Original Article

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Dentistry Section

Demystifying the Mysteries: Sexual Dimorphism in Primary Teeth

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ABSTRACT

Introduction: One of the critical steps in the process of identification is the sex determination of an unknown individual. Many studies have shown that sex can be determined using the human skeleton, especially by examining the pelvis and skull. Odontometric analysis of the human sexual variation has been less investigated, especially of primary dentition.

Aim: To verify the presence of sexual dimorphism in primary teeth of local population of Faridabad, Haryana, India.

Materials and Methods: The research was performed on dental casts of 500 children (250 boys and 250 girls, age range 3-5 years). Mesiodistal and buccolingual crown dimensions of maxillary and mandibular primary teeth were measured with a digital Vernier's caliper and were analysed for sexual dimorphism. Mann-Whitney-U test was used to check the statistical significance of difference in tooth dimensions among boys and girls.

Results: Differences were found in the mean values of mesiodistal and buccolingual diameters of primary teeth, in which boys generally had larger crown diameters than girls.

Conclusion: Primary teeth may be used as an additional tool for sex identification of juvenile skeletons where other dimorphic features are not much developed.

Keywords: Forensic dentistry, Odontometric analysis, Sex determination

INTRODUCTION

In the times when man has made mars look not so distant through scientific advancements on one hand, there is a sharp rise in death toll due to various criminal activities, road traffic accidents and natural calamities. These unfortunate incidents claim lives of individuals coming from all rounds of the world. The identity of the deceased, assailant or the cause of death is an essential input, which form the basis of various investigations. Lack of evidence to determine the identity of an individual leads to a dead-end in the investigation in many cases. War and terrorism disputes become difficult to solve due to lack of identity thus further escalating border tensions. In mass disasters, accidents and diseases it is difficult for the family members to identify the victims because of extensive destruction caused by fire and mutilation. With advancements in science and technology, it is only imperative that greater emphasis is laid on making correct human identification with greater certainty with available remains of a body. Further, it is time that after centuries of advancements in technology and accumulated knowledge, we take a leap forward in making a human life stay valuable and preserved, even after it has been lost. Thus, human identification is of utmost importance and it is defined as the recognition of an individual based on the physical characteristics unique to the individual [1].

Forensic odontologist and forensic anthropologist may work together and provide information that may be useful to confirm, or assist in determining the identity of an individual from their skeletal remains [1]. Establishing biological identity is basic to human identification. Not only does an accurate sex diagnosis effectively cut the number of possible matches to half, but also methods for estimating age-at-death and stature are often sex dependent [2]. Whenever, it is possible to predict the sex, identification is streamlined because then only missing persons of one sex need to be considered. In this sense identification of sex takes priority over age [3].

The most accurate results for sex assessment are obtained from DNA analysis, but it is a technique sensitive and exhaustive procedure [4]. Other reliable methods include morphological and metric analysis of the bony pelvis, as it is the skeletal segment, which presents most sexual dimorphism. Additionally skull may also be analysed for estimation of sex [5]. Measurements of the long bones, particularly those of the femur and humerus, may also provide highly accurate sex assessments [6]. But, sometimes because of the lack of skeletal evidence, the estimation of sex becomes difficult and especially in juvenile remains where majority of the sexually dimorphic features are not fully developed until adulthood. By analysing the teeth it is possible to study the sexual dimorphism of an individual from the patterns of dental development and eruption, dental morphology and dental dimensions.

As teeth are more resistant to degradation than bones the only available standard for discerning sex, in forensic practice, is the measurement of the dentition. Due to high mineral content, teeth are also highly resistant to bacterial disintegration, fracture and fire. Such characteristics make teeth important in forensic research and investigation [7]. In cases where severe destruction of body has occurred, dental identification becomes one of the most reliable methods of identification as the enamel of tooth is the hardest known biological substance, it can withstand drastic atmospheric conditions, prolonged immersion, desiccation, as well as excessive trauma. If sexual dimorphism in tooth-crown size is as pronounced in the deciduous dentition as it is in the permanent dentition, then it may be possible to correctly assess the sex of children as young as two years [8].

Since there are limited odontometric standards for determining sex in the paediatric population, as studies on the primary dentition are scarce, the purpose of this study was to analyse the presence of sexual dimorphism in the mesio-distal and bucco-lingual diameter of primary teeth. The proposed null hypothesis for the study was that there exists no significant difference in the dimensions of primary teeth of boys and girls.

MATERIALS AND METHODS

The present comparative cross-sectional study comprised of 500 children (250 boys and 250 girls) of 3-5 years of age with complete set of primary teeth. Sample size estimation was done using G Power software (version 3.0). A minimum total sample size of 490 (245 per group i.e., boys and girls) was found to be sufficient for an alpha of 0.05, power of 95%, 0.327 as effect size (assessed from a similar study [8]). This was rounded off to 500 (i.e., 250 boys and 250 girls).

Children were selected from the outpatient department of the Department of Paedodontics and Preventive Dentistry at Manav Rachna Dental College, Faridabad, Haryana, India. The Ethical Committee of Pt. BD Sharma University of Health Sciences, Rohtak, Haryana, approved the study. Parents of selected children were made aware of the experimental design and a written informed consent was obtained from them.

Children were clinically examined to make sure that no restoration was present (except class I restorations without lingual or buccal extensions). Another key consideration was that there must not be any obvious loss of tooth material mesiodistally or buccolingually as a result of caries, fracture or excessive wear. The visual examination must establish that the primary teeth are fully erupted and that no teeth should be congenitally absent and no deformed teeth should be present.

Principle investigator recorded complete maxillary and mandibular impressions of the study subjects with Neocolloid alginate (Zhermack, Italy) impression material. The impressions were taken and were disinfected with 0.5% sodium hypochlorite [9]. The impressions were poured in dental stone (Type III, Kalstone, Kalabhai Karson, India). The impressions were allowed to set and then the cast bases were made with dental plaster (Type II, Kaldent, Kalabhai Karson, India).

Five hundred cast pairs were obtained and the tooth size was measured according to the method described by Morrees CF [10]. Mesiodistal crown diameter was obtained by measuring the greatest distance between the contact points on its approximal surfaces, using a sliding digital Vernier's caliper held parallel both to the occlusal and vestibular surfaces. The buccolingual diameter was measured as the greatest distance between the labial and lingual surfaces of the tooth in a plane perpendicular to that in which the mesiodistal dimension was measured [11].

All the casts were coded to avoid bias, name and gender of the child was not mentioned and a coding list was prepared. This list was reserved with the principle investigator. Second investigator, who was not aware of the gender, took all the measurements and a support staff made the data entry in Microsoft Excel (Mac 2011, Version 14.0.0, USA). Measurements were made with the sliding digital Vernier's caliper having a resolution of 0.01 mm (SDN10 Baker's Gauges, India). The jaws for external measurement were sharpened to allow for easy access to the contact areas. Calibration for zero was checked after each measurement.

STATISTICAL ANALYSIS

Data was analysed using Statistical Package for Social Sciences (SPSS) version 21.0. Mann Whitney-U test (non-parametric test) was used to check the statistical significance of difference in tooth dimensions among boys and girls. The level of significance was set at $p<0.05$.

The percentage of sexual dimorphism was used as an indicator to describe the differences between boys and girls. This index was calculated using the formula following Garn SM et al., [12] i.e.,

Percentage of sexual dimorphism = {(male mean - female mean)/ female mean} X 100

Percentage of sexual dimorphism represents the difference between male and female mean values. A positive value indicates larger male tooth dimension, whereas, a negative value indicates larger female tooth dimension. If the value is close to zero, the magnitude of sexual dimorphism will be lower.

RESULTS

[Table/Fig-1] shows the overall gender wise comparison of mesiodistal dimensions of maxillary primary teeth where boys showed larger dimensions than girls. Significant differences were observed for all teeth except for the laterals incisors.

The mesiodistal dimensions of mandibular teeth, between the genders, was greater in boys than girls except lateral incisors (p-value: 0.053) [Table/Fig-2].

The buccolingual dimensions of maxillary primary teeth, depicted that boys had significantly larger first and second molars than girls (p-value:<0.001) [Table/Fig-3].

The buccolingual dimensions of mandibular primary teeth showed significantly larger dimensions for boys for mandibular second molar only (p-value: 0.016) [Table/Fig-4].

The mean percent dimorphisms in mesiodistal dimensions of primary teeth showed positive values indicating larger teeth dimensions in boys [Table/Fig-5].

[Table/Fig-6] shows the mean percent dimorphisms in buccolingual dimensions of primary teeth where positive values were observed for all maxillary teeth except central incisors (-0.639). For mandibular teeth negative values were seen for central (-1.408) and lateral incisors (-0.260) depicting larger dimensions in girls.

Thus, based on the results obtained the proposed null hypothesis for this study was rejected.

Tooth	Sex	Mesiodistal dimension		
		Mean	SD	P[a] value
Central incisor	Male	6.41	0.72	0.013
	Female	6.34	0.62	
Lateral incisor	Male	5.33	0.53	0.093
	Female	5.25	0.47	
Canine	Male	6.44	0.47	0.001
	Female	6.30	0.51	
First molar	Male	7.20	0.59	<0.001
	Female	6.95	0.52	
Second molar	Male	8.93	0.65	<0.001
	Female	8.73	0.59	

[Table/Fig-1]: Overall genderwise comparison of mesiodistal dimensions of maxillary primary teeth.
[a]Mann-Whitney U test

Tooth	Sex	Mesiodistal dimension		
		Mean	SD	P[a] value
Central incisor	Male	4.17	0.59	0.001
	Female	4.05	0.52	
Lateral incisor	Male	4.67	0.63	0.053
	Female	4.55	0.38	
Canine	Male	5.53	0.49	<0.001
	Female	5.39	0.44	
First molar	Male	7.72	0.55	<0.001
	Female	7.53	0.59	
Second molar	Male	9.66	0.68	<0.001
	Female	9.47	0.60	

[Table/Fig-2]: Overall genderwise comparison of mesiodistal dimensions of mandibular primary teeth.
[a]Mann Whitney U test

Tooth	Sex	Buccolingual dimension		
		Mean	SD	P[a] value
Central incisor	Male	4.66	0.64	0.754
	Female	4.69	0.72	
Lateral incisor	Male	4.29	0.64	0.169
	Female	4.25	0.69	
Canine	Male	5.50	0.62	0.061
	Female	5.42	0.61	
First molar	Male	8.33	0.62	<0.001
	Female	8.16	0.69	
Second molar	Male	9.50	0.79	<0.001
	Female	9.35	0.70	

[Table/Fig-3]: Overall genderwise comparison of buccolingual dimensions of maxillary primary teeth.
[a]Mann Whitney U test, SD: Standard deviation

Tooth	Sex	Buccolingual dimension		
		Mean	SD	P[a] value
Central incisor	Male	3.50	0.64	0.145
	Female	3.55	0.54	
Lateral incisor	Male	3.83	0.75	0.078
	Female	3.84	0.57	
Canine	Male	4.86	0.82	0.595
	Female	4.83	0.62	
First molar	Male	7.12	0.63	0.407
	Female	7.09	0.64	
Second molar	Male	8.86	0.60	0.016
	Female	8.76	0.59	

[Table/Fig-4]: Overall genderwise comparison of buccolingual dimensions of mandibular primary teeth.
[a]Mann Whitney U test, SD: Standard deviation

Arch	Tooth Number	Percent Dimorphism
Maxillary	Central Incisor	1.104
	Lateral Incisor	1.523
	Canine	2.222
	First Molar	3.597
	Second Molar	2.290
Mandibular	Central Incisor	2.962
	Lateral Incisor	2.637
	Canine	2.597
	First Molar	2.523
	Second Molar	2.006
Mean Percent Dimorphism		2.35%

[Table/Fig-5]: Mean percent dimorphisms in mesiodistal dimensions of primary teeth.

Arch	Tooth Number	Percent Dimorphism
Maxillary	Central Incisor	-0.639
	Lateral Incisor	0.941
	Canine	1.476
	First Molar	2.083
	Second Molar	1.604
Mandibular	Central Incisor	-1.408
	Lateral Incisor	-0.260
	Canine	0.621
	First Molar	0.423
	Second Molar	1.141
Mean Percent Dimorphism		0.56%

[Table/Fig-6]: Mean percent dimorphisms in buccolingual dimensions of primary teeth.

DISCUSSION

Ditch LE and Rose JC were the first who advocated the use of tooth dimensions for identifying sex [13]. Since then many studies have quantified sexual dimorphism in permanent dentition [1]. Primary teeth can be of particular value for this purpose, because other sexually dimorphic features are not well developed in children and also because teeth are better preserved than bone. If sexual dimorphism exists in the primary dentition, it could be used to determine the sex of individuals between 11 months and 12 years, when the completely formed primary crowns are present in the tooth crypts or oral cavity [14].

Children in the age group of three to five years with complete set of primary dentition were included in the study because around the age of six months primary dentition stage starts on the arrival of the mandibular central incisors and last till about six years by when the first permanent molars appear in the mouth [15].

Tooth measurements can be determined by using direct (intraoral) and indirect (dental cast) methods. Though the majority of authors use plaster models [10], there are few studies in which measurements have been obtained directly from the mouth of the individual [1,7].

In 2005 Anderson compared direct and indirect measurement technique and established that there was no statistically significant difference between the mean values obtained for tooth dimensions from both the methods [16]. But in 1960, Hunter SW and Preist WR [17] from their study established that to measure teeth in the mouth is more difficult than to measure on dental casts. Together, they also established that the mesiodistal measurements, when taken from the mouth produced reduced values when paralleled to the indirect method. They furthermore compared the measurements from the soaped and non-soaped casts and suggested that soaping systematically increases the size of the measurement, perhaps simply by the addition of a slight film.

To measure tooth dimensions, various methods have been employed, most commonly used are the dividers and the sliding caliper to obtain the metrical data of the teeth. Some investigators specified that the use of dividers gave, on the average, a significantly larger measurement of tooth size than did sliding calipers [17]. This is probably due to the taper on the points of the dividers. The true points do not touch the greatest width of the tooth when placed on the tooth, but rather the sides of the points. But with the use of sliding caliper, the measurements obtained were more accurate and also it was much easier [17]. The use of digital Vernier's calipers can also nearly exclude measurement transfer and calculation errors when compared with divider and calculator.

Hence, for this study indirect methods of measurement, non-soaped casts and a digital Vernier's caliper with a resolution of 0.01 mm were used.

The present study showed that the mesiodistal and buccolingual dimensions increased progressively from the central incisors to the second primary molars in the mandibular arch, while for the maxillary teeth, the dimensions increased from the lateral incisors to the second primary molars since the central incisors were larger in the maxillary arch [Table/Fig-1-4]. These findings are in agreement with Abu Alhaija ES and Qudeimat MA [18] Townsend GC [19] and Eigbobo J [20].

In this study, boys generally had larger mesiodistal dimensions as compared to girls for all the teeth. This is in accordance with the studies done by Morreess CF et al., (1957) [10], Anderson AA [16], Margetts B and Brown T [21], Eigbobo J [20], Kuswandari S and Nishino M [22].

Garcia-Godoy F et al., observed larger mesiodistal dimensions of both maxillary and mandibular teeth in boys except maxillary lateral incisor in Dominican Mullato children [23]. However, Hattab FN et al., claimed no statistically significant differences between measurements of male and female teeth [24]. Black TK reported larger mesiodistal diameter of teeth in boys as compared to girls, except the maxillary and mandibular incisors [8]. However, Coughlin JW indicated a larger female prenatal deciduous molar crown than male [25].

In the present study, the buccolingual dimensions of boys were larger than girls except for three teeth: the maxillary and mandibular central incisors and mandibular lateral incisor that were larger in girls. Statistically significant differences were found in the dimensions of maxillary first molar, maxillary second molar and mandibular second molar. Similarly, Black TK reported larger buccolingual dimension for maxillary central incisor in girls [8]. Margetts B and Brown T, Liversidge HM and Molleson TI observed larger buccolingual tooth size in boys for all the primary teeth [21,26]. Contrary to this, Garcia-Godoy F reported larger buccolingual dimensions for all the primary teeth in girls than boys where mandibular canine presented statistically significant difference [23]. Coughlin JW also noticed larger female prenatal primary molar crown buccolingually than boys [25]. Barberia E et al., reported no significant differences between the sexes in regard to the buccolingual sizes of any molar [27]. Eswara K et al., concluded that maximum sexual dimorphism was observed for the buccolingual dimensions and the boys in general had larger dimensions of primary molars [28].

Garn SM stated that teeth that are larger mesiodistally tend to be larger buccolingually. Similar findings were observed in this study [29]. Paknahad M et al., [30] from their radio-odontometric study concluded that second molar could be used as an additional support for assessment of sexual dimorphism in primary teeth.

The percentage of sexual dimorphism was calculated following Garn et al., method [12]. Positive values were obtained for mesiodistal dimensions of all primary teeth [Table/Fig-5]. In buccolingual dimensions, except for maxillary central incisor and mandibular lateral incisor, all values were positive [Table/Fig-6]. The mean percentage of sexual dimorphism ranged from 1.104% to 3.597% [Table/Fig-5] for mesiodistal dimensions and for buccolingual dimensions -0.639% to 2.083% [Table/Fig-6]. Overall mesiodistal dimensions (2.35%) showed more dimorphism than buccolingual dimensions (0.56%). Highest sexual dimorphism was observed for maxillary first primary molar both buccolingually and mesiodistally. This is in accordance with Kushwandari and Nishino, who reported highest dimorphism in the mesiodistal dimension of maxillary first molar [22] and also with Rodriguez-Florez who stated that with buccolingual dimension of maxillary first primary molar, sex prediction was correct up to 93.7% in girls and 90.9% in boys [31]. However, Harris and Lease reported that the mean percentage of sexual dimorphism ranged from less than 1% (maxillary lateral incisor) to just over 2% (mandibular central incisor) in a worldwide survey of primary teeth [32].

LIMITATION

Keeping in mind the frequent natural calamities, it is necessary to have a foolproof methodology to identify the deceased. Since one method cannot be sufficient, so we should strive forward to develop new techniques, which can be performed easily and at affordable costs. However, the research needs to be more exhaustive on account of the sample size. These studies are region specific and there are morphological variations depending upon the geographical conditions. Considering diverse geographical conditions of the country, it is proposed that similar studies should be carried out on varied subjects of different regions.

CONCLUSION

The presence of sexual dimorphism in the primary dentition of the children was adequately supported by the findings of this study. In general, boys displayed larger tooth crown dimensions than the girls.

Mesiodistally, boys exhibited larger dimensions than girls for both the maxillary and the mandibular arches except for the lateral incisors. These differences were statistically significant. Buccolingually, only some teeth displayed greater values for boys as compared to girls. These teeth were maxillary first molar, maxillary second molar and mandibular second molar. For the buccolingual dimensions of the maxillary central incisor, mandibular central incisor and mandibular lateral incisor, girls presented larger values, but these differences were not statistically significant.

The findings of this study add to our current information on the prevalence of sexual dimorphism in primary dentition.

With the results obtained from this study, it can be concluded that primary teeth dimensions can benefit in assessing the sex of the juvenile skeletons in cases of mass disasters and accidents, along with other reliable methods of sex determination.

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