

MORPHOMETRIC STUDY OF MASTOID PROCESS FOR SEXUAL DIMORPHISM

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ABSTRACT

Background: Bone is a highly vascular connective tissue and most plastic in nature next to blood; hence, it adapts to environmental and nutritional status apart from hormonal secretion. Hence, sexual dimorphism study is a challenge for medico-legal experts, anthropologists, and anatomists. **Materials and Methods:** 45 male and 30 female adult dry and nonpathological crania were studied. The various parameters of the mastoid process in known sex crania were measured by digital vernier calipers and recorded. **Results:** Except for the mastoid index, all the parameters of the mastoid process had a significant p-value ($p < 0.001$). The predicted sexual dimorphism of 18 (60%) female and 5 (11%) male crania was observed, and cross-validated crania of 17 (55.6%) females and 6 (13.3%) males were also observed. **Conclusion:** The present pragmatic study will be useful for medico-legal experts, anthropologists, and anatomists. By studying this mastoid process alone, he can predict the gender of crania.

INTRODUCTION

Sexual dimorphism has medico-legal, anthropological, and anatomical importance; bone is the most plastic tissue next to blood because many factors are known to influence and modify the course of bone development, such as deprivation of raw materials, vitamins, hormonal imbalances, and abnormal mechanical situations.^[1] But we have little idea how the genetic “blueprint” contained in the nuclei of the osteoprogenitor cells translated into action. There is a regulatory system involving osteoblasts and osteoclasts and the hormones parathormone and calcitonin.^[2] If the blood calcium level falls, the parathyroid glands are directly stimulated to increase their output of parathormones, which stimulates osteoclast activity, leading to bone resorption and release of calcium and phosphate in the blood. Parathormone is a powerful hormone, and if parathyroid hormone activity is abnormally high, the skeleton melts away and its components are lost in the urine.^[3] Normal growth of bone is dependent on the anterior pituitary, which stimulates cell division in the cartilaginous growth plates. In the absence of sufficient thyroxine, there are variations in the morphometric parameters of the skeleton. The rate of bone growth and maturation is influenced not only by age and sex but also by economic status and individual total body weight.^[4] Hence, an attempt

was made to evaluate the morphometric study of the mastoid process in both sexes.

MATERIALS AND METHODS

45 male and 30 female crania available in the anatomy department of the faculty of Medical Sciences, Khaja Banda Nawaz University, Kalaburgi-585101, Karnataka, were studied.

Inclusive Criteria: Non-pathological, dried, adult crania of known sex were selected for study.

Exclusion Criteria: Broken, pathological crania were excluded from study.

Method: The crania were studied to determine the validity of the mastoid process. Variables in sexual dimorphism. The mastoid process measurements were taken on the crania by using a sliding caliper (in mm) as per the standard anthropological parameters. The Frankfort plane was chosen and marked on the cranium. It is a horizontal plane passing through the upper margin of the external acoustic meatus and the lower margin of the orbital opening. The following measurements were studied on the mastoid process of crania:

1. **Mastoid length:** It was measured from a point on the Frankfurt plane vertically downwards to the tip of the mastoid process. The skull was placed on one side facing towards the observer. The fixed arm of the vernier caliper was

positioned tangentially on the upper border of auditory meatus.

2. **Medio-lateral diameter:** The measurement was taken from the highest part of the medial surface within the digastric fossa to the most lateral point of the mastoid process at the same level.
3. **Antero-posterior diameter:** Mastoid breadth was measured as a straight distance from the posterior end of incisura mastoidea (PEIM) to the nearest point on the posterior border of the external acoustic meatus.
4. **Mastoid process index:** maximum breadth / maximum length of mastoid process $\times 100$.
5. **Asterion to mastoidale (AST-MS):** Mastoidale (MS) is the tip of the mastoid process.
6. **Asterion to porion (PO):** The porion (PO) is the superior point of the external acoustic meatus.
7. **Porion to mastoidale (PO-MS).**

Statistical Analysis: Various parameters of sexual dimorphism were compared with a t-test, and predicted results were classified with percentages. The statistical analysis was carried out in SPSS software.



Figure 1: Mastoid Length measured from a point on the Frankfurt plane vertically downwards to the tip of mastoid process (Red arrow)

RESULTS

Table 1: Various parameters of mastoid process

- *Mastoid length:* 20.18 (± 1.65) in females, 25.34 (± 2.15) in males; t-test was 11.1 and $p < 0.001$.
- *Medio-lateral diameter:* 8.43 (± 1.30) in females, 10.73 (± 1.11) in males; the t-test was 8.2 and $p < 0.001$.
- *Antero-post diameter:* 18.22 (± 1.38) in female and 21.62 (± 1.28) in males; the t-test was 10.9 and $p < 0.001$.
- *Mastoid index:* 85.09 (± 15.2) in female and 84.82 (± 12.8) in male; the t-test was 0.08 and $p > 0.934$ (p-value is insignificant).
- *Asterion-mastoidale:* 45.60 (± 6.20) in female and 48.38 (± 2.36) in males; the t-test was 2.72 and $p < 0.001$.
- *Asterion - Porion:* 41.26 (± 2.06) in female and 45.84 (± 3.12) in males; the t-test was 7.07 and $p < 0.001$.
- *Porion - Mastoidale:* 26.14 (± 2.26) in female and 30.62 (± 3.42) in males; the t-test was 6.30 and $p < 0.001$.

Table 2: Classification of mastoid parameters

- *Observed:* 18 (60%) female and 5 (11.1%) male.
- *Cross validated:* 17 (56.6%) female and 6 (13.3%) male.

Table 3: Present findings are compared with previous studies

Table 1: Various parameters of mastoid process (in mm)

Sl No	Parameters	Female (30)	Male (45)	t-test	p-value
1	Mastoid length	20.18 (± 1.65)	25.34 (± 2.15)	11.1	$P < 0.001$
2	Medio-lateral diameter	8.43 (± 1.30)	10.73 (± 1.11)	8.2	$P < 0.001$
3	Antero-post diameter	18.22 (± 1.38)	21.62 (± 1.28)	10.9	$P < 0.001$
4	Mastoid Index	85.09 (± 15.2)	84.82 (± 12.8)	0.08	$P > 0.001$
5	Asterion-Mastoidale	45.60 (± 6.20)	48.38 (± 2.36)	2.72	$P < 0.001$
6	Asterion-porion	41.26 (± 2.06)	45.84 (± 3.12)	7.07	$P < 0.001$
7	Porion-mastoidale	26.14 (± 2.26)	30.62 (± 3.42)	6.30	$P < 0.001$

Table 2: Classification results of mastoid parameters

	Gender	Predicted group crania
Observed	Female	18 (60%)
	Male	5 (11.1%)
Cross validated	Female	17 (56.6%)
	Male	6 (13.3%)

Table 3: Present studies parameters are compared with previous workers

Workers with date	Population or race	Gender	No of skull	Mastoid length (mm)	Medio-lateral diameter (mm)	Antero-post diameter (mm)
Giles & Elliot (1963)	White Caucasian	Male	--	28.07	--	--
		Female	--	25.21	--	--
	Negra	Male	--	30.30	--	--
		Female	--	26.35	--	--
Sumati et al (2010)	North India	Male	30	28.3 ($\pm$ 4.0)	11.46 ($\pm$ 2.7)	17.52 ($\pm$ 4.69)
		Female	30	23.18 ($\pm$ 4.2)	8.68 ($\pm$ 2.6)	13.69 ($\pm$ 3.67)
Gupta AD et al (2012)	South India	Male	35	29.23 ($\pm$ 2.42)	11.24 ($\pm$ 2.0)	16.55 ($\pm$ 3.82)
		Female	35	22.44 ($\pm$ 3.77)	8.59 ($\pm$ 1.5)	12.78 ($\pm$ 2.47)
Vinecta Saini (2012)	North India	Male	104	35.82 ($\pm$ 3.55)	--	25.58 ($\pm$ 1.89)
		Female	34	31.86 ($\pm$ 3.32)	--	22.77 ($\pm$ 2.37)
Nidugala. H (2013)	South India	Male	40	35.63 ($\pm$ 3.91)	--	21.97 ($\pm$ 2.60)
		Female	40	30.55 ($\pm$ 4.09)	--	20.03 ($\pm$ 2.74)
Shobha (2015)	UP population	Male	50	28.62 ($\pm$ 0.62)	12.33 ($\pm$ 0.86)	17.36 ($\pm$ 1.03)
		Female	50	23.92 ($\pm$ 1.59)	12.38 ($\pm$ 1.56)	15.39 ($\pm$ 1.81)
Sukre SB et al (2017)	Maharashtra population	Male	80	25.32 ($\pm$ 0.37)	10.71 ($\pm$ 0.22)	21.60 ($\pm$ 0.32)
		Female	52	20.17 ($\pm$ 0.60)	8.42 ($\pm$ 0.27)	18.21 ($\pm$ 0.51)
Present study (2026)	North Karnataka	Male	45	25.34 ($\pm$ 2.15)	10.73 ($\pm$ 1.11)	21.02 ($\pm$ 1.28)
		Female	30	20.18 ($\pm$ 1.65)	8.43 ($\pm$ 1.30)	18.22 ($\pm$ 1.38)

Present observed results are more or less in agreement with previous studies.

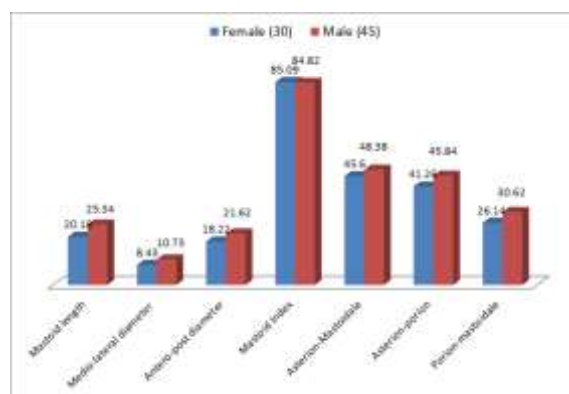


Figure 2: Various parameters of mastoid process (in mm)

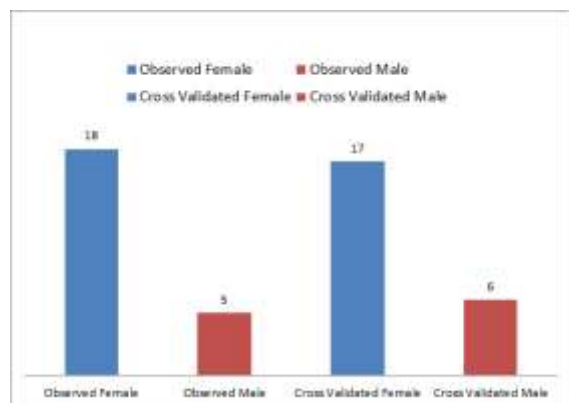


Figure 3: Classification results of mastoid parameters

DISCUSSION

The present morphometric study of the mastoid process for sexual dimorphism in the North Karnataka population shows various parameters of the mastoid process, viz., mastoid length, medio-lateral diameter, antero-posterior diameter, asterion-mastoidale, asterion-porion, and porion-mastoidale have significant p-values (Table 1). The observed classification had 18 (60%) females and 5 (11%) males. The cross-validation had 17 (56.6%) females

and 6 (13.3%) males (Table 2). These findings are more or less in agreement with previous studies.^[5,6,7] [Figure 1]

The mastoid process is not present at birth; it may owe its existence to the pull of the muscles inserted into it and is usually better developed in men than women.

The length and breadth variations in both sexes and on both sides could be due to developmental factors. The otic capsules develop from a number of ossification centers that unite to become the petrosal bone. The petrosal bone is first located in the lateral wall of the neurocranium.^[8]

Due to expansion of the cerebral hemisphere, it was relegated to the ventrolateral position called the "mastoid process." Moreover, evolution affects various parts of the body that have been asymmetrical.^[9] The lower extremities attained their man-like form before the skull; similarly, the skull and its various parts also exhibit evidence of asymmetric evolution, which results in variations of length and breadth of the mastoid process (MP).^[10] The petromastoid bone has various ossification centers. These centers may express their morphometrical individuality, which may result in variations in the length and breadth of the mastoid process (MP). It is also observed that tubercles, tuberosities, and processes (projections) are formed in direct response to external stimuli.^[11]

CONCLUSION

The present morphometric study of the mastoid process (MP) will be helpful to medico-legally explain how to predict the gender on the basis of morphometric parameters of the MP. Moreover, anthropologists can classify the present study of MP from another region of India and abroad with sexual dimorphism; the present study demands embryological, nutritional, and genetic studies because the exact mechanism and formation of MP

are still unclear. It is hypothesized or presumed that the probable function of the MP is related to the degree of development and pull of several muscles attached to it and is presumably related to the balance of the head on the spinal column against the gravity when the variations of the gravity in both sexes may result in variations in the length and breadth of the MP.

Limitation of study: Owing to availability of limited crania and lack of latest techniques, we have limited findings and results to the pull of tendons or ligaments.

- This research paper is approved by the Ethical Committee of faculty of Medical Sciences Khaja Banda Nawaz University, Kalaburgi-585104, Karnataka
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REFERENCES

1. Petaros A, Sholts SB, Slaus M, Bosnar A and Wärmländer SKTS. Evaluating sexual dimorphism in the human mastoid process: A viewpoint on the methodology. *Clin. Anat.*, 2015; 28: 593-601.
2. Krüger GC, L'Abbé EN, Stull KE, Kenyhercz MW. Sexual dimorphism in cranial morphology among modern South Africans. *Int J Legal Med.* 2015;129(4):869-875.
3. Sinhorini PA, Costa IAP, Lopez-Capp TT, Biazevic MGH, de Paiva LAS. Comparative analysis of four morphometric methods for sex estimation: A study conducted on human skulls. *Leg Med (Tokyo).* 2019; 39:29-34.
4. Sumati, Patnaik VVG, Phatak A. Determination of Sex from Mastoid Process By Discriminant Function Analysis. *Journal of Anatomical Society of India.* 2010; 59(2):222-228.
5. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Sex estimation from the mastoid process among North Indians. *J Forensic Sci.* 2012; 57(2):434-439.
6. Ghule Shubhangi B, Mahajan Amrut A, Wagh Kailash B, Ambali MP. Sexual dimorphism in foramen magnum and mastoid process. *International Journal of Recent Trends in Science and Technology.* 2014; 12(1): 56-59.
7. Shah S, Patel P. Sexing the human skull using the mastoid process. *NHL Journal of Medical Sciences.* 2013;2(2):75-78.
8. Bhagya B, Hema N, Ramakrishna A. Validation Metrics of the Mastoid Triangle. *Journal of Health and Allied Sciences.* 2013; 3(2):044-045.
9. Gupta AD, Banerjee A, Kumar A, Rao SR, Jose J. (2012). Discriminant Function Analysis of Mastoid Measurements in Sex Determination. *Journal of Life Sciences.* 2012; 4(1):1-5.
10. Verma Shobha, Babu CS. Sex determination by mastoid process in western UP population. *J of research in Human anatomy and embryology.* 2015.
11. Kemkes A, Göbel T. Metric assessment of the "mastoid triangle" for sex determination: a validation study. *J Forensic Sci.* 2006; 51(5):985-989.