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Evaluation of New Morphometric Parameters for Sex Determination of Human Skull.

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Article

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ABSTRACT

Estimation of sex, age, ethinicity and stature forms the basic pillars of medico-legal, bioarcheological and forensic anthropological studies. In the field of forensic anthropology, fragmentary human remains demand special approach, as they are inflicted by different types of inhumation, or physical insults. The basicranium is best suited for such studies, as it is well protected by soft tissues like muscles, ligaments and tendons, even in the most mutilated or disfigured remains of human skull. This article analyzes the performance of the diagnostic tests for sex determination by examining the basicranium, using the measurements of occipital condyles, which would in turn establish relationship between the sexes and their bilateral differences. In this study 100 skulls (50 male and 50 female) were obtained from teaching skeletal collections at the anatomy departments of government and private medical colleges at Nagpur and Udaipur. From these skulls the axial length of the occipital condyles (ALOC) and the anterior intercondylar distance (AICD) were measured using a sliding vernier caliper. Students 't' test was used to compare the male-female and left-right measurements.The results showed that the ALOC (of both sides) and the AICD prarameters were significantly longer in males than in females ($p<0.001$). This study shows that these cephalometric parameters of the basicramium are sexually dimorphic and therefore could be used in sex determination protocols.

INTRODUCTION

Identity as defined by Alves [1] is a set of physical characteristics functional or psychic, normal or pathological that defines an individual. The morphological characteristics obtained through craniometric measurements, act as a guide towards identification of an individual and enable us to determine the sex.

According to Arbenz [2] applications of knowledge of physical anthropology for the purpose of forensic medicine constitutes forensic anthropology.

Sex determination plays a crucial role in the identification of human remains as it narrows the possibility for identification by 50%. This becomes more difficult in fragmentary human remains where they may be compromised by different types of inhumation by physical insults such as explosions, fires, mutilation, mass disasters, which may frustrate the use of traditional morphogenetic sex determination methods by the investigator.

Krogman and Iscan [3] have stated in their studies the importance of the skeleton, the pelvis and the skull for sex determination in forensic anthropological examinations. Bass [4] states that skull is probably the second best choice of the whole of the skeleton to be studied for sex determination.

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Most authors have previously emphasized about the dimorphic features of the skull and pelvis above the rest of human skeleton.

The skull offers a high level of resistance to adverse environmental conditions over time, resulting in greater stability in conserving the dimorphic features, as compared to other skeletal bone pieces.

Gapert, Black and Last [5] confirmed that the base of skull is by far best preserved in the process of decomposition and damage as it is well protected by large mass of soft tissue.

In a review of morphological indicators of sexual dimorphism, 17 most important morphological indicators used by researchers were analysed, and their values as the determinants of sex in the modern skulls were established individually as well as collectively [6].

The occipital condoyles were amongst these 17 morphological indicators. These authors have reported that sex determination by observation of the occipital condyles shows a good performance ratio (ODDS RATIO 14:1), a high accuracy (79.3%), with greater sensitivity and predictive values for males [6].

As suggested by the available literature on morphometric studies, we can second our choice of undertaking our present study due to the following reasons

a) The importance of skull in sex determination
b) The importance of basicranium in anthropological studies, due to its availability even in adverse conditions.
c) Lesser known facts and studies aimed at determining the sex through occipital bone.
d) Scarcity of Indian studies utilizing the aforementioned work of great authors and forensic experts.
e) The use of accurate methods and well demarcated distinguishing features to identify the differences between genders.

Thus, the present study, which was carried out using resources available, by and large, to majority of medical experts in a developing country like ours, where resources are limited and so are the expertise, with the purpose to determine the existence of sexual dimorphism in the dimension of occipital condyle measured directly on the skull.

MATERIALS AND METHOD

Skulls were collected from the collection at department of anatomy at Indira Gandhi Government Medical College Nagpur, Geetanjali Medical College, Udaipur and Darshan And Pacific Dental Colleges Udaipur. The skulls with the evidence of trauma or deformity were excluded.

Finally, 100 skulls of known sex (50 male and 50 female) were subjected to following measurements using a sliding vernier caliper (with least count of 0.001mm)

1. Axial length of occipital condyles (ALOC)

2. Anterior intercondylar distance (AICD)

To, avoid observer and instrument bias, all readings were taken by the same investigator using the same vernier caliper.

The data thus collected was summarized (mean $\pm$ standard deviation) and analyzed using student 't' test to find out significance at $\alpha = 0.05$.

RESULTS

Comparative statistics with the values for the means and standard deviations for each dimension of the occipital condyles in both males and females are presented in Table-1.

In all the 100 analyzed skulls, all the linear dimensions where higher in males than females. This data when put to statistical analysis proved the significant difference with $p < 0.001$ in all values calculated for males with that of females.

The values for the means of lineal dimension observed in males and females are presented in Table-1.

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Table 1: Parameters – gender comparative results for occipital condyles

	Sex	N	Mean	Std. Deviation	'p' value*
ALOC Right	male	50	25.55	2.81565	<0.001**
	female	50	23.118	1.90688	
ALOC Left	male	50	26.124	2.67113	<0.001**
	female	50	22.184	2.1028	
ALOC combined	male	50	25.862	2.70396	<0.001**
	female	50	22.676	1.74011	
AICD	male	50	18.32	1.25471	<0.001**
	female	50	15.442	1.73159	

**p is significant at <0.001

In the studied skulls the maximum and minimum value for the ALOC (right) were 31.5mm and 19.5mm respectively, whereas the same values for the ALOC (left) were 32.5mm and 17.7mm. The maximum and minimum readings for the AICD were 20.6mm and 12.6mm respectively.

In the male skull the mean values for the ALOC (right), ALOC (left) and AICD were found to be 25.55mm, 26.12mm and 18.32mm respectively.

The same values for the females read as 23.12mm, 22.18mm and 15.44mm respectively.

Although significant difference was found amongst all the linear measurements between male and female skull, no significant association was found on bilateral measurements.

DISCUSSION

This study was conducted to provide information on the gender and bilateral morphological differences in the floor of the skull.

The significantly greater axial lengths of the right and left occipital conayles (ALOC-R, ALOC-L) in males can be attributed to the presence of the similar differences studied previously by authors for foramen magnum dimensions.

It is well documented fact, that morphometrically and structurally the occipital condyles and foramen magnum are related to one another. As suggested by some previous authors the saggital and transverse diameters of foramen magnum are longer in males as compared to females ,which in turn would indirectly also affect the dimensions of the occipital condyles as they are intrimly related [7,8,9].

Lang [10] reported that the axial length of occipital condyle of the right side ranged from 15 to 27 mm with an average value of 22.9mm, whereas the axial length of occipital condyle for the left side ranged from 15 to 29mm, with an average of 22.9mm.Oour study reported the maximum and minimum lengths of the right ALOC to be 31.5mm and 19.5mm, whereas the same readings for the left ALOC ranged from 32.5mm as a maximum to 17.7mm as the minimum reading, while the mean values for the ALOC (right) and ALOC (left) were 25.55mm and 26.12mm respectively. Emine et al[11] also studied the same parameters, and their values ranged from 20mm to 31.5mm for the right side axial length of occipital condyle, with the average of 24.36mm, whereas the range from 18.3mm to 31mm was observed for the left axial length of occipital condyle with an average of 24.0 mm.

The differences are possibly due to racial variations in the cranial morphometrics of the 3 different studied populations. However the nonsignificant differences between the right and left axial lengths of our studied samples agree with those obtained by Lang and Emine et al, who also did not find any significant bilateral differences in the sample.

In our study, the results pointed out a significant difference between male and female skulls, in seldom taken measurement of the anterior inercondylar distance ($p<0.001$). This is yet again explained by the possible reason of significantly greater dimension (transverse) for the foramen magnum in males and the significantly wider anterior intercondylar distance in our present study.

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According to Lang, this parameter ranged from 16mm to 30mm, with a mean value 23.6mm. Emine et al calculated the range from 10.5mm to 20.3mm, with mean value of 15.4mm.

In our study the range was from 12.6mm to 20.6mm which is very close to the one observed by Emine et al, while the mean values for the males was found to be 18.32mm and that of the females was 15.44mm, this data cannot be compared as both the authors did not measure them separately for the genders. The range of AICD, values calculated by Lang and our study, shows differences, which could be attributed to the method of measuring the AICD, in our study and Emine et al's study, AICD was calculated between the anterior inner points of the occipital condyle, while in Lang's method the distance was calculated between the anterior circumferences of the condyles.

CONCLUSIONS

In the skull sample analyzed, a significant sexual dimorphism in the occipital condyle linear dimensions were observed. The linear morphometric measurements applied to the axial length of occipital condyle and the anterior intercondylar distance were effective in determining the gender of Indian skulls.

Thus along with the other anthropological measurements of the basicranium like for those of the foramen magnum these linear morphometric methods of measuring occipital condyle can be effective in obtaining reliable results for determination of gender in Indian human skulls.

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