Available online at www.elixirpublishers.com (Elixir International Journal)

Physiology and Anatomy

Elixir Physio. & Anatomy 76 (2014) 28358-28361

ISSN: 2229-712X

Mastoid process - A tool for sex determination- A morphometric study in north Indian population

Pawika Singh[1], Abhishek Bahadur Singh[2], Prerna Gupta[1], Muktyaz Hussein[3] and Nava Kumar Bezbaruah[1]

[1]Department of Anatomy, Integral Institute of Medical Sciences and Research, Lucknow, U.P. India.

[2]Department of ENT, King George Medical University, Lucknow, U.P. India.

[3]Department of Anatomy, Govt. Medical College, Ambedkar Nagar, U.P. India.

ARTICLE INFO

Article history:
Received: 25 September 2014;
Received in revised form:
27 October 2014;
Accepted: 6 November 2014;

Keywords
Mastoid process,
Tool for sex determination,
Morphometric study.

ABSTRACT

The mastoid region is favourable for sex determination, as it is the most protected region and resistant to damage due to its anatomical position at the base of the skull. The skull is traditionally considered to be the best skeletal indicator of ancestry and the second best indicator of sex next to the pelvis. The objective of this study is to verify the efficacy of a new method for determination of sex of fragmentary human skeletal remains in the native state of U.P., India. Knowledge of sex estimation through mastoid process is important for Anatomist, physical and forensic anthropologists.

Introduction

The mastoid process is a pyramidal shaped posterior projection of the mastoid portion of the temporal bone located on each side of the head behind the ear. It is situated just behind the external auditory meatus, and lateral to the styloid process. The mastoid bone forms the attachment area for many muscles which is the reason for the process to be more robust in males due to larger muscle mass as compared to females [1]. The mastoid process has been studied by various researchers in different populations for sexual dimorphism. A technique reported by De and Segre 2003[1] for sex differentiation in the mastoid process is made by calculating the total area of the mastoid triangle.

The technique involves measuring the distance between three triangular points (Porion, Mastoidale and Asterion), calculating the area of this triangle and then adding the left & right mastoid triangle areas of the skull which gives the total area used to identify sex. If the value of the total area is greater to or equal to 21447. 40 mm, it represents a male skull, and values less than or equal to 1260.36 mm indicates a female skull (95% confidence). [1] Total area of both mastoid triangles is used for the study due to asymmetry of the mastoid process between the skulls. Unequal mastoid process is formed due to pneumatisation and the size of the mastoid air cell system is determined by the degree of pathological involvement of the middle ear during childhood. [2] The mastoid process is typically more robust in males. Sex differences in the shape and size of the mastoid process are investigated using traditional morphological and metric methods. New approaches such as the mastoid triangle method as reported by Krogman, 1962[3]; Paiva and Segre, 2003[4]; Williams and Rogers, 2006[5] initially yielded very promising results but later was found to be inconsistent for sex differentiation by Suazo et al, 2008[2].

The mastoid region is favourable for sex determination, as it is the most protected region and resistant to damage due to its anatomical position at the base of the skull. The mastoid process is sexually dimorphic, has been affirmed non-metrically by Hoshi 1962[6], Williams and Rogers 2006[5] and metrically by De Moulin 1992[7], Sarangj et. al. 1992[8], Saavedra de Paiva and Segre 2003[1]. Discriminant function analysis is an entirely objective statistical technique for sex determination. It selects the minimum number of traits yielding maximum discriminatory effectiveness. The efficacy of sex discriminant functions is not sure in populations other than the ones from which they have been derived. Faced with a skull of unknown prevalence it is obviously wisest to determine first its race and then its sex by the function appropriate to sex within that race.

Materials and methods

Present study was carried out on 40 human adult dry skulls, obtained from the Department of Anatomy, Integral Institute of Medical Sciences & Research, Integral University and King George Medical University, Lucknow U.P. These were examined for sex determination by usual parameters such as observing capacity, glabella, orbits, supraorbital ridges, zygomatic arch, palate and various foramina. Again all the skulls were examined for their mastoid metric measurements for determination of sex. After that efficacy of the new method of determination of sex was calculated.

Inclusion criteria

The skulls of known sex in which spheno-occipital junction was synostosed and the mastoid part of temporal bone was intact.

Exclusion criteria:

The skulls with physical damage, apparent deformity, defect and in which spheno occipital junction was not synostosed (juvenile skull).

Method of collection of data

The mastoid measurement was obtained with sliding Vernier caliper to the nearest millimeters (mm) as per standard anthropological conventions and then the size of Mastoid process was calculated. The mastoid measurements were taken on both sides, and then the average of both was considered for statistical analysis.

Tele:
E-mail addresses: nigarhus@gmail.com

All the measurements were taken after taking biometric training and by a single observer to avoid any inter-observer error.

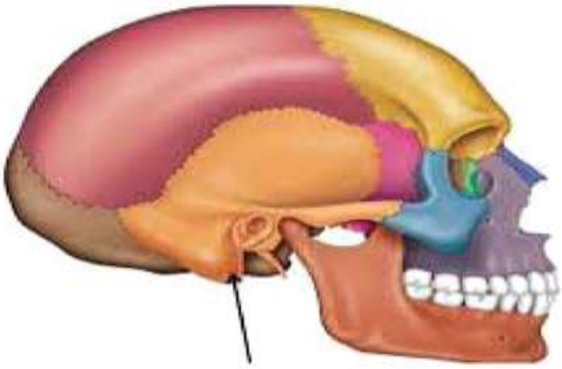

Figure 1. Showing Mastoid Process with arrow in Human Skull.

Measurement of Mastoid Length (Figure 2)

The length of the mastoid process was measured from a point on the Frankfurt's plane vertically downwards to the tip of the mastoid process. With the skull lying on its right side and facing the observer, the calibrated bar of the caliper was placed just behind the mastoid process on the left side, so that the fixed arm was tangent to the upper border of the auditory meatus and it was pointing to the lowest point on the border of the orbit. The calibrated bar should be perpendicular to the Frankfurt's plane of the skull. The measuring arm was moved until it was in level with the tip of the mastoid process, using the flat surface of the arm.

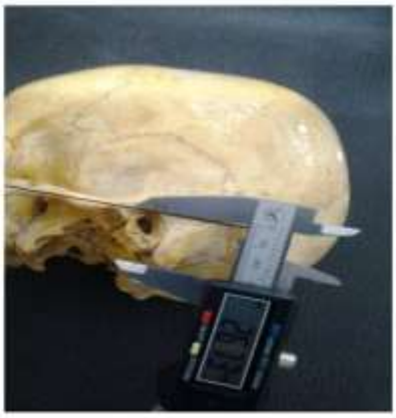

Figure 2.Showing measurement of Mastoid Process Length by digital vernier calliper.

Measurement of Mastoid Length (Medio-lateral Diameter) (Figure 3)

It was taken from the highest part of the medial surface of the mastoid process within the digastric fossa to the most lateral point of the mastoid process on the same level.

Figure 3. Showing measurement of Mastoid Process Breadth by digital vernier calliper

Measurement of Antero-Posterior Diameter of the Mastoid Process (Figure 4)

It was taken from the lowest point at which the tympanic plate abuts against the anterior surface of the mastoid process to the posterior border of the mastoid process on the same level.

Figure 4. Showing measurement of Antero-Posterior diameter of Mastoid Process by digital vernier calliper.

Size of the Mastoid Process

Length X Antero-Posterior Diameter X Breadth

100

Statistical Analysis

The statistical procedures were computed with SPSS (v. 16.0; SPSS Inc., Chicago, IL). The unpaired t-test was used to compare the parameters between male and female. Both stepwise and direct discriminant analysis were used to calculate specific discriminant formulae that can be applied to fragmentary remains. The p-Value <0.05 was considered significant.

Results And Observations

In the present study mastoid process was intact and measurable for all the 40 skulls (27 male and 13 female). The results and observations are shown in the following tables.

Mastoid Length

Table 1: Comparison of Mastoid Length between male and female skulls

Mastoid	**Male**		**Female**		**p-value[1]**
Length	**(n=27)**		**(n=13)**		
	Mean	**SD**	**Mean**	**SD**	
Right	27.51	2.57	23.51	2.06	0.0001*
Left	27.21	2.94	23.51	2.06	0.0001*
Total	27.36	2.71	23.51	2.06	0.0001*

[1]Unpaired t-test, *Significant

Right and left as well as total mastoid length were significantly (p=0.0001) higher among males as compared to females (Table1 & Figure2).

Mastoid Breath

Table 2: Comparison of Mastoid Breadth between male and female skulls

Mastoid	Male		Female	p-value	
Breath	(n=27)		(n=13)		
	Mean	SD	Mean	SD	
Right	10.75	1.84	9.66	1.83	0.08
Left	10.78	2.05	9.70	1.61	0.10
Total	10.76	1.84	9.68	1.72	0.08

[1]Unpaired t-test

There was no significant difference (p>0.05) in the mastoid breadth between male and female (Table 2 & Figure 3).

Antero Posterior (AP) Diameter

Table 3: Comparison of AP Diameter between male and female skulls

AP	**Male**		**Female**		**p-value**
Diameter	(n=27)		(n=13)		
	Mean	SD	Mean	SD	
Right	15.29	2.54	12.43	6.03	0.04*
Left	15.67	3.24	11.43	3.79	0.001*
Total	15.48	2.72	11.93	4.90	0.005*

1Unpaired t-test, *Significant

The AP diameter was significantly ($p<0.05$) higher among males than females (Table 3& Figure 4).

Size of mastoid process

Table 4: Comparison of size of mastoid process between male and female skulls

Size	**Male**		**Female**			**p-value**
	(n=27)		**(n=13)**			
	Mean	**SD**	**Mean**	**SD**		
Right	2.58	0.59	1.73	0.86	0.001*	
Left	2.60	0.68	1.59	0.57	0.0001*	
Total	2.59	0.61	1.66	0.71		0.0001*

1Unpaired t-test, *Significant.

A significant ($p<0.01$) difference was observed in the size of mastoid process between male and female (Table 4).

Discussion

The mastoid process is a pyramidal shaped posterior projection of the mastoid portion of the temporal bone located on each side of the head behind the ear. It is situated just behind the external auditory meatus, and lateral to the styloid process. the mastoid process is absent or rudimentary in the neonatal skull .it forms postnatally ,as the sternocleidomastoid muscle develops and pulls on the bone. The mastoid bone forms the attachment area for many muscles which is the reason for the process to be more robust in males due to larger muscles as compared to females. The mastoid process has been studied by various researchers in different populations for sexual dimorphism. A technique reported by Paiva & Segre 2003[1] for sex differentiation in the mastoid process is made by calculating the total area of the mastoid triangle. The technique involves measuring the distance between three triangular points (Porion, Mastoidale and Asterion), calculating the area of this triangle, adding the left & right mastoid triangle areas of the skull which gives the total area used to identify sex.

The mastoid region is considered as the most protected and resistant to damage due to its anatomical position at the base of the skull. The qualitative assessment of the mastoid process has been widely used to estimate the sex of an individual due to characteristics such as their size, ruggedness for muscular inserts, or mastoid process inclination. The accuracy of sex determination obtained by mastoid process measurements is similar or more accurate than some of the previous works like the studies conducted by Sumati and Patnaik in 2010 (76.7%) [11], 80.0 percent by Kajanoja 1966[12], 85.0 percent by Keen 1950[13], 82.0-89.0 percent by Giles and Elliot 1963[14], 80-95 percent by Tanaka et al. 1979[15] and 90.0 percent by Hanihara 1999[16].

The present study distinguishes itself from previous studies by focusing on sex determination using the mastoid processes which are often well preserved parts of fragmentary crania and also ranking the mastoid variables as per their discriminatory ability. Hoshi 1962[6] classified mastoid process into three main types (male type, neutral type and female type) based on direction of mastoid process. Mean values of mastoid length, medio-lateral diameter, antero-posterior diameter and size of mastoid process were significantly more in males than in females. They were analyzed with highly objective discriminant function and it showed that the four variables, when put together, correctly determined the sex in 90 percent of the sample. Subsequent to stepwise discriminant function analysis, mastoid length was found to be the best sex determinant and when used alone it correctly assessed the sex in 97.5 percent cases.

The discriminant function equation to determine the gender of skulls based on mastoid process has been computed by Sumati and Patnaik 2010[11] for North Indian population. The studies conducted by Patil and Mody 2005[17] in Central India and among north Indian skulls by Sumati and Patnaik 2010[11] revealed that the sex within a given race can be best described by a unique discriminant equation. Therefore, compared with the most important historical studies dealing with the sex determinations of skulls, the present study shows improved results. These results are based on anthropometric techniques, and open paths for further studies based on statistics, which could be of considerable aid to medico-legal investigation. The technique for sexing skulls presented in this study offers a practical alternative to other methods and meets the needs and realities of the forensic investigation in our country today. Thus, the discriminant function equation is unique to skulls of the present study population. Traditionally, physical anthropologists have used two methods of skeletal sex estimation, namely morphological (non-metrical) and metrical, including geometric morphometrics.

The skull is traditionally considered to be the best skeletal indicator of ancestry and the second best indicator of sex (next to the pelvis) by White et al., 2012[18] therefore, the skull is likely the best skeletal element to examine ancestral variation in sexual dimorphism between two groups. Previous research indicates that there is generally some degree of variation in the expression of sexual dimorphism across ancestral populations. The formulae derived from discriminant function analysis tend to yield less accuracy when applied to populations other than the original population from which the formulae are derived. Gupta et al 2012[19] developed a new standard for determination of sex of fragmentary human skeletal remains, using the mastoid process. It also attempts to assign rank to the commonly measured parameters of mastoid with regards to their sex discriminatory power. Logistic regression was also applied on mastoid variables to validate the results of discriminant function analysis. Discriminant function analysis revealed that mastoid process correctly classified the sex in 90 percent of the subjects and mastoid length was found to be the best determinant for sex. A discriminant function equation specific for the present study skeletal population has also been derived from the variables.

Conclusion

In our study we found that both right and left as well as total mastoid length were significantly ($p=0.0001$) higher among males as compared to females. There was no significant difference ($p>0.05$) in the mastoid breadth between males and females. The Anteroposterior diameter was significantly ($p<0.05$) higher among males than females. A significant ($p<0.01$) difference was observed in the size of mastoid process between males and females. Overall, 97.5% of the subjects were correctly classified.

References

1. De Paiva L A, Segre M. Sexing the human skull through the mastoid process. Rev Hosp Clin Fac Med São Paulo. 2003; 58(1): 15-20.

2. Suazo G I C, Zavando M D A, Smith R L. Sex determination using mastoid process measurements in Brazilian skulls. International Journal of Morphology 2008; 26(4):941- 944.
3. Krogman WM. The human skeleton in forensic medicine. Springfield, IL: Charles C Thomas, 1962.
4. Paiva LAS, Segre M. Sexing the human skull through the mastoid process. Rev Hosp Cln. Fac Med Sao Paulo 2003; 58(1):15–20.
5. Williams BA, Rogers TL. Evaluating the accuracy and precision of cranial morphological traits for sex determination. J Forensic Sci 2006; 51:729–35.
6. Hoshi H. Sex difference in the shape of the mastoid process in normal occipitalis and its importance to the sex determination of the human skull. Okajima's Folia Anat Japonica 1962; 38: 309-17.
7. De Moulin F. Importance de certaines measures cranienes (en particulier de la longueur sagittaie de la mastoid) dans la determination sexuelle descranes. Bull et Mem de la Soc D anthropol deParis 1972; 9(Series 12): 259-64. Cited in Sarangi MP, Das S, Sharma GK. Mastoid module a clue to sex determination. Indian Anthropologist 1992; 22(2): 91-3.
8. Sarangi MP, Das S, Sharma GK. Mastoid module a clue to sex determination. Indian Anthropologist 1992; 22(2): 91-3.
9. Sumati, Patnaik. V G V.V.G. Phatak, Ajay G. A.G. Determination of sex from mastoid process by discriminant function analysis. Journal of Anatomical Society of India, Volume 59, Issue 2, December 2010, Pages 222-228.
10. Kajanoja P Sex determination of Finnish crania by discriminant function analysis. American Journal of Physical Anthropology1966. 24: 29–34.
11. Keen JA. Sex differences in skulls. American Journal of Physical Anthropology1950, 8: 65–79.
12. Giles E, Elliot O Sex determination by discriminant function analysis of crania. American Journal of Physical Anthropology1963. 21: 53–58.
13. Tanaka T, Hanihara K, Koizumi K Sex determination of the modern Japanese skulls by means of discriminant function. Sapporo Medical Journal1979. 48: 582–593.
14. Hanihara T, Dodo Y, Kondo O, Nara T, Doi N, Sensui N. Intra- and inter observer errors in facial flatness measurements. Anthropological Science1999, 107: 25–39.
15. Patil KR, Mody RN. Determination of sex by discriminant function analysis and stature by regression analysis a lateral cephalometric study. Forensic Sci In.2005, 147(2-3): 175-180.
16. White, T. D., Black, Michael T., & Folkens, Pieter A. Human Osteology (3rd ed. 2012) San Diego, Ca: Academic Press.
17. Gupta A. Das, Banerjee Arindom, Kumar Anil, Rao Sambasiva R. and Jose Josna. Discriminant Function Analysis of Mastoid Measurements in Sex Determination. J Life Sci, 2012; 4(1): 1-5.