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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 investigative 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,

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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 shows 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, bucco-lingual 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:

[(Mean m-d canine dimension + (Mean m-d canine dimension in females + S.D) in males S.D)] / 2 (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].

Odontometric differences

The odontometric differences between male and female are generally explained as a result of greater genetic expression in males[12].

Microscopic methods

Sex determination using Barr bodies

Sex can also be determined by the study of X &Y chromosomes in the cells which are not undergoing active division. 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 upon the humidity and temperature of the ambient atmosphere. X chromatin and intra-nuclear structure is also known as Barr body as it was first discovered by Barr and Bertam (1949)[13]. It is present as a mass usually lying against the nuclear membrane in the females[13].

In a study done by Das et al (2004)[14] it has been shown that up to a period of four weeks after death we can determine the sex accurately from the study of X & Y chromosomes, keeping in view the variation of temperature and humidity.

Whittaker and coworkers determined sex from necrotic pulp tissue stained by quinacrine mustard using fluorescent Y chromosome test for maleness and claimed that upto 5 weeks after death, sex determination can be done with high degree of accuracy[15].

Duffy et al[16] showed that Barr bodies and F bodies Y chromosomes are preserved in dehydrated pulp tissues upto one year and pulp tissues retain sex diagnostic characteristics when heated upto 100Úc for one hour.

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)

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

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.

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