Gender Determination: A View of Forensic Odontologist

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ABSTRACT

Forensic odontology is an investigative aspect of dentistry that analyzes dental evidence for human identification. Forensic odontology plays an important role in establishing sex, age, and race of victims. Many times, determination of sex / gender using skeletal remains presents a great problem to forensic experts, especially when only fragments of body are recovered. Forensic odontologist can assist other experts to determine sex of the remains by using teeth and skull traits. Various features of teeth, like morphology, crown size, root length etc are, characteristics differentiating male and female sexes. There are also differences in skull pattern and skull traits of two sexes. These help a forensic odontologis to identify the sex of the remains.

Key words: Forensic odontology; Sex determination; Canine dimorphism; Polymerase Chain Reaction (PCR); Amelogenin.

INTRODUCTION

The British Association for forensic odontology defined forensic odontology as branch of forensic medicine that, in the interests of justice, deals with the proper examination, handling and presentation of dental evidence in a court of law.

Forensic odontology is an investigatory aspect of dentistry that analyzes dental evidence for human identification. Apart from assisting in the identification of an individual, it reveals the age and gender of the same. Determination of sex using skeletal remains presents a great problem for forensic experts, especially when only fragments of the body are recovered[1].

Forensic dentists can assist other experts in determining sex of the remains by using information of the dental and skeletal remains.

Dental remains as teeth are an excellent material in living and nonliving populations for anthropological, genetic, odontologic and forensic investigations. Being the hardest and chemically the most stable tissue in the body, they are selectively preserved and fossilized, thereby providing best records for evolutionary change. Their durability in the face of fire and bacterial decomposition makes them invaluable for identification[2].

Various features of teeth, like morphology, crown size, root length etc, are differentiating characteristic between males and females. There are also differences in the skull pattern. These help a forensic odontologist to identify the sex. New developments like PCR,
amplification assist in accurately determination of the sex of the remains[3].

**Classification of methods used for sex determination**

- Visual method or clinical method
- Microscopic methods
- Advanced methods

**Visual method or clinical methods**

Differences between the sexes with respect to:

- a. Tooth size
- b. Root length and crown diameter
- c. Using canine dimorphism
- d. Tooth morphology and sexing
- e. Dental index
- f. Odontometric differences

**Microscopic methods**

- a. Sex determination using Barr bodies

**Advanced methods**

- a. Sex determination using Polymerase Chain Reaction (PCR)
- b. Sex determination using enamel protein

**Visual / Clinical methods**

**Sex difference in tooth size**

Teeth may be used for sex differentiation by measuring their mesiodistal and buccolingual dimensions[4]. Studies show significant differences in crown dimensions of male and female teeth, and both deciduous and permanent. Mandibular canines show the greatest dimensional difference with large teeth in males than in females. Pre-molar, first and second molars and maxillary incisors are also known to have significant differences[5].

**Root length and crown diameter**

Using optical scanner and radiogrammetric measurements on mandibular permanent teeth, sex determination can be done with 80% accuracy by measuring root length and crown diameters[3].

**Sex determination using canine diamorphism**

In the field of forensic odontology, permanent canine teeth and their arch width (distance between the canine tip) contribute to sex identification through dimorphism. The dimensions of canine teeth have been studied by several methods, including Fourier analysis (Minzuno, 1990), Moire topography (Suzuki et al, 1984) and the measurement of linear dimensions such as mesiodistal width, buccolingual width and inciso-cervical height (Anderson and Thompson (1973)[7], Garn et al, (1967)[8]; Rao et al (1988a, b)[9& 11].

A study by Anderson and Thompson (1973)[7] showed that mandibular canine width and inter-canine distance was greater in males than in females and permitted accurate differentiation between the sexes in 74% of cases.

Garn et al (1973)[8] studied sexual dimorphism by measuring the mesiodistal width of canine teeth in different ethnic groups. Furthermore, the mandibular canine showed a greater degree of sexual dimorphism than the maxillary canine.

Rao et al (1988)[9] reported that the mesiodistal width of mandibular canines was significantly greater in males than in females.

**Tooth morphology and sexing**

Distal accessory ridge, a non metric feature on the canine is the most sexually dimorphic crown trait in the human dentition, with males showing significantly higher frequencies and more pronounced expression than females[10].

**Dental index**

In addition to absolute tooth size, tooth proportions have been suggested for...
differentiating the sexes. Mandibular canine index proposed by Rao[11] and associates has given an accurate indication of sex in an Indian population. Using the mesiodistal (m-d) dimension of the mandibular canines, these researchers obtained the formula:

\[(\text{Mean m-d canine dimension} + \text{(Mean m-d canine dimension in females + S.D) in males S.D}) / 2 \text{ (S.D- Standard Deviation)}\]

The values obtained using this formula is 7.1mm and the maximum possible mesiodistal dimension of mandibular canines in females. The same dimension is greater in males than females. The success rate of determining sex using the above formula was close to 89%. However, relative to the near 100% accuracy using pelvis and skull, sexing by odontometrics is relatively poor[4].

**Advanced methods**

**Sex determination using PCR**

Polymerase Chain Reaction (PCR) is a method of amplifying small quantities of relatively short target sequences of DNA using sequence-specific oligonucleotide primers and thermostable Taq DNA polymerase[17].

The teeth can withstand high temperature and are used for personal identification in forensic medicine. In the case of few teeth or missing dental records, there is not enough information to identify the person. The dental pulp enclosed by the hard tissue is not influenced by temperature, unlike the buccal mucous membrane, saliva, and calculus[6].

In a study by Tsuchimochi T et al (2002), they 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[17].

Hanaoka et al (1996) 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 shown to be a useful method in determining the sex of an individual[18].

Sivagami and coworkers (2000) prepared DNA from teeth by ultrasonication, and subsequent PCR amplification, and obtained...
## Skull traits of two sexes (Krogman/Narayan Reddy)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General size</strong></td>
<td>Large endocranial volume &gt; 200 cc</td>
<td>Small, lighter with thin walls</td>
</tr>
<tr>
<td><strong>Architecture</strong></td>
<td>Rugged</td>
<td>Smooth</td>
</tr>
<tr>
<td><strong>Glabella</strong></td>
<td>More pronounced</td>
<td>Less pronounced</td>
</tr>
<tr>
<td><strong>Orbits</strong></td>
<td>Square, lower, smaller with rounded margins.</td>
<td>Rounded, higher, larger, sharp margins.</td>
</tr>
<tr>
<td><strong>Supra-orbital ridges</strong></td>
<td>Prominent</td>
<td>Less prominent</td>
</tr>
<tr>
<td><strong>Forehead</strong></td>
<td>Steeper &amp; less rounded</td>
<td>Vertical, round &amp; fantile</td>
</tr>
<tr>
<td><strong>Check bones</strong></td>
<td>Heavier, laterally arched</td>
<td>Lighter &amp; more pronounced</td>
</tr>
<tr>
<td><strong>Zygomatic arch</strong></td>
<td>More pronounced</td>
<td>Less pronounced</td>
</tr>
<tr>
<td><strong>Frontal eminence</strong></td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td><strong>Parietal eminence</strong></td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td><strong>Occipital area</strong></td>
<td>Muscle lines &amp; protuberance marked</td>
<td>Muscle lines &amp; protuberance less marked</td>
</tr>
<tr>
<td><strong>Mastoid process</strong></td>
<td>Medium to large, round &amp; blending</td>
<td>Small to medium smooth &amp; pointed.</td>
</tr>
<tr>
<td>i. Base</td>
<td>Sites of muscle insertion are marked</td>
<td>Less marked</td>
</tr>
<tr>
<td>ii. Digastric groove</td>
<td>Deep</td>
<td>Less deep</td>
</tr>
<tr>
<td>iii. Condylar facet</td>
<td>Long and slender</td>
<td>Shorter and broad</td>
</tr>
<tr>
<td><strong>Occipital Condyle</strong></td>
<td>Larger</td>
<td>Small</td>
</tr>
<tr>
<td><strong>Palate</strong></td>
<td>Larger, broader, U-shaped</td>
<td>Small &amp; parabola shaped</td>
</tr>
<tr>
<td><strong>Frontal sinus</strong></td>
<td>Well developed</td>
<td>Less developed</td>
</tr>
<tr>
<td><strong>Nasal aperture</strong></td>
<td>High &amp; narrower margins &amp; sharp</td>
<td>Lower &amp; broader</td>
</tr>
<tr>
<td><strong>Foramina</strong></td>
<td>larger</td>
<td>Smaller</td>
</tr>
<tr>
<td><strong>Foramen magnum</strong></td>
<td>Large &amp; long</td>
<td>Small and round</td>
</tr>
</tbody>
</table>
100 % success in determining the sex the individual[19].

**Sex determination from enamel protein**

Amelogenin or AMEL is a major matrix protein found in the human enamel. It has a different signature (or size and pattern of the nucleotide sequence) in males and females. The AMEL gene that encodes for female amelogenin is located on the X chromosome amelogenin and AMEL gene that encodes for the male amelogenin is located on the Y chromosome. Females have two identical AMEL genes or alleles, where males have two different AMEL genes. This can be used to determine the sex of the remains with very small samples of DNA[3].

**CONCLUSION**

Forensic odontologist assists in determination of gender where skeletal remains present a great problem to forensic experts, especially when only fragments of body are recovered. Thus, forensic odontologist plays a key role in identifying the gender.

**REFERENCES**

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