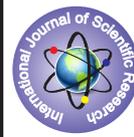


TEETH MORPHOMETRIC ANALYSIS AS A VALUABLE AID IN SEX DETERMINATION



FORENSIC SCIENCE

KEYWORDS: Sex determination, forensic odontology, Sexual dimorphism, inter-canine arch width, inter-molar arch width.

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ABSTRACT

Sex determination of a person becomes the first priority of a forensic investigator in the process of investigation. Dental evidence plays a crucial role in providing informative data towards establishing the unknown's identity. Studies in the field of Forensic Odontology have shown that canines and molars can withstand extreme temperatures and various insults. They present the highest sexual dimorphism amongst all teeth, making them ideal teeth in forensic investigative procedures. This study comprising 300 subjects (150 males and 150 females) was intended to measure the inter-canine arch width and inter-molar arch width in both maxillary and mandibular arches to determine the sexual dimorphism for these teeth and thus evaluating the efficacy of the molars over canines in sex determination.

INTRODUCTION:

Forensic odontology is that branch of dentistry which deals with the proper handling, examination, evaluation and presentation of dental findings in the interest of justice. This branch has been utilized for many years for the identification of victims and suspects in mass disasters, abuse and organized crimes.¹

One's identity is what one has earned all through his or her lifetime. What if it is lost in cases of sudden unexpected death? In events like air, rail and road mishaps, chemical, nuclear bomb explosions, hurricanes or any other disastrous conditions, the bodies are usually destroyed beyond identification. In such situations when only the skeletal remains are found, the first priority of the forensic investigators is to establish the remains identity.²

The durability of the dentition to survive in extreme conditions of fire and bacterial decomposition makes them invaluable for identification.²

The most reliable diagnostic features for the determination of sex are the innominate bones of an adult. Depending upon the completeness of a sample, sex may be determined from the cranium, long bone dimensions, pelvic structures, etc. using postmortem radiographs and the accuracy of sex differentiation by using such methods ranges from 96 to 100%. But in more severe cases of devastations and body fragmentation or decomposition, the biometric methods using dental remains are the most dependable and reliable means of identification, as the tooth being the hardest substance in the human body, which can withstand drastic atmospheric conditions like very

high temperatures and humidity, prolonged immersion, desiccation, extensive trauma as well as advanced stage of decomposition and moreover many people would have been to a dentist and may have antemortem data for comparison.^{2,3}

The identification of sex is of significance in case of major disasters where bodies are often damaged beyond recognition. Sex determination using dental features is primarily based upon the comparison of tooth dimensions in males and females or upon the comparison of frequencies of non-metric dental traits like Carabelli's trait of upper molars, deflecting wrinkle of the lower first molars, distal accessory ridge of the upper and lower canines or shovelling of the upper central incisors. This is based on the fact that although the morphology of the tooth structure is similar in males and females, the size of the tooth does not necessarily remain the same, as the tooth size is determined by cultural, environmental, racial and genetic factors leading to sexual dimorphism.³

Sexual dimorphism refers to the systemic difference in form (either in shape or size) between individuals of different gender in the same species. Teeth of various species are known to exhibit sexual dimorphism. Teeth measurements seem to be the most reliable method in forensic investigations due to its advantages of being quick, less time consuming, non-invasive and easy to perform.⁴

The first step of a trained forensic odontologist is to identify the sex from whatever human dental remains are present as a specimen. If available, the mandibular canine simplifies the investigators job to great extent in gender identification.^{2,3}

The maxillary and mandibular canines are not only exposed to less plaque, calculus, abrasion from brushing or heavy occlusal loading than other teeth, they are also less severely affected by periodontal disease and so, usually are the last teeth to be extracted with respect to age. These findings indicate that maxillary and mandibular canines can be considered as the 'key teeth' for personal identification. In the field of forensic odontology, permanent canine teeth and their arch width (distance between the canine tips) have been reported to show sexual dimorphism.⁴

Recently, there has been an increased interest in using molars as an aid in gender determination. Since, first permanent molars are the first permanent teeth to erupt in the respective arches and also have less chance of being impacted; therefore, an attempt has been made to compare the accuracy of inter-molar arch width between the first permanent molars to inter-canine arch width in gender determination and to validate it as an accurate entity for gender determination in cases where canines are missing.

The present study was intended to establish the impact of the 'sex factor' on the inter-molar distance of the maxillary and mandibular arches in Telangana Indian population and to evaluate the usefulness of inter-molar arch width over inter-canine arch width in sex determination for various forensic investigations.

AIMS AND OBJECTIVES:

- To determine, evaluate and compare the inter-canine and inter-molar arch widths in the maxillary and mandibular arches, thus determining the efficacy of inter-molar arch width in gender identification and to validate its use as an important forensic tool.

METHODOLOGY:

- The study sample comprised of 300 dental casts that belonged to 150 male and 150 female students, age ranging between 18 to 25 years from SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
- Subjects were selected after careful oral examination and were chosen to fulfill the following criteria:

- Age: 18-25 years
- Free from malocclusion
- Have no missing anterior teeth
- Having canine teeth free from:
 - Proximal restorations
 - Excessive incisal attrition.
 - Dental erosion or abrasion
 - Dental trauma.

MATERIALS:

- Alginate impression material.
- Type IV Dental Stone
- Electronic Digital Vernier Callipers giving readings upto two decimal points. (with resolution of 0.02mm).

METHODS:

Impressions of maxillary and mandibular arches were made using alginate impression material and study models were prepared using dental stone. On the study models, maxillary inter-canine and inter-molar arch width; and mandibular inter-canine and inter-molar arch width measurements were recorded using Digital Vernier calipers.

The inter-canine arch width was calculated from the cusp tip of canine on one side to the cusp tip of the canine on the opposite side, while the inter-molar arch width was calculated from the central fossa of first permanent molar on either side.

The width was measured three times and the average inter-arch width of maxillary and mandibular jaws was obtained to minimize

the intra-observer error. The descriptive statistics was calculated (mean, range and standard deviation), for both maxillary and mandibular inter-canine distance and maxillary and mandibular inter-molar distance. From these measurements the percentage of sexual dimorphism was calculated.

The observed maxillary and mandibular inter-arch width was subjected to statistical analysis to assess sex difference using unpaired t-test. The level of statistical significance was set up at $p < 0.001$.

ARMAMENTARIUM:



CLINICAL EVALUATION



MATERIALS USED



MAXILLARY INTER-CANINE ARCH WIDTH



MAXILLARY INTER-MOLAR ARCH WIDTH



MANDIBULAR INTER-CANINE ARCH WIDTH



MANDIBULAR INTER-MOLAR ARCH WIDTH

RESULTS:

Table 1: Mean values of the measurements in males and females.

CRITERIA	SEX	N	MEAN	STD.DEV	S.D
MXIC	Male	150	33.61	2.83	0.11
	Female	150	33.65	1.71	
MDIC	Male	150	24.75	2.15	2.13
	Female	150	25.29	1.57	
MXIM	Male	150	47.30	2.36	4.39
	Female	150	45.31	3.01	
MDIM	Male	150	40.91	2.94	5.16
	Female	150	38.90	2.44	

MXIC = Maxillary inter-canine width; MDIC = Mandibular inter-canine width; MXIM = Maxillary inter-molar width; MDIM = Mandibular inter-molar width; N = number of subjects; STD.DEV = Standard deviation; S.D. = Sexual dimorphism.

The mean maxillary inter-canine arch width measured in males was 33.61 ± 2.83 and in females it was 33.65 ± 1.71 (Table 1).

The mean mandibular inter-canine arch width measured in males was 24.75 ± 2.15 and in females it was 25.29 ± 1.57 (Table 1).

The mean maxillary inter-molar arch width measured in males was 47.30 ± 2.36 and in females it was 45.31 ± 3.01 (Table 1).

The mean mandibular inter-molar arch width measured in males was 40.91 ± 2.94 and in females it was 38.90 ± 2.44 (Table 1).

Statistical analysis was done to compare the means of the inter-canine and inter-molar width in both maxillary and mandibular arches for males and females. All the results were found to be significant with a 'p' value < 0.05 .

Sexual dimorphism:

Sexual dimorphism in maxillary and mandibular inter-canine and inter-molar arch width was calculated separately using formula given by Garn & Lens (1967).

$$\text{Sexual dimorphism} = (X_m - X_f) - 1 \times 100$$

where: X_m - mean mesio-distal width in males and X_f - mean mesio-distal width in females.

The sexual dimorphism in maxillary inter-canine arch width in males and females was found to be 0.11 and in mandibular inter-canine arch width was found to be 2.13 (Table 1).

The sexual dimorphism in maxillary inter-molar arch width in males and females was found to be 4.39 and in mandibular inter-molar arch width was found to be 5.16 (Table 1).

DISCUSSION:

Sex determination of skeletal remains form a part of archaeological and medicolegal examinations. The method may vary and depend upon the available bones and their condition. The identification of sex is of significance in cases of mass fatality incidents where bodies are damaged beyond recognition. Further, in situations where only fragments of jaw bones with teeth (or teeth alone) are found, then sex determination is possible only with the help of teeth.³

In forensic cases, it is common to recover partial remains like fragmented skull, jaws and other bones of the body. The teeth being one of the strongest human tissues are known to resist a variety of ante-mortem and post-mortem insults and are one of the most commonly recovered remains.

Because no two oral cavities are alike and dentition is as unique as fingerprints, it can be used for human identification. The use of dentition in gender determination has been explored and advocated owing to its strength and resistance to various insults. As teeth are the hardest and chemically the most stable tissue in the body, they are an excellent material in living and non-living populations for forensic investigations.⁵

Individual identification depends on different parameters like age, gender and race. Gender determination is one of the important steps employed in the identification of an individual.

In the past, M. Abdulla et al., (1998), Aliaa Omar et al., (2009), Neelampari Parikh et al., (2013) and MJ Baheti et al., (2014) have advocated use of mesio-distal width of canine, inter-canine width and canine index of both maxillary and mandibular arches in determining the gender.^{5,6,7,8}

But research done by Boaz et al., (2007) and Acharya et al., (2011) have found that the measurements using canines, do not reflect the gender difference accurately.^{9,10}

Also these measurements are not useful in individuals with missing canines. In such cases, width of molars or inter-molar arch width may be used in gender determination. Hence, in the present study inter-molar arch width was used to determine the gender and the results were compared with inter-canine arch width to assess a better method for gender determination.

In the present study, the mean inter-molar width in both maxilla and mandible was significantly higher in males than in females (Table: 1). This observation is in agreement with the study done by Esam M. Mehlab et al.,(2012) who aimed to evaluate the age and sex dependent changes of the craniofacial skeleton in 200 subjects within the age period of 7-17 years. They have found in their study that maxillary inter-molar arch width in males was 48.60 and in females was 46.22. Whereas the mandibular inter-molar arch width in males was 48.70 and females was 46.51.¹¹

The results of the present study are also in accordance with the study done by Ritu Jindal et al.,(2013) where they have measured inter-molar arch width in 300 subjects within age group of 12-14 years and found that maxillary inter-molar arch width in males was 50.35 and females was 48.99. Whereas the mandibular inter-molar arch width in males was 44.75 and in females was 41.90.¹²

However, in the present study, there is no statistically significant difference between the mean maxillary and mandibular inter-canine width between males and females (Table: 1). This observation was in agreement with the study done by Kaddah et al.,(1998), who stated that no statistically significant difference was obtained between males & females while measuring the inter-canine distance.⁴

Thus the idea of using the inter-molar arch width over inter-canine arch width in the present study has proved to be a very competent tool to address sexual dimorphism in the male and female populations.

CONCLUSION:

Although the odontometric measurements based on canines are quite popular and have been used from time to time for determining gender, these are rendered invaluable in cases where canines are absent. Therefore, in such cases molars play a crucial role in the determination of the gender.

On the basis of the results of our study, we can conclude that inter-molar arch width can bring about a significant insight to carry out legitimate examination and sex determination of the subjects in various forensic and archeological investigations.

However, it is recommended to conduct similar studies on various populations with a larger sample size, as this parameter is subjected to change based on the geographic distribution.

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