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CRANIOFACIAL MEASUREMENTS: DETERMINANT OF SEXUAL DIMORPHISM IN NORTH INDIAN POPULATION?

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ABSTRACT:

Background: Discrete skull bones have been used extensively for gender determination for medico-legal purposes but only a few studies have utilised the skull as a whole for the same. This study highlights the importance of linear measurements of skull for sexual dimorphism with the help of Paranasal Sinus (PNS) radiograph.

Materials and method: Linear measurements on digital PNS radiographs of 100 subjects (50 females and 50 males) aged 20 years and above were recorded. Statistical analysis was done to assess sexual dimorphism and to find which measurement holds the maximum and least gender wise variation.

Result: The mean values for all the measurements obtained were found to be higher in males as compared to the females. This difference was statistically significant for Bigonion width, Bimastoidale width, distance between fronto-zygomatic sutures bilaterally and for maximum skull width at the level of superior orbital margin. ($p < 0.05$). Individual formulaes derived for both genders by discriminant functional analysis were found to be 77% accurate.

Conclusion: Simple linear measurements done on PNS radiographs can be useful for gender determination. Since cranial patterns are population specific more studies should be conducted on a larger sample size to assess their reliability for sexual dimorphism.

Keywords: Forensic, Craniometric Measurements, Sexual Dimorphism, Paranasal Sinus View, Skull, Discriminant Analysis

INTRODUCTION:

The identification of any human being whether living or dead, is the most important aspect of forensic science since it has a social, economic and legal significance. Identification can be done with the help of either soft tissues, hard tissues or both. But in most of the cases soft tissue structures of the deceased are unavailable due to carbonisation or disintegration and the only option left is in the form of bones or teeth which help to solve the mystery. [1]

The determination of age, gender, ethnicity and stature serve as the backbone of any anthropological examination. [2] Almost all the bones of the human skeleton are sexually dimorphic. According to Krogman (1986) it has been proposed that the accuracy rate for gender determination using various bones is 95% for pelvis, 90% for skull, 98 % for skull and pelvis together and 80% for other bones of the body. [3] Hence, skull is the second best indicator of gender after the pelvis.

The skull has been profitably used for gender determination due to the following reasons like it is better preserved in the archaeological context, frequently separated from the rest of the skeleton while preserving in the museums and shows a considerable amount of geographic and diachronic variation in its morphology. [4]

Cranioscopy, is the study of skull based on its morphology and craniometry measures the dimensions of the skull and face. Both together tell about the differences in the gender however craniometry gives a more consistent result since it is based on quantitative and statistical evaluation of the skull. [5]

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Radiographic assessment of the skeleton provides both the architectural and morphological details & variations among the sexes. [3] According to literature search, the accuracy rates for radiographs in the assessment of gender as proposed by Tin-Hsin Hsiao et al in 2010, ranges between 80-100%. [6] Amongst all the types of radiographs used in the field of forensic odontology, the lateral cephalograms and Orthopantomograms (OPGs) are the most extensively used ones. According to the literature search, very few of the studies have been accomplished for determination of gender using the Paranasal Sinus (PNS) radiographs of the skull.

Based on the above mentioned facts, the present study was conducted with the aim to investigate about the sexual dimorphism in the human skull by taking linear measurements on the PNS skull radiographs.

Objectives: To investigate and correlate gender with the linear measurements taken as Bigonion width, Bimastoidale width, Inter infraorbital foramina distance, distance between fronto-zygomatic sutures bilaterally, and maximum skull width at the level of superior orbital margin.

MATERIAL AND METHODS:

The ethical clearance for the execution of the study was obtained from the Institutional ethical clearance committee of the college. PNS skull radiographs were taken for 100 healthy subjects (males and females) who visited the outpatient department of oral medicine and radiology of our college.

Inclusion criteria

- Subjects with no history of surgical or medical diseases that could affect the growth & development of skull.
- Subjects with normal growth & development and dental conditions.
- Radiographs of diagnostic quality recorded using fixed parameters.

Exclusion criteria

- Congenital/ developmental anomalies of head & neck region.
- Fracture or gross pathological defect of the face.
- Radiographs inappropriate to view the landmark points chosen.
- Patient not willing to be a part of the research.

All the subjects were aged between 20 to 70 years and were divided into 2 equal groups:

- Group A: males (n=50)
- Group B: females (n=50)

After selection of the subjects, they were explained about the purpose of the study and the potential radiation hazards. Following which an informed consent was obtained from them.

With the use of adequate protective measures to safeguard the subjects against the x ray radiation exposure, the radiographs were taken for each of them using KODAK 8000 C Panoramic and Cephalometric system at standard exposure parameters (80kVp, 10mA). The subjects were made to stand erect with their heads facing towards the image receptor and the mid sagittal plane lying perpendicular to the image receptor. Further the head of the subject was tilted backwards such that the canthomeatal line made an angulation of 37^{o} with the receptor. For correct angulation of the skull in a standardised manner and to minimize radiographic error, a divider (geometric instrument) was fixed at an angulation of 53^{o} to the ear rod on one side which approximates with the external acoustic meatus. Before positioning the patient on the cephalostat, with the help of a temporary marker and ruler canthomeatal line was made which served us as a reference for tilting the patient's head at correct. After taking the radiographs the mark of ink was removed with help of cotton dipped in spirit. All radiographs were taken in closed mouth position (figure 1).

There were 5 landmark points chosen on each radiograph bilaterally and horizontal

distances were measured between each of them with the help of Kodak Digital Imaging Software version 6.12.32.0 as shown in figure 2.

Statistical analysis

For statistical evaluation of the data, Students T test was applied and mean, standard deviations (SD), T value and P values for all the variables were calculated and compared. Significance was set at p value < 0.05. Further, Discriminant functional analysis was performed for classification of gender.

RESULTS:

The mean values for all the measurements obtained were found to be higher in males as compared to the females (Graph 1). This difference was found to be statistically significant for Bigonion width, Bimastoidale width, Distance between fronto-zygomatic sutures bilaterally and for maximum skull width at the level of superior orbital margin. ($p < 0.05$). Also, this difference was highly significant for Bigonion width, Bimastoidale width and distance between fronto-zygomatic sutures bilaterally ($p<0.001$) as shown in table 1

Discriminant functional analysis was performed to detect variations seen among the two genders on the basis of the linear measurements taken. (table 2)
Two separate formulaes for males and females were obtained:

- Female = -119.630+0.009(I) + 0.956 (II) + 0.091(III) + 1.521(IV) - 0.340 (V)
- Male = -135.389 + 0.148(I) + 1(II) + 0.046 (III) + 1.527(IV) - 0.35 (V)

The percentage of individuals sexed correctly according to discriminant functions was found to be 77% (Table 3)

DISCUSSION:

Determination of gender is an integral part of any anthropological examination and helps to establish the biological profile of any person living or dead. [6] It is a great challenge for forensic expert to identify victims in cases of victim identification, in cases of mass casualties like floods or train and airplane crash injury, earthquakes etc. [2] Procedures like facial reconstruction would be extremely challenging if the correct gender of the deceased is not identified. [6]

The most common method of gender determination is visual inspection of the shape and relative proportion of sexually dimorphic features. However more reliable one is the metric approach. According to Vanrell (2009), the accuracy rate of gender determination based on the morphological characteristics of the skull and mandible has been reported to be 77% and that on the basis of the metric assessment is greater than 90%. [1]

Several studies have been successfully conducted by various authors on the dry human skull to prove its sexual dimorphism. [7, 8, 9, 10, 11, 12] However, radiographic assessment of skull and specifically the PNS skull radiographs have not been used much for assessment of sexual dimorphism. Anthropometric measurements of skull when determined on radiographs have been found to be 80-100% accurate. [13] In the radiographic studies conducted so far, lateral radiographs and orthopantomograms are the most extensively used radiographs. Many studies have been conducted to prove the sexual dimorphism based on the linear measurements taken on the lateral cephalograms as well. [6,13,14] Lately, Computed Tomography has been broadly utilised for studying the sexual variations in various structures of the skull like the mastoid process or maxillary sinus. But the Para nasal sinus (PNS) skull radiographs have not been used for assessment of sexual dimorphism. Thus, the present study was undertaken on PNS skull radiographs to assess sexual dimorphism based on the linear measurements taken on these radiographic views of the skull.

Following statistical evaluation, Student t test displayed mean values of all the measurements higher in males as compared with the measurements taken on radiographs recorded for female subjects signifying a larger skull dimension in males as a whole. This result was in favour of other studies which have been conducted on either dry skull or radiographs in the past. [7, 8, 9, 10, 11, 12]

Out of the five measurements recorded on the PNS skull views, Bigonion width, Bimastoidale width, distance between fronto-zygomatic sutures bilaterally and maximum skull width at the level of superior orbital margin were found to be sexually dimorphic and significantly related to the gender of the individual. Three out of these four measurements i.e. Bigonion width, Bimastoidale width and distance between fronto-zygomatic sutures bilaterally showed a strong relationship with the gender of the individual ($p<0.001$)

The sexual dimorphism of the intergoinial distance proved in the present study has also been established in other studies conducted by Jayakaran et al. (2000), Franklin et al. (2007), Ranganath et al. (2008), Ongkana et al. (2009), Vinay et al. (2013), Singh R et al (2015), but none of these studies were done on the paranasal sinus skull radiographs. [15]

Similar to the present study, sexual dimorphism with the help of Bimastoidale distance has been studied by Amin W et al in 2015 which was done on digital images obtained from Cone-Beam Computed Tomography (CBCT) of the study subjects of Jordanian origin. [16]

The distance between the frontozygomatic suture bilaterally also showed significant variations in both the genders ($p<0.001$) but this result was different form the study conducted by Deog-Im Kim et al 2015 ($p=0.071$) [17] & Klales RA on CT image of the skull. [18]

Maximum width of the skull at the level of superior orbital margin was higher for males as compared with females, the difference being statistically significant ($p= 0.001$). Similar result was obtained in study conducted by Sangvichien S et al in 2007 [5] but the study was conducted using dried human skulls instead of radiographs as used in the present study. Another study conducted by Anabor E et al (2011) in dry human skulls gave a similar result by demonstrating sexual dimorphism in various dimensions of human male and female skull like the minimum frontal breath which is the distance between the right temporal crest of the frontal bone to the left.[19]

CONCLUSION:

This study was carried out to investigate the possibility of using the PNS skull view for sex determination with the help of linear measurements only. The results proved a positive variation with the distances and the gender of the subjects. Measurements like the bigonion, bimastoidal width and the maximum skull width can serve as a very important parameter for sexual dimorphism assessment. Some variations were obtained when comparison was made with the studies conducted in the past which can be attributed to the fact that the cranial patterns are population specific and may be affected by other environmental factors.

However, as studies on sexual dimorphism of cranium are very few, hence it is recommended that further research work should be done not only to prove the accuracy of the formulaes obtained after discriminant analysis but also to assess other skull parameters which have not been studied much for sexual dimorphism.

Summary: Skull is one of the most reliable sources of gender determination and for this purpose radiographs have played an important role. However, the Paranasal sinus (PNS) skull radiograph has not been used routinely for the same purpose. Linear

measurements have been used for evaluation of sexual dimorphism either on dry skull or on the radiographs but evaluation of multiple parameters simultaneously have not been conducted. So the present study was conducted for evaluation of sexual dimorphism on the PNS skull radiographs on the basis of 5 linear measurements recorded on the radiographs. The results obtained showed not only variations between the two genders when an overall comparison was made but also when individual parameters were analysed out of all the five measurements four showed statistically significant variations. Also, the bimastoidale width, bigonial width and the distance between the frontozygomatic sutures showed a highly significant variation in males and females of the study population. Further, more research needs to be done on a larger sample to draw conclusion regarding sexual dimorphism of the skull.

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TABLES:

Table 1: Students T test to compare the two genders

	Sex	N	Mean	Std. Deviation	t	df	p value
I	Male	50	100.752	9.00284	6.055	98	<0.001
	Female	50	90.612	7.69181			
II	Male	50	133.8	9.089936	4.944	98	<0.001
	Female	50	124.842	9.029658			
III	Male	50	58.786	7.986903	1.608	98	0.111
	Female	50	56.294	7.503725			
IV	Male	50	108.912	7.5733	4.419	98	<0.001
	Female	50	102.56	6.7776			
V	Male	50	138.208	16.1859	3.595	98	0.001
	Female	50	127.632	13.06512			

Table 2: Fisher's linear discriminant functions

	Gender	
	Female	Male
I	.009	.148
II	.956	1.000
III	.091	.046
IV	1.521	1.527
V	-.340	-.350
(Constant)	-119.630	-135.389

I: Bigonion width , II: Bimastoidale width , III: inter infraorbital foramina distance ,IV: Distance between fronto-zygomatic sutures bilaterally ,V: maximum skull width at the level of superior orbital margin

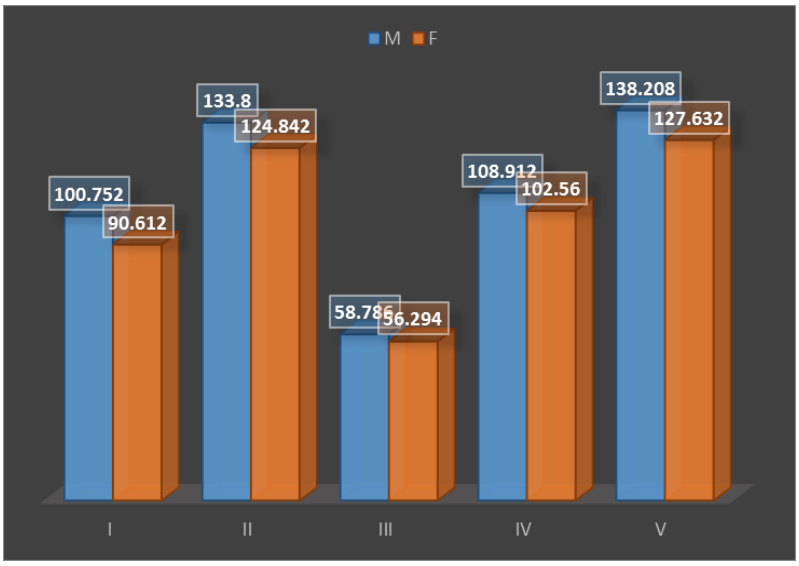
Table 3: Classification Results

		Gender	Predicted Group Membership		Total
			Female	Male	
Original	Count	Female	37	13	50
		Male	10	40	50
	%	Female	74.0	26.0	100.0
		Male	20.0	80.0	100.0

a. 77.0% of original grouped cases correctly classified.

GRAPHS:

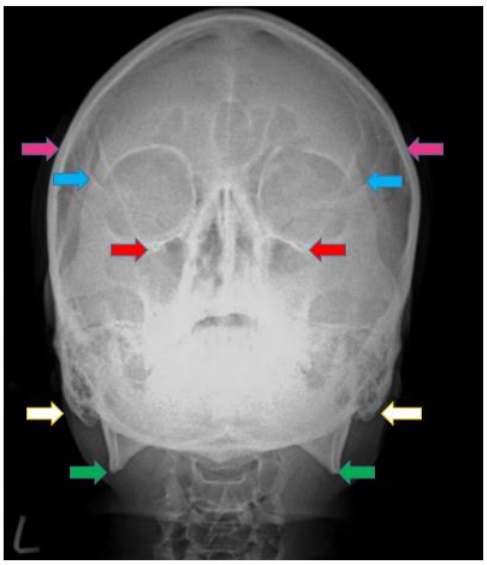
Graph 1: Mean values of both genders



FIGURES:

Figure 1: Patient positioning on cephalostat

Figure 2: Landmarks chosen for study purpose on the radiographs



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