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Anatomy

SEX DETERMINATION IN NORTH INDIAN POPULATION USING INION-OPISTOCRANIUM -ASTERION (IOA) TRIANGLE-A RESEARCH STUDY.

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ABSTRACT

Introduction: Sex determination is one of important parameters in identification of an individual. Skull is one of the most studied bone in physical anthropometry not only to determine sex but also to study race, age and evolutionary sequence.

Materials and Methods: A total of 80 dry adult skulls (55 male and 25 female) was used in this study. Parameters measured were Asterion-Opistocranium (AO) length. Asterion-Inion(AI) length, Inion- Opistocranium (IO) length and the area of the IOA triangle for every skull on both sides.

Result: The sexual dimorphism ratio for the mean measurements were >1 indicating that the male crania were larger in all linear dimensions. Sexual dimorphism ratio for area of IOA triangle was highest (1.55) making it the most sexually dimorphic parameter; among linear parameters sexual dimorphism ratio for IO was highest (1.40).

Conclusions: Sexual dimorphism exists for the evaluated parameters. The anthropometric measurement of IOA triangle can be of additive value in sex determination of unknown skull. Area of IOA triangle is more reliable tool for sex determination in comparison to linear parameters.

KEYWORDS : Sexual dimorphism, Skull, IOA triangle

INTRODUCTION:

Identification of any person is required for death certification and for personal, social and legal reasons. Sex determination is one of important parameters in identification of an individual. According to the Cambridge dictionary of human biology and evolution Sex is defined as "A biological category based upon reproductive attributes and roles in sexually reproducing species".[1]

In forensic science any medicolegal investigation of skeletal remains start from the determination of species. If bones are of human origin then the sexual dimorphism in different bones retrieved is done and finally moving on to determination of race, age and time of death of the person. The four available methods of sex determination are morphological, metrical, geometric and molecular; out of these bone morphology is oldest and commonly used. [2]

When entire skeleton is available for examination, sex determination is relatively easy but in medicolegal cases identification of sex sometimes needs to be done from isolated bones or their fragments from crime scenes in order to establish the possible identity of victim. Skull is one of the most studied bone in physical anthropometry not only to determine sex but also to study race, age and evolutionary sequence. Accuracy of sex determination using skeletal remains can be understood by Krogman's sexing of 750 adult skeletons. His success rate was: for entire skeleton- 100%; pelvis only - 95%; skull only- 92%, pelvis plus skull- 98%, long bones only- 80%, long bones plus pelvis- 98%.[2]

This study uses a metric method by calculating parameters of a triangle defined by points inion, opistocranium and asterion on dry adult skull bones.The aim of the study is to see whether the sexual dimorphism exists with respect to parameters of IOA triangle and if exists then to assess the accuracy of this method in North Indian Haryanvi population.

MATERIAL AND METHODS:

This study was done in the department of anatomy, Pt. B. D. Sharma PGIMS, Rohtak. A total of 80 dry adult skulls (55 male and 25 female). All skulls were screened for damage and deformity. Only fully ossified skulls were used for this study.

Inion (I), Opistocranium (O) and Asterion (A) points were identified and marked using a black colour permanent marker.

Inion: Most most prominent point in the posterior aspect of the occipital calvarium occurring at the intersection of the left and right superior nuchal line. (Fig. 1 & 2)

Opistocranium:
Most posteriorly protruding point on the base of the skull located in the mid-sagittal plane. (Fig. 1 & 2)

Asterion: Meeting point of the Lambdoid, Occipitomastoid and Parietomastoid sutures. (Fig. 1 & 2)

A digital calliper with a precision of 0.01mm was used to measure following parameters on both sides:

1) Asterion- Opistocranium (AO) length.
2) Asterion-Inion(AI) length.
3) Inion- Opistocranium (IO) length.

Area of the IOA triangle was calculated for every skull on both sides using Heron's formula.

$$A=\sqrt{s(s-a)(s-b)(s-c)}$$

Here a,b and c are the sides of triangle and $s=\frac{(a+b+c)}{2}$

IOA index was calculated as : $IOA\ Index = \frac{IO}{IA} X100$

All observations and measurements were taken thrice and their mean was taken. Data were analysed for central tendency and descriptive statistics were performed.

OBSERVATIONS:

The sexual dimorphism ratio for the mean measurements were >1 indicating that the male crania were larger in all linear dimensions. Sexual dimorphism ratio for area of IOA triangle was highest (1.55) making it the most sexually dimorphic parameter; among linear parameters sexual dimorphism ratio for IO was highest (1.40).

Figure 3,4,5 and 6 show scatter plot of linear relationship between left and right male asterion-inion length, left and right female asterion-inion length, left and right male asterion-opistocranium length and left and right female asterion-opistocranium length respectively. The upward sloped fit line in all the scatter plots and a positive Pearson's correlation coefficient (r) meant that there was positive correlation between left and right side parameters. A higher value of (r) for male parameters show stronger correlation between these linear parameters in males as compared to female.

Fig 7 and 8 show scatter plot of linear relationship between areas of IOA triangles of left and right sides in males and females respectively. Very high positive value of 'r' with respect to area of IOA triangle showed a very strong and positive correlation between right and left side.

Fig 9, 10, 11 and 12 shows the comparison of data in male and female skulls.

DISCUSSION:

Accurate determination of sex is of great importance to forensic doctors, anatomists and anthropologists. Large number of methodology have been described so far for determination of sex including clinical examination, anthropometry, radiological examination, growth charting, chromosomal analysis but anthropometric measurement of bone still remains the most common method of determining sex.[3-8] Cranial bone analysis whether morphometric or morphological have played an important role in sex determination.

Size, body proportions and architectural differences are the three primary biological differences between males and females.[9] Males generally have more body mass index than females as they have more muscle mass and more weight of axial skeleton. Lots of studies were done for sex determination using skull for various parameters like foramen magnum, mastoid triangle, mastoid process, mandible and various lengths and landmarks.[10,11] Orish et al in 2014 had done similar study for sex determination technique using IOA triangle in Nigerian population and showed that male parameters were higher than female and statistically significant at $p < 0.05$ which correlates well with the present finding.

In this study area of IOA triangle of male (2240.69 mm^2) was found to be significantly higher than that of female (1448.21 mm^2). Our results on IOA triangle seem to agree with the finding of study done on Nigerian skulls by Orish et al and Pal A et al.[12, 13]

CONCLUSION:

According to the methodology used in this study the following conclusions have been drawn:

1. Sexual dimorphism exists for the evaluated parameters
2. The anthropometric measurement of IOA triangle can be of additive value in sex determination of unknown skull.
3. Area of IOA triangle is more reliable tool for sex determination in comparison to linear parameters.

Table I: Descriptive statistics of parameters for male Skull.

Parameter	mean± SEM (mm)	Geometric mean (mm)	Range	Coefficient of variation	S.D.	Sample size	Pearson's correlation coefficient (r)
IO	35.14±0.86	34.56	21.01-48.54	18.15%	6.38	55	-
Lt AI	67.05±0.52	62.93	54.03-70.79	5.77%	3.87	55	0.624
Rt AI	64.48±0.54	64.36	54.4-72.27	6.29%	4.06	55	
Lt AO	71.32±0.66	71.15	58.86-82.18	6.87%	4.90	55	0.710
Rt AO	72.69±0.67	72.51	54.29-83.52	6.85%	4.98	55	

Table II: Descriptive statistics of parameters for female Skull.

Parameter	mean± SEM (mm)	Geometric mean (mm)	Range	Coefficient of variation	S.D	Sample size	Pearson's correlation coefficient (r)
IO	24.95±0.73	24.68	17.32-32.58	14.78%	3.69	25	-
Lt AI	57.47±0.62	57.38	51.43-62.35	5.46%	3.14	25	0.491
Rt AI	58.62±0.76	58.50	49.91-68.99	6.52%	3.82	25	
Lt AO	62.77±0.70	62.67	53.82-67.84	5.57%	3.50	25	0.196
Rt AO	63.44±0.74	63.33	51.91-69.37	5.89%	3.74	25	

Table III: IOA index in males and females

Sex	Lt IOA Index	Rt IOA Index	Average IOA Index
Male	40.76%	42.35%	41.55%
Female	30.87%	31.09%	30.98%

Table IV: Area of IOA triangle in males and females.

Sex	Left (mm^2)	Right (mm^2)	Total area (mm^2)	Pearson's correlation coefficient (r)
Male	1107.78	1132.91	2240.69	0.95
Female	716.93	731.28	1448.21	0.93

Table V: sexual dimorphism ratio of different parameters

Parameters	Male mean	Female mean	Sexual dimorphism ratio (Male mean/ female mean)
IO	35.14 mm	24.95 mm	1.40
AI	63.76 mm	58.04 mm	1.09
AO	72 mm	63.1 mm	1.14
Area of IOA triangle	2240.69 mm^2	1448.21 mm^2	1.55

Table VI: Comparison of parameters in different population.

Author	Place of study	Sample size	Sex	Parameters					
				IO (mm)	IA (mm)		AO (mm)		Area OF IOA (mm^2)
					Right	Left	Right	Left	
Orish et al (2014)	Nigeria	100 (78 male + 22 female)	Male	30.03	63.64	64.69	69.73	71.09	1938.88
			Female	22.34	57.48	59.74	60.92	61.68	1305.68
Pal et al (2018)	India (West Bengal)	70 (38 male + 32 female)	Male	50.83	60.49	58.69	75.15	73.01	2998.78
			Female	40.42	57.20	55.82	69.15	66.38	2270.69
Present study (2018)	India (Haryana)	80 (55 male + 25 female)	Male	35.14	64.48	67.05	72.69	71.32	2240.69
			Female	24.95	58.62	57.47	63.44	62.77	1448.21

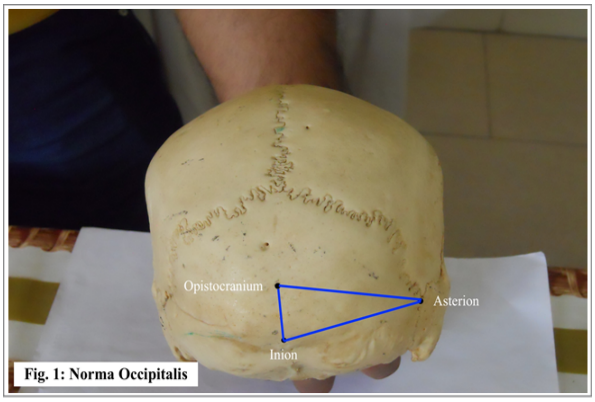


Fig. 1: Norma Occipitalis

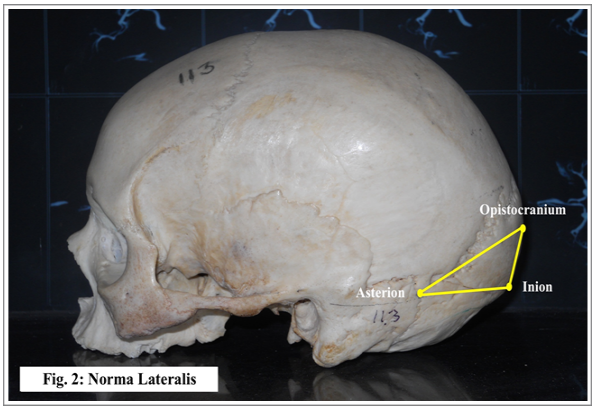
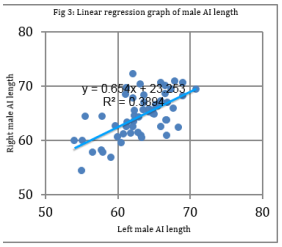
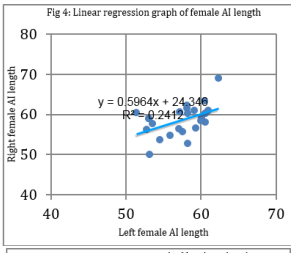
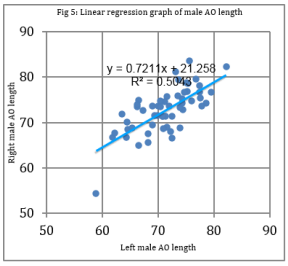
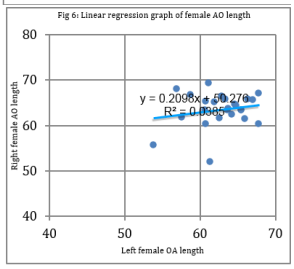


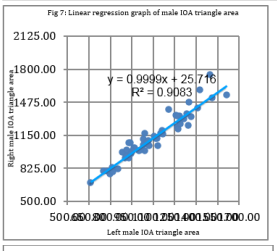
Fig. 2: Norma Lateralis

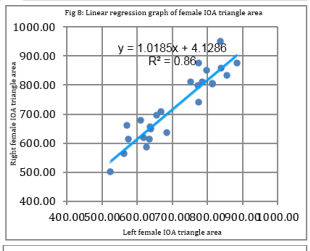


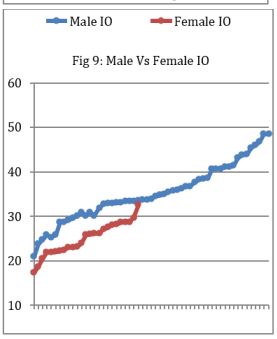


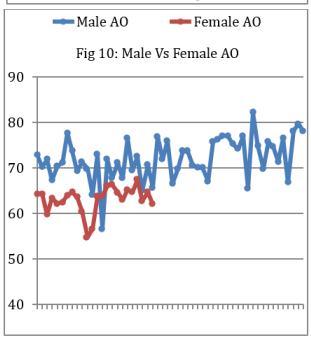


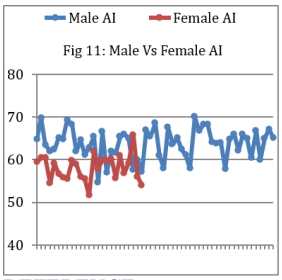


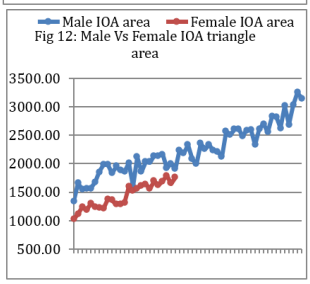












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