained using straight forward visual comparison from dentures.

DENTAL PROFILING

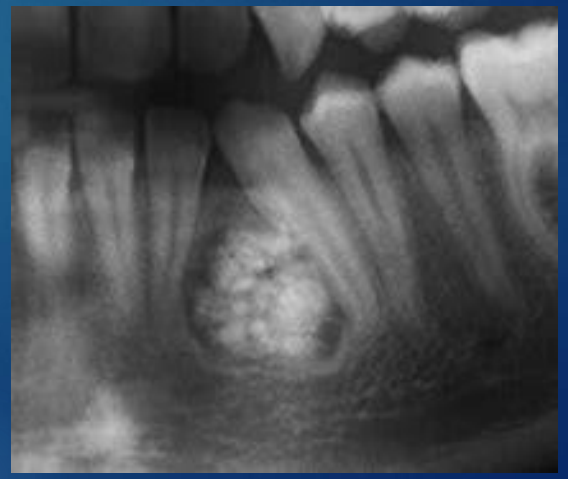
Identifing the Ethnicity from Teeth

- Traditionally, the human species has been categorized into three ‘races’ – Caucasoid, Mongoloid, Negroid.
- Many of the best traits of estimation of race are found in the mid facial skeleton, including the area of nose, mouth and cheek bones.
- Landmarks – a)shape of the cranium, b)lateral projection of zygomatic arches, c)shape and contour of the orbits and d)nasal aperture.

Dental features – metric (tooth size) and non metric (tooth shape).

- **Metric features** are based on measurements - considerably influenced by local environmental factors
- **Non metric** in terms of presence or absence of a particular feature - are more inheritable.

 Shovelling,
 Carabelli's cusp
 3 cusped maxillary 2 nd molar
 4 cusped mandibular molars
 Odontome
Two rooted upper premolar
Two rooted upper molar
Two rooted lower canine



Sex differentiation

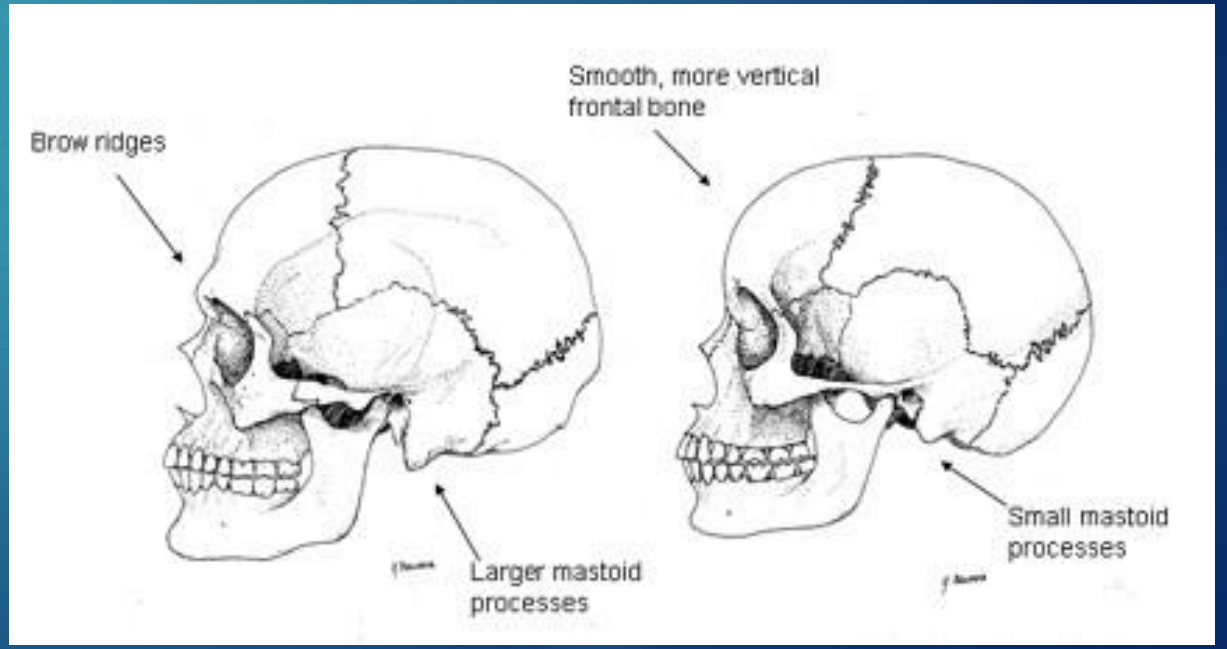
Sex can be determined based on :

1. Data from morphology of skull and mandible,
2. Metric features
3. DNA analyses of teeth

Sexing from craniofacial morphology and dimension:

- Acc. to Botha and Chandra- these features are not reliable until well after puberty.
- Use of multiple features tend to be more accurate.
- Williams and Rogers predicted sex using 6 more traits –

1. Mastoid
2. supraorbital ridge
3. size and architecture of skull
4. zygometic extension
5. nasal aperture
6. mandibular gonial angle- the accuracy was 94%.



Sex differences in tooth size

- Sex differentiated - measuring mesiodistal and buccolingual dimensions of tooth.
- Canines - maximum sex difference
  Mandibular canines - exposed to less plaque, calculus, abrasion from brushing, or heavy occlusal loading & less severely affected by periodontal disease and so they are the last teeth to be extracted with respect to age.
- Premolars, first and second molars as well as maxillary incisors are also have significant difference

Skull features	Male	Female
Size/architecture	Big/rugged	Small/smooth
Frontal and parietal eminence	Small	Large
Forehead	Sloping	Vertical
Supraorbital ridges	Medium to large	Small to medium
Glabella	Moderate to marked curve	Flat or slight curve
Orbits	Squared, low, rounded margins	Rounded, high, sharp margins
Nasal aperture	High , thin sharp margins	Lower, wider rounded margins
Zygomatic arch	Extends	Does not
Occipital	Muscle lines marked	Muscle lines not marked
Mastoid process	Medium to large	Small to medium
Occipital condyles	Large	Small
Glenoid fossa	Deep	Shallow
Foramen magnum	Large and long	Small and round
Palate	Large, U-shaped	Smaller, parabolic
Mandible features		
General features	Large, broad ascending ramus	Small, narrow ascending ramus
Condyles	Large	Small
Shape of chin	Square	Rounded/pointed
Gonial angle	Less obtuse, flares	More obtuse, does not flare
Body height	High symphysis	Low symphysis

SEX DETERMINATION BY DNA ANALYSIS

- Amelogenin (AMEL) –Major matrix proteins secreted by the ameloblasts of the enamel
- AMEL gene coding → located on the X chromosome and the Y chromosomes in humans.
- Females (XX) have two identical AMEL genes but the males (XY) have two non identical genes.
- Preparing DNA from teeth authors obtained 100% success in determining sex of the individual.

Dental Age Estimation

- Dental age is one of the few measures of physiologic development that is uniformly applicable from infancy to late adolescence
- Age estimation using the dentition may be grouped into 3 phases.

1. Aging in prenatal, neonatal and early post natal
2. Age estimation in children and adolescents and
3. Age estimation in adults

Age estimation in prenatal,neonatal and early post natal children

- Primary tooth germ forms→7 th week in utero (IU)
- Enamel formation of deciduous teeth →1 st year.
- Permanent first molar → germ formation →3.5 - 4 months IU.
- Age estimation in this group - very accurate.
- It makes use of histological techniques, which enable observation of tooth mineralization up to 12 weeks before it is actually apparent on radiographs.
- The neonatal line - indicator of birth.

Age estimation in children and adolescents

- Two events – A) tooth emergence or eruption and B) tooth calcification.
- Deciduous teeth: emergence →genetic control→6M- 2.5 years.
- Permanent teeth: under the influence of the intra oral environment, being affected by infection, arch space and premature tooth loss.
- Methods: 1) tooth calcification 2) Demirjian's method 3) value of 3 rd molars

- Evaluation of radiographs to assess tooth calcification is a much better alternative, since:

1) Calcification can be observed from radiographs for a period of several years.

2) It is not altered by local factors

3) The study of tooth calcification also let us assess age at periods when no emergence takes place (2.5-6 years and > 12 yrs).

- Advantage- a)simple, b)easy to master • Age estimation - accurate.
- Dental calcification - better indicator of age in first two decades of life

DEMIRJIAN'S METHOD

An age estimation method that assesses mandibular left side teeth.
Tha calcification of the teeth was divided into 10 stages and numbered '0' to '9'

THIRD MOLARS IN AGE ESTIMATION

- Valuable indicator of age in the age group of 16-23 yrs.
- When all 4 third molars have completely calcified, the chances of the individual being 18 yrs old is 96.3% and 95.1% for males and females respectively.
- When only one or two third molars present, the lower third molars are the best predictors of whether an individual is 18 yr old.

AGE ESTIMATION IN ADULTS

- Age estimation in adults is challenging when compared to younger age groups - “are influenced not only by the age of the individual, but also by numerous endogenous and exogenous factors, such as disease, nutrition and physical strain”.
- Methods:

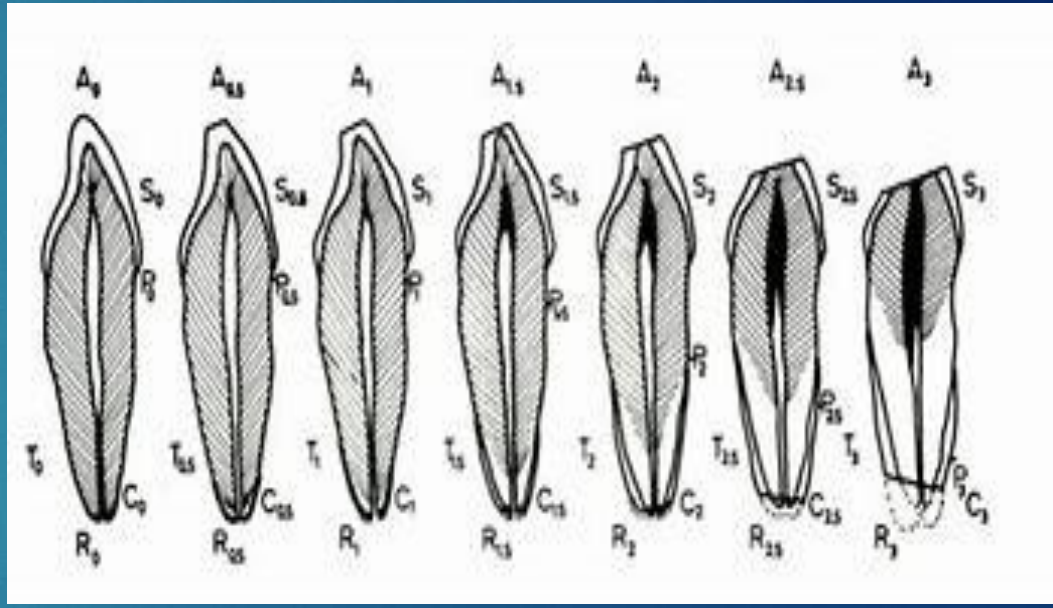
1. Gustafson’s method
2. Root Dentin translucency
3. Incremental line of cementum
4. Pulp to tooth ratio

Gustafson's method

- In 1950, Gosta Gustafson developed a method for age estimation based on morphological and histological changes of the teeth

- Assessed regressive changes such as:

1. Amount of occlusal attrition (A)
2. Coronal secondary dentin deposition (S)
3. Loss of periodontal attachment (P)
4. Cementum apposition at the root apex (C)
5. Root resorption at the apex (R)
6. Dentine translucency (T)



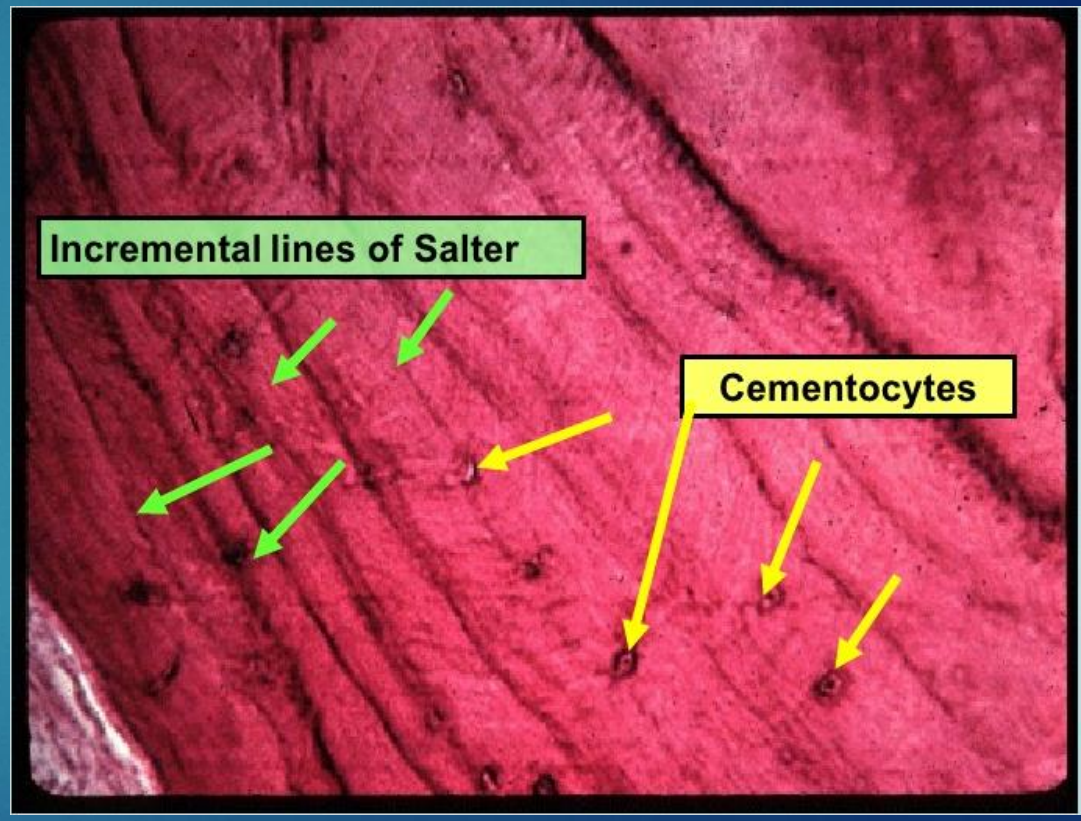
Age was estimated using the formula **11.43+(4.56×X)**

Root Dentin Translucency

- Root dentin → translucent → 3 rd decade of life
- Begins at the apex and advance coronally.
- ↓ Diameter of dentinal tubules - ↑ intratubular calcification - ↑ translucency.
- Johnson- recognized it as best to age estimation.
- Bang and Ramm- root translucency increases with age.

Incremental Lines of Cementum

- Kagerer and Grupe-- Acellular cementum incremental lines are used in estimation.
- Mineralized unstained cross sections of teeth, preferably mandibular central incisors and third molars are used.
- Author Claims accuracy to within 2-3 years of actual age.
- Hypomineralized bands in the incremental line — indicates pregnancy, skeletal trauma and renal disorders which can be related to persons life-history → facilitating identification.

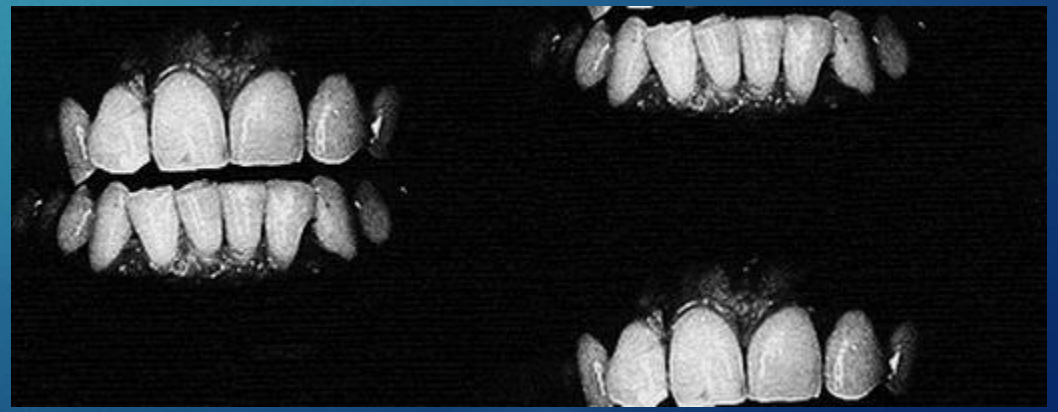


Pulp-to-Tooth area ratio

- Measuring the area of pulp chamber /root canal and the tooth area of canines on radio graphs and calculate theis ratio is known as Pulp-to-Tooth ratio.
- The method is based on principle of age related secondary dentin deposition ans as age increases area of the pulp chamber/root canal reduces which is reflected in decrease in Pulp-to –Tooth area ratio or PTR.
- Linear regression formula used in Indians Age = 64.413-(195.265×PTR)

BITE MARKS

- Bitemarks have been defined by MacDonald as a "*mark caused by the teeth either alone or in combination with other mouth parts*"
- ABFO defines bite-marks as "a pattern left in an object or tissue by the dental structures of an animal or human,"
- During sexual attacks including sexual homicide, rape and child sexual abuse, bite marks are clustered around parts of body associated with sexuality.



Classification of Bite Marks

Mac Donald's Classification:

i. Tooth Pressure Marks: Marks produced on tissues as a result of direct application of pressure by teeth. These are generally produced by the incisal or occlusal surfaces of teeth.
ii. Tongue Pressure Marks: When sufficient amount of tissue is taken into mouth, the tongue presses it against rigid areas.
iii. Tooth Scrape Marks: These are caused due to scraping of teeth across the bitten material. They are usually caused by anterior teeth and present as scratches or superficial abrasions.

Webster's Classification

- Type 1- food item fractures readily-limited tooth penetration eg- hard chocolate
- Type 2- considerable food penetration eg- apple & other firm fruits
- Type 3- complete penetration of food item with slide marks-eg cheese

Bite Mark Appearance

- **Type of injury**
- Compression of the skin surface due to tooth pressure during a bite initially causes indentations.Indentations,while ideal for bite mark analysis ,seldom persist for more than a few minutes unless the victim is dead.
- It is followed by brief period of oedema over the bite mark,which usually obscures the bite mark.Once it subsides,subcutaneous bleeding becomes apparent.These are referred as contusion or bruises

Identifying the injury as a Bite Mark

- **Gross features**:
- circular/elliptical mark - upper & lower arch
- central area ecchymosis - sucking action
- **Class features**: differentiate b/n tooth type
- incisors – rectangular
- canines - triangular
- premolars + molars
- spherical/point shaped
- **Depends on attrition**
- Individual features: fractures/rotations/spacing

Site of Bite Marks

- • Females are usually bitten - breasts, abdomen, thighs, buttocks and pubis, while
- Men are usually bitten - back, arms, shoulders, chest and penis.
- In cases of self-defense the victim can bite on the hands and arms of an assailant

Bite Mark Investigation

- Bite mark cases have to be dealt step by step in the following way:

1. Description of bite marks
2. Collection of evidence from the victim
3. Collection of evidence from the suspect
4. Bite marks comparison

I. Description of bite marks:

Both in the living and deceased victims the following vital information should be recorded.

- **Demographics:**

- Name, age, sex, race, case number, date of examination, and name of the examiners should be recorded.

- **Location of the bite mark:**

- Anatomic location, contour - flat, curved or irregular and state the tissue characters
- Skin - fixed or mobile.
- Underlying tissue - bone, cartilage, muscle or fat.

➢ Shape of the bite marks:

• round, ovoid, crescent or irregular in shape.

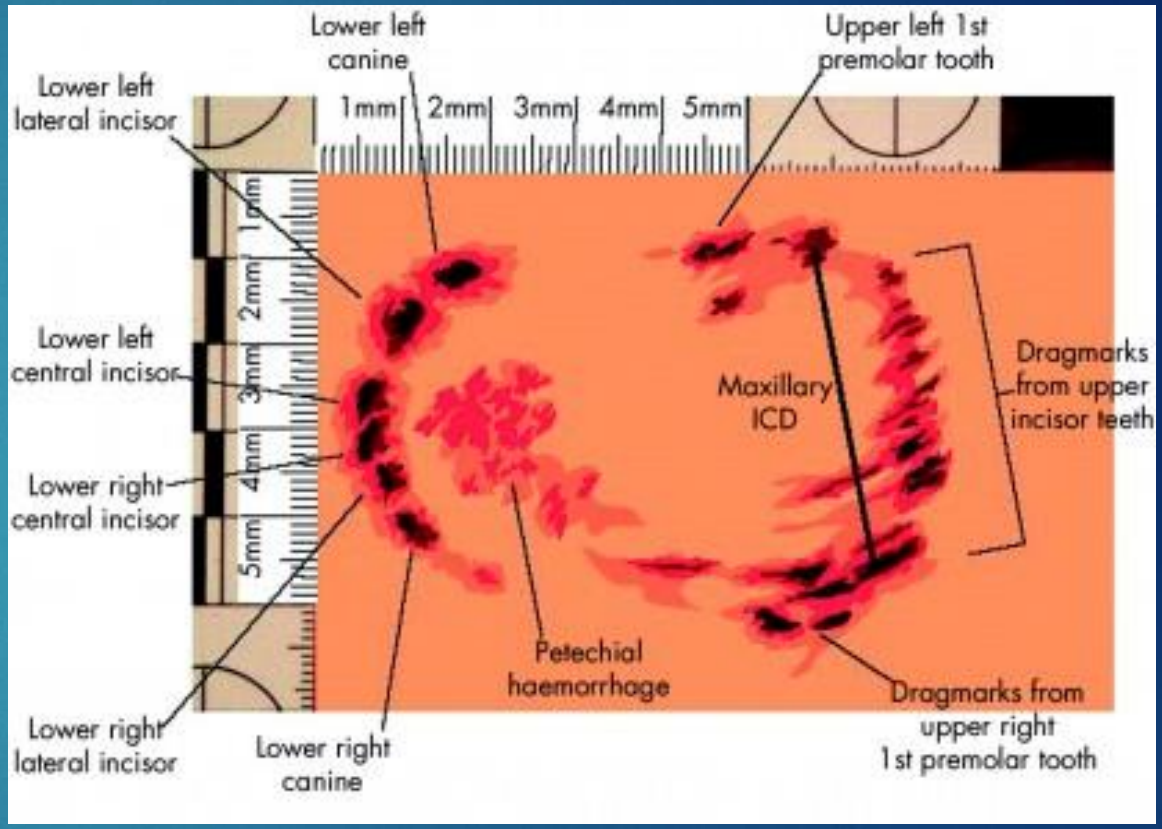
➢ Color of the mark

➢ Size of the mark:

Both vertical and horizontal dimensions should be recorded in metric system.

➢ Type of injury:

Petechial hemorrhage, Contusion, Abrasion, Laceration, Incision, Avulsion



II. Data collection from the victim:

Steps in the examination of the victim:

A. Visual Examination

- Type of injury,
- Contour & texture,
- Physical appearance (color and size), location
- If the victim is dead, visual examination must be done before an autopsy.

B. Photographs of the bite marks should be made immediately.

1. Orientation photographs
2. Close-up photographs

C. Salivary swabbing:

- Saliva deposited on skin may have WBCs and sloughed epithelial cells which may be a source of DNA, enabling direct link to the suspect

D. Impression of bite mark

- Rubber base material such as vinyl polysiloxanes with dimensional stability should be used.

III. Examination of the suspect:

• History of dental treatments after or just before the bite mark has to be noted.

➢ **Photographs**:

• Full face, frontal, occlusal and lateral views of the dental arches should be taken.

➢ **Examination:**

• TMJ status, facial asymmetry, muscle tone, maximum opening of mouth, deviation while opening and closing movements, Tongue movements, periodontal status should be noted. Special attention should be given to the arrangement of dentition

➢ **Saliva swabbing should be performed**

➢ **Upper and lower dental models should be prepared.**

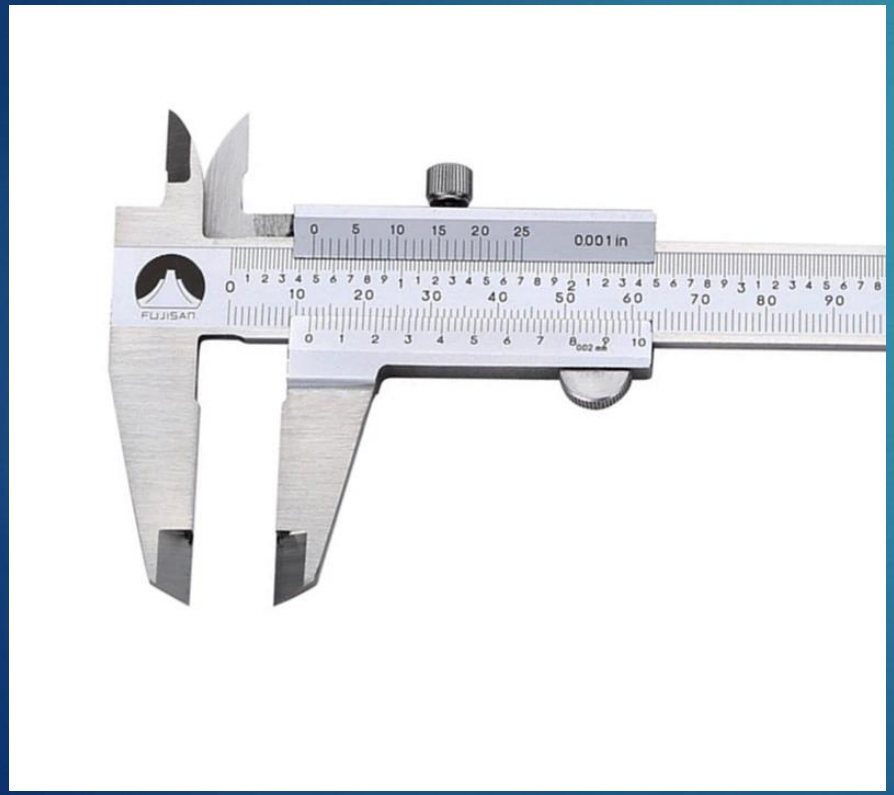
IV. Evaluation of evidence

- While evaluating the bite mark first the cause of the mark has to be determined, since bite marks may be caused by nonhumans or humans.

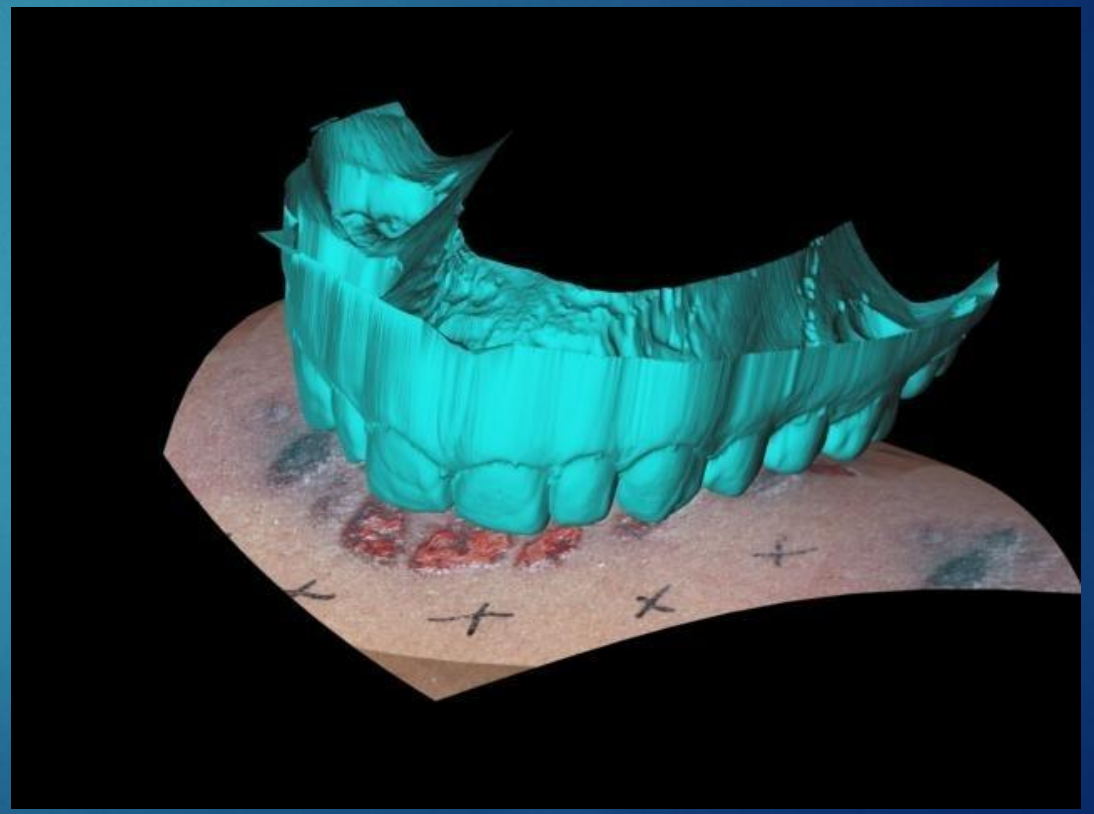
BITE MARK ANALYSIS AND COMPARISON

- **Metric analysis**

Vernier calipers



Computer Digitalisation Method



Pattern Association

- **Direct method-** suspects model are placed directly over the bite mark photograph
- **Indirect method-** incisal and occlusal edge of the suspect's teeth may be traced on to clear acetate and superimposed on life-size bite mark photographs.

CONCLUSIONS OF BITE MARK ANALYSIS

By Levie

Positive identification: characteristic matches between the bite mark pattern and the pattern of the suspect's teeth.

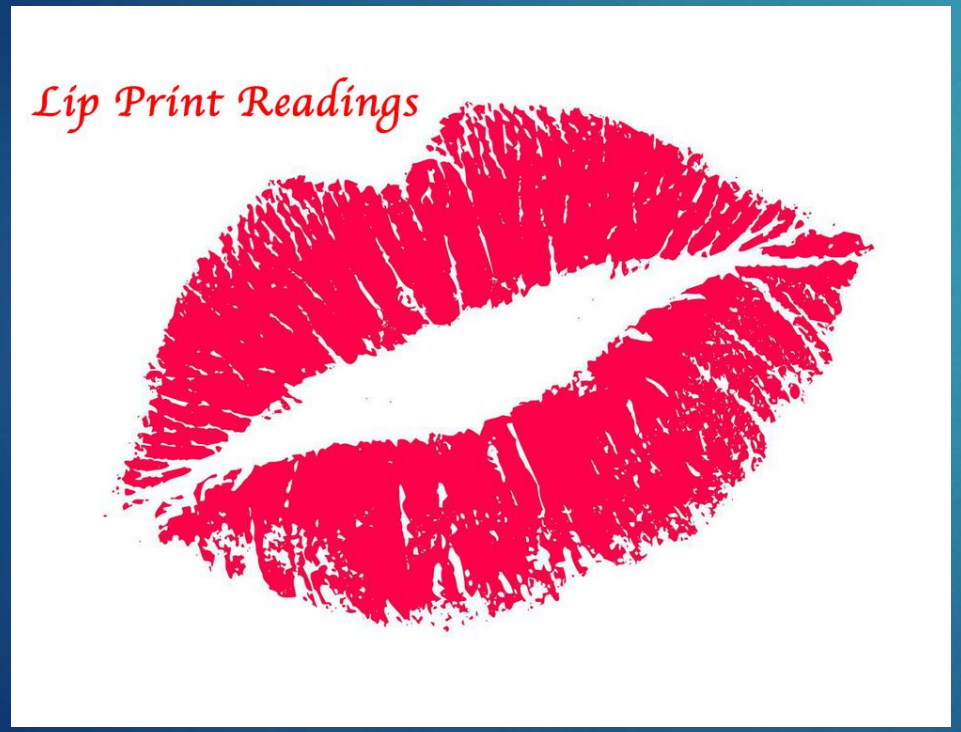
Possible identification:

- This implies that although the suspect's teeth could have made the bite mark, there are no characteristic matches to be absolutely certain.

Excludes identification:

- When features on the bitemark indicate that the suspect's teeth could definitely not have caused them, it represents a Negative or exclusion.

LIP PRINTS



CHEILIOSCOPY

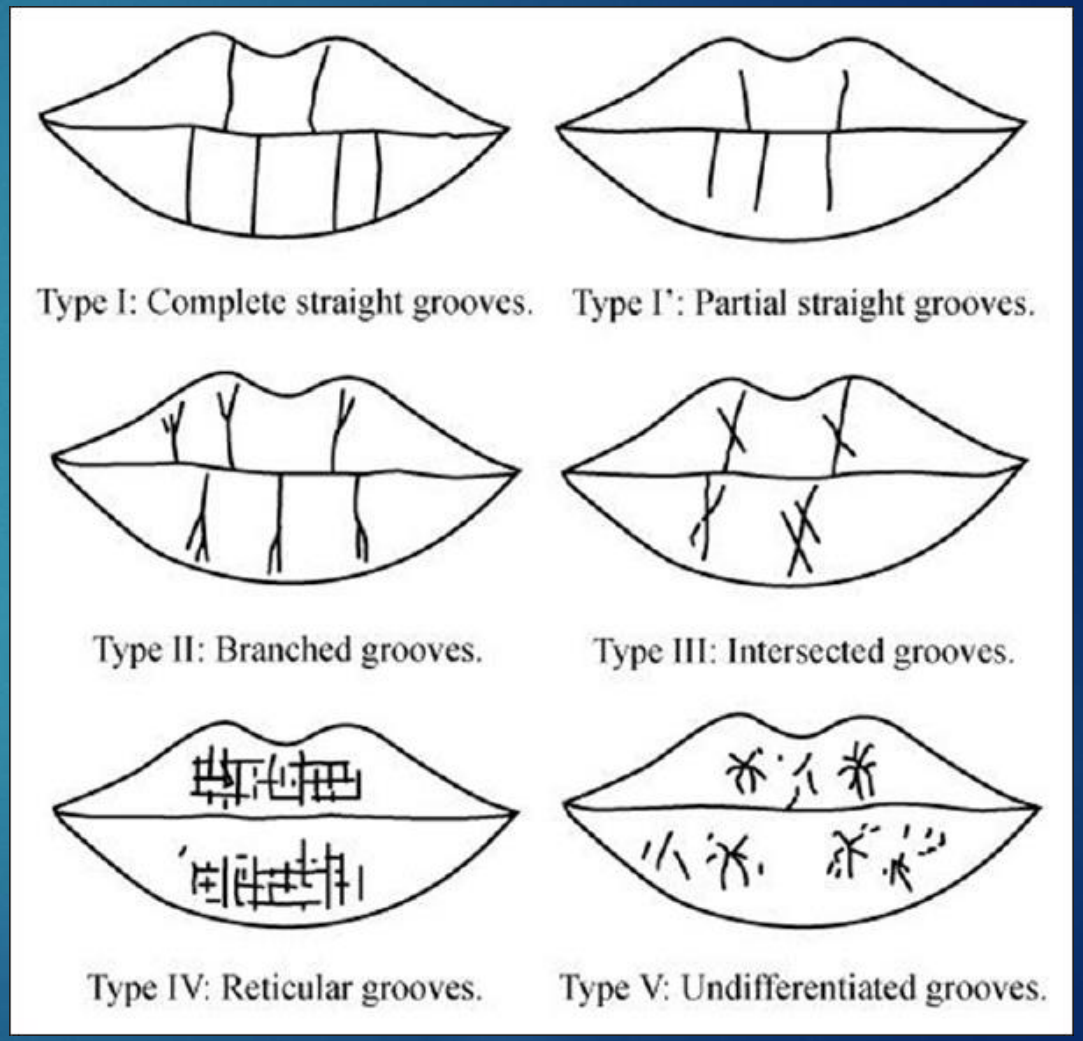
Lip Prints:

Cheiloscopy is a forensic investigation technique that deals with identification of humans based on lips traces.

- Lip prints have to be obtained within 24 hours of time of death to prevent erroneous data that would result from post mortem alterations of lip.
- Pattern depends on whether mouth is opened or closed.
- Closed mouth position - well defined grooves
- Open position - ill defined and difficult to interpret.

Tsuchihashi Classification

- Type I - Clear-cut vertical grooves that run across the entire lip
- Type I' - Similar to Type I, but do not cover the entire lip
- Type II - Branched grooves
- Type III- Intersected grooves
- Type IV - Reticular grooves
- Type V - Grooves that cannot be morphologically differentiated.



- Lip prints are usually left at crime scenes and can provide a direct link to the suspect.
- Traditionally, the use of lipsticks was essential to leave behind colour traces of lip prints.

Disadvantage of Lip Print Investigation:

- Major trauma to the lips can result in scarring.
- Surgical treatment rendered to correct any abnormality also affects the size and shape of the lips, thereby altering the pattern and morphology of the grooves.
- The prints produced may differ in appearance depending on the pressure applied and its direction.

Dentist as an Expert Witness:

- Expert witness is an advisor to the court and may give opinions, draw inferences or interpret facts about which the judge has special knowledge.
- A dentist may be required to testify in malpractice cases, other criminal and civil cases. In principle he should act only as an advisor to the court and not an advocate of either side. All the court exhibits should be simple and straight forward which can be understood by the judges.
- Always simple and clear language should be used.

CONCLUSION

- The roles of any forensic scientist are to collect, preserve and interpret trace evidence, then to relay the results to the judicial authority in a form of a report.
- Forensic Odontology is the forensic science that is concerned with dental evidence.
- Dental records that are used to provide patients with optimal dental service could also be very beneficial to legal authorities during an identification process.
- Therefore, all forms of dental treatments should be recorded and kept properly


Thank
you