Forensic Odontology
• Forensic – latin word ‘Forum’ meaning court of law

• FDI defines as ‘that branch of dentistry which, in the interest of justice, deals with proper handling of dental evidence, and with proper evaluation and presentation of dental findings’

• History dates back to 66 AD

• Adolph Hitler - dental identification
Role of forensic odontologist

- Identification of human remains through dental records and assisting at location of mass disaster
- Gender identification
- Age estimation of the both, the living and the deceased
- Bite mark analysis
- Presenting evidence in court
identification

- Identity - Characteristics by which a person may be identified
- Traditional methods - visual recognition, personal property
- Physical features – Acquired and inherited features
- Dental – resistant to post mortem decomposition
Basis for dental identification

• Teeth – hardest in human body
• Resistant to decomposition – teeth, fillings
• Probabilities-
Human Identification

• Comparison of antemortem data with postmortem data
• Presumptive vs. positive identification
Positive identification

- Dental record comparison
- DNA
- Fingerprints
- Radiological
Types of Evidence

• Inclusive
  – The evidence is included in the population of items that came from the crime scene

• Exclusive
  – The evidence is excluded from the items in the crime scene

• Direct
  – Known by personal knowledge

• Circumstantial
  – Knowledge by inference
Activity

• Look at dental x-rays and mark major features on the dental chart provided

• Look for
  – Cavities
  – Fillings
  – Bridgework
  – Missing teeth
Crime investigation
Bite marks
Taking a Bite Out of Crime
Forensic Dentistry
BITE MARKS

- Mark made by the teeth either alone or in combination with other mouth parts *Mc Donald*

- Patterned injury
Cameron and Sims Classification

1. Agents
   a. Humans
   b. Animals
   c. Mechanical

2. Materials
   a. Skin and body tissues
   b. Food substances
   c. Other materials chewed habitually
Mc Donald’s classification

- Tooth pressure marks
- Tongue pressure marks
- Tooth scrape marks
- Complex marks

Webster’s Classification

- **Type I** – Limited depth of tooth penetration
- **Type II** – Considerable depth of tooth penetration
- **Type III** – Complete or near complete penetration
FACTORS INFLUENCING THE BITE MARKS

- Type of tissue
- Age
- Sex
- Medical status
- Time
TYPES OF BITE MARK INJURY

• Indentations

• Contusions or Bruises

• Lacerations

• Avulsions
Indentations

Compression of the skin surface due to tooth pressure during a bite
Contusions or Bruises

Reddish / purplish discoloration of skin surface due to blood escape into subcutaneous tissue.
Lacerations

Break in integrity of skin surface due to the bite
IDENTIFICATION OF BITE MARK

• Gross features
• Classical features
• Individual features
Gross features

Circular / Elliptical mark
Classical features

Pattern present in the bite mark
Individual features

Represents teeth with fractures or rotations
<table>
<thead>
<tr>
<th>Non- Sexual</th>
<th>Sexual (male)</th>
<th>Sexual (Female)</th>
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<td>Chest</td>
<td>Thigh</td>
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<td>Chest</td>
<td>Arm</td>
<td>Anterior Shoulder</td>
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</table>

Shoulder

Neck

Arm

Pubic area
HISTOPATHOLOGICAL STAGES

• Stage 1 – 0 to 18 hrs – Scab formation

• Stage 2 – 30 to 70 hrs - Epithelial regeneration

• Stage 3 – 5 to 12 days - Subepidermal granulation

• Stage 4 – after 12 days – Regression
# HISTOPATHOLOGICAL CHANGES IN BITE MARKS

<table>
<thead>
<tr>
<th>Time (Hrs)/Days</th>
<th>Predominant cells / Deposits</th>
<th>Clinical color</th>
<th>Healing</th>
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<tr>
<td>0-18 hrs</td>
<td>PMNL, Macrophages</td>
<td>Red/blue/purple to black</td>
<td>Peripheral fibrosis</td>
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<tr>
<td>30-70 hrs</td>
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<td>Green to blue</td>
<td>Central necrosis</td>
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<tr>
<td>5-12 days</td>
<td>Haemosiderin</td>
<td>Brown to green</td>
<td>Capillary growth</td>
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<td>12-14 days</td>
<td>-</td>
<td>Tan yellow</td>
<td>Granulation tissue</td>
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BITE MARK INVESTIGATION

- Preliminary questions
- Bite mark evidence collection from the victim and Suspect
- Bite Mark analysis and comparison
- Conclusion of bite mark analysis
Photographs

Conventional Photograph

Digital photograph
Photographs

Orientation Photographs

Close-up Photographs
Salivary swab

Use cotton swab moistened with distilled water.

- Applications
  - Salivary DNA ANALYSIS

Cotton swab

Pre-moistened swab
Impressions

Impression of the Victim

Impression of the Suspect

Dental models of the Suspect
BITE MARK ANALYSIS

• Metric Analysis – odontometric triangle method

• Pattern Association

• Test bites

• Other methods
  1. Trans illumination of tissue
  2. Scanning electron microscopy
  3. video superimposition
  4. stereomicroscopy
Metric analysis

Vernier Calipers

Bite Mark

Computer digitization method
Odontometric triangle method

- Triangle made on bite marks and teeth models by marking three points

- Two reference points on outer most convex point of canines and one in the center of centrals

- Three angles measured and compared
Pattern Association

Bite mark photograph from victim

Comparison

Models from suspect
Overlays

Dental cast tracing

Image on a transparent film

Radiograph taken from radiographic material applied to wax bite
Test bite Media

Styrofoam

Wax
CONCLUSION

- Positive Identification
- Possible Identification
- Excludes Identification
LIP PRINTS
• Wrinkles and grooves – Sulci labiorum rubrorum.
• Imprint produced – lip prints (Cheiloscopy)
Classification

- Santos:
  - Simple wrinkle
    - Straight line
    - Curved line
    - Angled line
    - Sine shaped curve
  - Compound wrinkles
    - Bifurcated
    - Trifurcated
    - Anomalous
Classification

- **Tsuchihashi**
  - **Type I** - Clear cut grooves covering entire lip
  - **Type II** - Branchd grooves
  - **Type III** - Intersected grooves
  - **Type IV** - Reticular grooves
  - **Type V** - Grooves that cannot be morphologically differentiated
Disadvantage

- Trauma and scar formation
- Surgical treatment
- Mobility and pressure application of lip
Mass Disasters
Mass disaster is an unexpected event that causes severe injury and death to a number of people.
NATURAL MASS DISASTERS

Earth quakes

Tsunami in 2004
ACCIDENTAL MASS DISASTERS

- Air craft and train crashes, building fires

Swiss air crash of flight in 1998
INTENTIONAL MASS DISASTERS

- Bombing of buildings
- World trade center attack in 2001
CHALLENGES IN MASS DISASTERS

- Large number of human remains
- Fragmented and burned remains
- Difficulty in determining who was involved in the disaster
- Acquisition of meaningful medical and dental records
- Legal, jurisdictional and political issues
METHODS OF IDENTIFICATION

• Physical identification
• Finger prints
• Dental records
• DNA analysis
PHYSICAL IDENTIFICATION

• Less exact but capable method of identification
• Photos can be taken of the victim, focusing on items like medical operations, jewellery, tattooing, scars, eye and hair color
FINGER PRINTING

• Believed to be unique to each finger

• Details do not change over time

• Victim identification success rate is fairly high

• Will be less obtainable from victims due to the fast decomposition of the human body
DENTAL RECORDS

• Dental patterns are unique for every individual

• Dental identification can be confirmed in a matter of hours
DENTAL COMPARISON

- Teeth - DNA extraction from tooth pulp
- General characteristics:
  - Age,
  - Sex,
  - Race
- Charting - diagrammatic methods to record teeth for extractions, fillings, missing teeth
- Antemortem records - previous dental work
- Bite mark comparison
DNA ANALYSIS

- Precise method for identification
- Very time consuming and expensive process
- Very sensitive technique with contamination problems
- Usually match victim samples with samples taken from personal items or from known relatives
GENOMIC DNA

- Genomic DNA is found in the nucleus of each cell and represents the DNA source for most forensic applications.
MITOCHONDRIAL DNA

• Cells contain mitochondrial DNA (mtDNA), the sequence of building blocks of which can be determined to assist in identification.

• Higher copy number

• mtDNA is maternally inherited
DNA IDENTIFICATION ANALYSIS

- DNA sampling
- DNA Analysis and technology
- DNA database searching
• Post mortem sample collection

• Antemortem sample collection

• Matching
POST MORTEM SAMPLE COLLECTION

Examination for scars, tatoos and jewellery

Autopsy
POST MORTEM SAMPLE COLLECTION – VICTIM IDENTIFICATION

Photos of the bodies
Fingerprints
Dental images
### Victim Identification

**Nature of disaster:**

**Place of disaster:**

**Date of disaster:**

**Sex unknown:**

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<th>Without clothes</th>
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ANTEMORTEM SAMPLE COLLECTION

Sample Collection

Sample Preparation
Sample Labelling

Sample Storage

Sample Documentation
ANTEMORTEM RECORDS

VICTIM IDENTIFICATION

Family name: ____________________________

Forename(s): ___________________________

Date of birth: __________ Day __________ Month __________ Year

Nature of disaster:

Place of disaster:

Date of disaster: __________

Police force handling identification:

NCB of county: ___________________________

Police file No.: ___________________________

Reasons for assuming that person concerned is victim of disaster:

Police officers evaluation: Is above person a victim? [ ] Possibly [ ] Probably [ ] Undoubtedly

DNA: [ ] Reference samples collected [ ] Profiles ordered [ ] Profiles enclosed
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</table>
FINGER PRINT MATCHING
DENTAL COMPARISON

X-ray comparison

Filled teeth

Erosion
DENTAL IDENTIFICATION

- The age of children- determined by the analysis of tooth development and subsequent comparison with developmental charts.
- Conclusions are usually accurate to approximately ±1.5 years.
- Charts such as those developed by Ubelaker graphically illustrate the development of the dentition from 5 months in utero to 25 years, illustrating the deciduous, mixed and permanent dentitions.
IDENTIFICATION USING PHOTOGRAPHS
DNA MATCHING

- Genetic database systems to comparing AM and PM DNA samples
- Combines DNA profiles from 3 sources:
  a) Victims personal effects
  b) Relatives
  c) Remains
- Mass Fatality Identification System
  “M-FISys” in 2001
- The software then crosschecks all the profiles
TYPES OF DNA

2 TYPES:
- NUCLEAR/ GENOMIC DNA
- MITOCHONDRIAL DNA

GENOMIC/ NUCLEAR DNA
- Located in the nucleus of cells
- Commonly used in forensics cases
MITOCHONDRIAL DNA

- Present in the mitochondria of cells
- Each cell has a high copy no. of mt DNA
- Can substitute in cases where nuclear DNA is unavailable
- Exclusively inherited from mother
- Can be used to establish identity in cases where there is a gap of several generations
DENTAL AGE ESTIMATION METHODS....
Makes use of morphologic, radiographic, histological and biochemical methods to examine age dependant changes in teeth.

May be grouped into three phases—
- ageing in prenatal, neonatal & early postnatal
- age estimation in children & adolescents
- age estimation in adults
AGE ESTIMATION IN PRENATAL, NEONATAL, AND EARLY POSTNATAL CHILD

- Primary tooth germ begins to form at 7 weeks IU
- Enamel form of all deciduous teeth is usually complete by the first year.
- Permanent 1st molar shows germ formation first at about 3.5-4 months.
- Histological techniques are used which enables observation of tooth mineralization up to 12 weeks before it is actually apparent on radiographs. This method is highly technique sensitive.
Adv. of radiography is that it is non invasive, requiring no tissue sectioning.

Neonatal line may take up to three weeks after birth to form.

If neonatal line is present it indicates a live birth.

For age estimation of skeletal remains
  - dry weight of mineralized tooth cusps is measured.
  - developing teeth in a child at 6 mnths IU weigh about 60 mg, 0.5 mg in newborn & 1.8g at 6 mnths postnatal
NEONATAL LINES
AGE ESTIMATION IN CHILDREN AND ADOLESCENTS

- Two events used to measure dental age are:
  - eruption
  - tooth calcification

- Age estimation can be done by study of tooth emergence which involves visual assessment limited to deciduous teeth since their emergence is under genetic control.

- Emergence pattern of permanent teeth are under influence of intraoral environment, being affected by infection, arch space and premature teeth loss.
ERUPTION SEQUENCE
Evaluation of calcification is better done using radiographs since
- calcification can be observed for a period of several years.
- not altered by local factors.
- assessment of age at periods of no emergence can also be done.

Schour and Masslers method
- 20 chronological stages of tooth development have been described (4 months IU - 21 years of age)
- chart is based on histological sections which permits direct comparison with radiographs
Demirjans method
- makes use of a scoring system
- dev of seven mandibular teeth on left side was divided in eight stages each, named A-H
- each tooth is assigned a ‘maturity score’
- maturity score for each tooth is added and a total maturity score obtained.
- this score is then plotted on a chronological age conversion table
AGE ESTIMATION IN ADULTS

➤ GUSTAFON’S METHOD

- Assesses regressive changes such as
  - amt. of occlusal attrition (A)
  - Coronal secondary dentin deposition (S)
  - Loss of periodontal attachment (P)
  - cementum apposition at root apex (C)
  - root resorption at apex (R)
  - dentin translucency (T)

- For each regressive changes, diff scores ranging from 0-3 were assigned. (eg- A0, A1, A2, A3)

\[ X = A3 + S2 + P2 + C1 + R2 + T1 \]
- **Maples & Rice correction**
  \[ \text{AGE} = 13.45 + 4.56X \]

- **Johanson’s improvements**
  - proposed seven grades (0, 0.5, 1, 1.5, 2, 2.5, 3)
  \[ \text{AGE} = 11.02 + (5.14A) + (2.3S) + (4.14P) + (3.71C) + (5.57R) + (8.98T) \]

- The method has inaccuracies in calculation and hence has been discredited.
DENTINE TRANSLUCENCY

- Root dentin starts to become translucent during the 3rd decade of life beginning at the apex and advancing coronally

  - Alteration is due to decreased diameter of dentinal tubules due to calcification.

- Diff in RI b/w intratubular organic & extratubular inorganic matter is equalized resulting in increased translucency of affected dentin.

  - For age estimation, translucency length (in mm) or area may be measured on intact or sectioned teeth
AGE = B0 + B1X + B2X2 (Zones of translucency <= 9 mm)
AGE = B0 + B1X (Zones > 9 mm)

B0 - regression constant
B1, B2 - regression coefficients
X - translucency length

Disadvantages
- irregular junction of translucent and non-translucent zones, difficulty in measuring length.
- under estimation of age in older age groups.
OTHER METHODS

- Age estimation from incremental lines of cementum.
- Radiographic method of Kvaal and associates.
- Amino acid racemisation.
- Age estimation from changes in tooth colour.
- Craniofacial estimators of age [closure of cranial sutures, mandible (body, ramus, mental foramen, condyle)].
SEX DIFFERENTIATION

- Sexing from craniofacial morphology and dimensions.
- Sex differences in tooth size.
- Sex determination by DNA analysis.
CONCLUSION

• Forensic dentistry plays a major role in the identification of those individuals who cannot be identified visually or by other means. The unique nature of our dental anatomy and the placement of custom restorations ensure accuracy when the techniques are correctly employed.