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Original Research Article

EVALUATION OF FORAMEN MAGNUM IN SEX DETERMINATION USING COMPARISON OF CALCULATED DISCRIMINANT SCORE VALUE AND MORPHOLOGICAL CHARACTERISTICS IN DRIED HUMAN SKULL

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ABSTRACT

Background: Sex determination is one of the crucial factors used for Forensic investigations. Skull and pelvis are the two bone structures used for sex determination since ages. However, the postcranial bones, particularly the long bones, are helpful in determining sex, in the absence of skull and pelvis.
Objectives: To evaluate dimensions of foramen magnum in sex determination using comparison of its calculated discriminant score value and morphological characteristics.
Materials and Methods: The study was carried out using dried human skulls available in Rohilkhand Medical College and Hospital (RMCH), Bareilly and nearby medical colleges after seeking approval from Institutional Ethics Committee and permission from the authority of the institutes to access the human fried skulls for the purpose of data collection.
Results: Various research and studies have been conducted on the subjects of Indian population which includes dimensions of sternum, mastoid angle, mastoid process, hand dimensions, clavicle, cephalograms, pelvis, osteometric and morphometric parameters of foramen magnum, foot dimensions, femur and so on, to establish sexual dimorphism on skeletal elements. Identification of sex is usually done based on differences in shape and size of the morphological marks. The morphological marks are more subjective and sex determination depends on experience of the investigator. Hence visual methods of sexing skull are likely to be inaccurate when performed by an inexperienced worker.
Conclusion: This study is conducted to evaluate dimensions of foramen magnum in sex determination using comparison of its calculated discriminant score value and morphological characteristics.
Keywords: Sex determination; forensic; osteometric; morphometric; foramen magnum.

INTRODUCTION

Identification is the determination of the individuality of a person. The identification of sex from human remains is of fundamental importance in Forensic Medicine especially in the identification of missing persons and in anthropology for reconstructing the lives of ancient populations.[1,2]

The identification of a dead body is required in cases of sudden and unexpected death, fires, explosions, railway or aircraft accidents, mutilated or hidden decomposed bodies or foul play. Osteometry includes the measurements of the skeleton and its parts. The technique has been successfully used in the estimation of stature, age, sex and race in forensic and legal sciences.[1]

Sexing of the skull is predominantly done using non-metric parameters, which are at best appropriate only in relative terms. When skeletonized remains are recovered, forensic experts may use methods that are based on the measurement of various bone parameters for sex determination. If only skulls or parts of upper jaw are available, analysis of cranial osteological traits like shape of the glabella, size of the mastoid process, shape of orbit, frontal profile, shape of the occipital protuberance or size of the foramen magnum may be helpful.[3]

In the process of reconstruction of biological profile of unidentified human skeletal remains, determination of sex is considered as one of the foremost entity, skull and pelvis being the forerunner in providing the most accurate data compared to other bones in establishment of sexual dimorphism.[4]

In sexing a skull, the initial impression is often the deciding factor; a large and robust skull is generally male, a small and gracile skull is female. This subjective approach of sexing skull may sometimes produce misleading results. Methods based on measurements and morphometry are accurate and can be used in determination of sex from the skull.[3]

The purpose of our study is to determine the sex using the documented physical morphological characteristics and compare it with the sex determined by the discriminant score formula.

In literature, there is paucity of data on this area, especially in this region, hence this study is intended to be conducted.

Aim and objectives

Aim: To evaluate foramen magnum in sex determination using comparison of its calculated discriminant score value and morphological characteristics in unknown dried human skull.

Objectives

1. To measure osteometric/morphometric parameters of Foramen Magnum and calculate discriminant score to categorize the skull into male and female.
2. To differentiate sex based on physical morphological characteristics of dried human skull.
3. To compare sex determined by discriminant score and physical morphological characteristics.

MATERIALS AND METHODS

The study was carried out using dried human skulls available in Rohilkhand Medical College and Hospital (RMCH), Bareilly and nearby medical colleges after seeking approval from Institutional Ethics Committee and permission from the authority of the institutes to access the human fried skulls for the purpose of data collection. Duration of study was 6 months. Measurements were taken using digital Vernier Calliper of 0.01 accuracy.

Physical morphological parameters was tabulated by three individual observers to exclude bias.

Discriminant score formula: D = - 12.273 + (0.136 x FMSD) + (0.078 x FMTD) + (0.165 x FMC) + (-0.008 x FMA).[11]

If the discriminant score is > 0.018, it was considered as male skull and if discriminant score is <0.018, it was considered as female skull. 11

The physical morphological parameters of skull considered are as follows.[12]

1. Forehead
2. Glabella
3. Frontonasal junction
4. Orbits
5. Supraorbital ridge
6. Bony ridge along the upper border of external auditory meatus
7. Parietal eminences
8. Occipital prominence
9. Mastoid process
10. Digastric groove

The physical morphological parameters of mandible considered are as follows.[12]

1. Symphysis menti
2. Posterior border of ascending ramus
3. Angle of body and ramus
4. Mental tubercle
5. Angle between body and ramus

Comparison accuracy of sex determination (both discriminant score and physical morphological parameters predicting same sex) was calculated using standard mathematical percentage formula.

Sample Size: Human dry skulls available in Rohilkhand Medical College and nearby medical colleges.

Inclusion Criteria

1. All dried skulls.

Exclusion Criteria

1. Fractured or deformed skull and mandible of any kind involving to any extent.
2. Any bony lesion covering or obstructing the Foramen Magnum and Foramen Ovale.

FORAMEN MAGNUM- (Osteometric Parameters)

1. The Foramen Magnum Sagittal Diameter (FMSD) direct distance from Basion (midpoint on the anterior margin of Foramen Magnum) to Opisthion (midpoint on posterior margin of Foramen Magnum).[9]
2. The Foramen Magnum Transverse Diameter (FMTD) maximum distance between the lateral margins of foramen magnum,[9]
3. The Foramen Magnum Area (FMA)
4. The foramen Magnum Circumference (FMC).

RESULTS

The analysis was carried out in following steps:

1. Measurement of Foramen Magnum Sagittal Diameter (FMSD) and Foramen Magnum Transverse Diameter (FMTD).
2. Calculation of Foramen Magnum Area (FMA) and Foramen Magnum Circumference (FMC).

3. Calculation of Discriminant score using FMSD, FMTD, FMC, FMA and classifying the unknown skulls into Male and Female sex.
4. Classification of sex using physical morphological parameters of skull and mandible.
5. Comparison of calculated sex using the discriminant score and sex determined by physical morphological characteristics.

Table 1: Skull bone

Sl no.	Sex of the skull using morphological parameters	Observer 1	Observer 2	Observer 3	Final result
1	Male	15	15	15	15
2	Female	13	13	13	13

Table 2: Mandible

Sl no.	Sex of the mandible using morphological parameters	Observer 1	Observer 2	Observer 3	Final result
1	Male	15	15	15	15
2	Female	13	13	13	13

Table 3: Sex determination according to calculated discriminant score value

Sl no	FMSD	FMTD	FMA	FMC	Discriminant score value	Male/Female according to Discriminant score value	Male/Female according to morphological features
1	35.3	29.2	809.56	101.77	> 0.018	Male	Male
2	33.1	28.7	746.11	97.32	< 0.018	Male	Female
3	34.3	29.5	794.71	100.5	> 0.018	Male	Male
4	37.2	32.1	937.86	109.15	> 0.018	Male	Male
5	28.2	25.7	569.21	84.76	<0.018	Female	Female
6	28.4	26.0	579.94	85.53	<0.018	Female	Female
7	32.3	29.2	740.76	96.73	> 0.018	Male	Male
8	27.4	24.8	533.70	82.1	<0.018	Female	Female
9	34.0	31.2	833.15	102.51	> 0.018	Male	Male
10	26.8	23.9	503.06	79.77	<0.018	Female	Female
11	28.6	26.5	595.25	86.61	<0.018	Female	Female
12	33.8	30.2	801.70	100.69	> 0.018	Male	Male
13	28.2	25.6	567.00	84.61	<0.018	Female	Female
14	26.3	24.1	497.81	79.24	> 0.018	Female	Male
15	32.7	30.6	785.89	99.49	> 0.018	Male	Male
16	31.3	28.6	703.07	94.19	< 0.018	Male	Female
17	34.2	29.3	843.43	103.14	< 0.018	Male	Female
18	32	29	728.85	95.93	> 0.018	Male	Male
19	34	31.2	833.15	102.51	> 0.018	Male	Male
20	33.5	30.4	799.85	100.49	> 0.018	Male	Male
21	32.9	29.6	764.85	98.31	> 0.018	Male	Male
22	25.8	23.4	474.16	77.38	<0.018	Female	Female
23	27.5	24.5	529.16	81.82	<0.018	Female	Female
24	34	31.3	835.82	102.66	> 0.018	Male	Male
25	34.1	30.6	819.53	101.78	> 0.018	Male	Male
26	26.4	24	497.63	79.26	<0.018	Female	Female
27	28.2	25.3	573.64	85.06	<0.018	Female	Female
28	33.5	29.7	781.43	99.45	> 0.018	Male	Male

DISCUSSION

In the remote times, cranial and postcranial bones were subject to traditional morphological methods for establishment of sexual dimorphism which were often subjectively associated with high degree of variations among observers.[4] Therefore, research related to combination of both morphometric parameters and discriminant function analysis (DFA) on cranial bones in South Indian population and Tibetan refugee population dwelling in India was carried out by Naikmasur et al. (2010) and concluded that the accuracy percentage of sex determination in South Indians and Tibetan refugees were 81.5% and 88.2% respectively.[5] These kind of DFA models are distinguished parameter specific to various population, and similar parameters needs to be established and developed to formulate sexual dimorphism standards across various populations.[5] Various studies conducted on North Indian population shows that consideration of multiple parameters of femur bone can predict sexual dimorphism with an accuracy of 90.2%.[6-8] Continuous standardisation and updated works related to osteometric parameters in anthropology are of dire importance in the present scenario due to growing secularism of population as well as differences in existing population.[4]

In our study, based on the morphological parameters, 15 skulls were found to be of male sex and 13 skulls were of female sex. On comparision with the discriminant score value, the accuracy percentage was 93.33 percent in males and 76.92 percent in females with overall accuracy of 85.13 percent.

S K Jain et al. (2013) carried out a study on 68 human adult skulls (38 male and 30 females) of known sex and age (22 to 60 years), having no skull anomaly collected from museum of anatomy department of TMMC & RC Moradabad and from nearby medical colleges. Prior sexing of the skull was done as per 14 morphological parameters before determining the sex using morphometric calculations. The comparison of the morphometric analysis obtained in this study showed that the anteroposterior diameter of the foramen magnum (male) was (36.9±0.2) and anteroposterior diameter of foramen magnum of female skulls was (32.9±0.3). Regarding the transverse diameter of the foramen magnum, in present study male skulls (31.5±0.27) the same measure for the female skulls was (29.5±0.28).[10]

Uthman AT et al. (2012) conducted a study on 88 patients (43 males and 45 females; age range, 20–49 years) were selected for this study. Foramen magnum sagittal diameter, transverse diameter, area and circumference were measured and data were subjected to discriminant analysis for gender using multiple regression analysis. The equation provided for calculating D was as follows:

D=−12.273+(0.136×FMSD)+(0.078×FMTD)+(0.165×FMC)+(−0.008×FMA);

this is useful in classifying an unknown skull (after obtaining the selected measurements) into either male (if the discriminant score is>0.018) or female (if the discriminant score is<0.018).[11] The discriminant analysis of all the variables used in the study provided the highest accuracy of correct sex classification. By substituting the values of the measured variables, the accuracy rate would be 73.3% in females and 90.7% in males, with an overall accuracy rate of 81%, as seen in the equation.[11]

CONCLUSION

Accuracy of Sex determination is a multi-approach process and various techniques are implemented for this purpose. Many studies are conducted all over the world for increasing the accuracy of this process, which leads to discovery of new methods of increased accuracy in this field.

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