Original Article

Indian Journal of Anatomy
Volume 8 Number 1, January - March 2019
DOI: http://dx.doi.org/10.21088/ija.2320.0022.8119.7

Morphology and Morphometric Study of Mastoid Process in Human Dry Skulls with its Clinical Implications

Hema N[1], Swetha B[2]

Abstract

Aim: To evaluate morphometric measurements of mastoid process in temporal bone and to determine their bilateral differences. *Introduction:* Mastoid process is conical projection of mastoid part of temporal bone. It is situated behind external acoustic meatus and is connected with occipital and parietal bone by occipito-mastoid and parieto-mastoid sutures. The junction of these sutures with lambdoid meet at asterion, which coincides with postero-lateral fontanelle. The external surface is rough and inner surface presents a notch and a groove. It presents mastoid foramen which transmits emissary veins. *Methods*: One hundred South Indian dry skulls of unknown sex and age were studied from the bone collection available at Anatomy department. The parameters of mastoid process like Shape, Breadth, Height, Surface area and Volume were determined. The absence of mastoid foramen was also noted. *Results*: We observed mainly 4 types of shapes of mastoid process in our study. Ovoid, Globular, Conical and Bifid. Ovoid shaped process in most cases and Bifid shape is seen least in our study. Breadth and Height of mastoid process are more on the right side when compared to left side. Surface area in cms and Volume was in cubic cm also showed to be slightly more on the right side. All the parameters showed right sided dominance. Mastoid foramina were absent in 6 mastoid process. 3 on left side and 3 on right side.

Keywords: Mastoid process; Mastoid foramen; temporal bone; asterion.

How to cite this article:
Hema N, Swetha B. Morphology and Morphometric Study of Mastoid Process in Human Dry Skulls with its Clinical Implications. Indian J Anat. 2019;8(1):35-40.

Introduction

Mastoid is the posterior region of temporal bone. It has an outer surface roughened by the attachments of occipital part of occipital frontalis and auricularis posterior. It projects down as conical mastoid process in the posteroinferior region of the temporal bone. Sternocleidomastoid, Splenius Capitis and Longissimus Capitis are attached to lateral surface. There is deep mastoid notch on the medial aspect to which posterior belly of digastric is attached. The borders are serrated for articulation with neighbouring bones. The internal surface bears a sulcus which is separated from mastoid air cells by a thin lamina [1]. Mastoid foramen is present in posterior part of mastoid temporal bone. It may be absent in few and when present, it transmits an emissary vein which communicate sigmoid sinus with post auricular vein or occipital vein and a small meningeal branch of occipital artery [2]. Generally morphological features of mastoid process are described as larger, heavier in males and smaller, more pointed in females [3].

Author's Affiliation: [1]Associate Professor, Department of Anatomy, ESICMC and PGIMSR, Rajajinagar, Bangalore Karnataka 560060, India. [2]Associate Professor, Department of Anatomy, BGS Global Institute of Medical Sciences, Bengaluru, Karnataka 560060, India.

Corresponding Author: Hema N, Associate Professor, Department of Anatomy, ESICMC and PGIMSR, Rajajinagar, Bangalore Karnataka 560060, India.

E-mail: hemanesi@gmail.com

Received 14.12.2018 | **Accepted** 14.01.2019

Materials and Methods

One hundred South Indian dry skulls of unknown sex and age were studied from the bone

collection available at Anatomy departments of Mysore Medical college, ESICMC and PGIMSR, Rajajinagar and BGS Global Institute of Medical Sciences, Bangalore. The following parameters of mastoid process were determined:

1. Shapes of the mastoid process were recorded on both the sides (Fig. 1).
2. MDB- Mastoid breadth/ width of the mastoid process was measured as a line extending from porion (point on the upper margin of external acoustic meatus) to asterion using divider and measuring scale.
3. MDH- Mastoid height / length measured from mastoidale (lowest point of mastoid process) to the intersection of the 1st line which is drawn from porion to asterion using divider and measuring scale (Fig. 2).
4. Surface area was recorded by using square reticule. The lateral surface of the mastoid process of the skull under study was superimposed on a transparent graph sheet which is called as square reticule.

The outline of mastoid process was drawn on square reticule from porion to asterion transversely and to mastoidale using sketch pen. The total number of squares within the outline was counted on the graph sheet which gave the surface area in square centimetres (sq cms) (Fig. 3).

The roughened area on the lateral surface of mastoid process was also marked and calculated

5. Volume was determined by water displacement method after preparing external mould of mastoid process using model clay (Fig. 4).

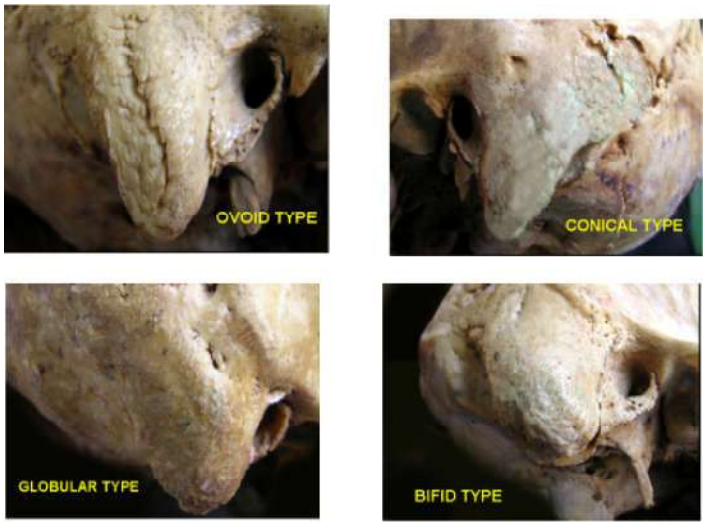


Fig. 1: Different shapes of mastoid process

Table 1: Percentage of Shapes of Mastoid Process on both the Sides

Shape	Right	Left
Ovoid	47	61
Conical	41	30
Globular	10	02
Bifid	02	07

Table 2: Measurement of Mastoid Breadth and Height (cms)

	Right			Left		
	Max	Min	Avg	Max	Min	Avg
Breadth	4.2	2.2	3.2	3.6	2.0	3.08
Height (length)	5.5	2.2	3.63	5.2	2.5	3.4

Table 3: Previous Studies on Mastoid Length by Various Authors

Author	Year	Population	Mean mastoid length in males	Mean mastoid length in females
Giles [22]	1963	Caucasian	28.06 mm	25.10 mm
Giles [22]	1963	Nigroes	30.32 mm	26.34 mm
Sumathi [8]	2010	North Indian	28.3 mm	23.18 mm
Das Gupta [23]	2012	South Indian	29.23 mm	22.44 mm

6. Absent mastoid foramen was noted.

Results

1. Different shapes of the mastoid process were observed on both the sides. (Fig. 1)

Ovoid, Conical, Globular and Bifid shapes were observed. Bifid shaped process was least observed. Percentage of shapes of mastoid process on both the sides is given in Table 1.

2. Breadth and Height (length) of mastoid process are more on the right side when compared to left side. (Table 2 and Fig. 2). Comparative results of the height of mastoid process with previous authors is shown in Table 3.
3. Total surface area and roughened area (which is due to the attachment of muscles) was marked and calculated which also showed that it is more on the right side. (Table 4 and Fig. 3)
4. Volume was measured in cubic cm which also showed to be slightly more on the right side. (Fig. 4).
5. Absent mastoid foramen was found in 6 specimens. (Fig. 5)

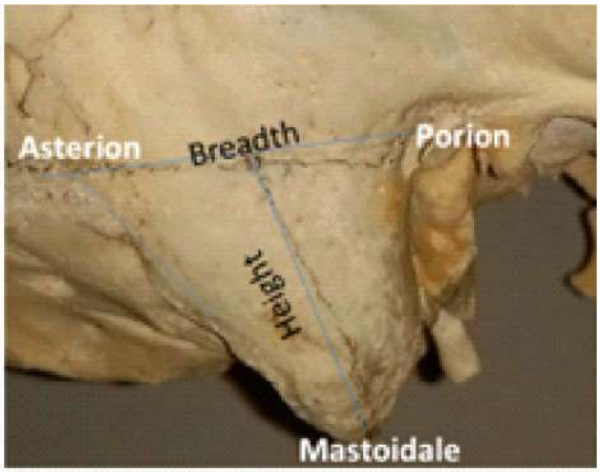


Fig. 2: Breadth and height of mastoid process

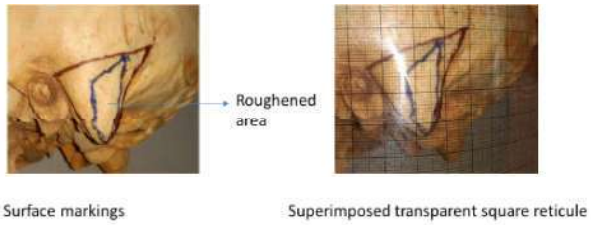


Fig. 3: Surface area

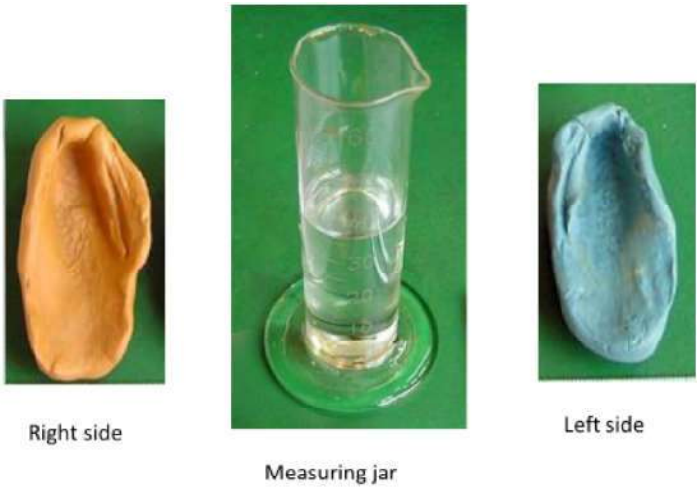


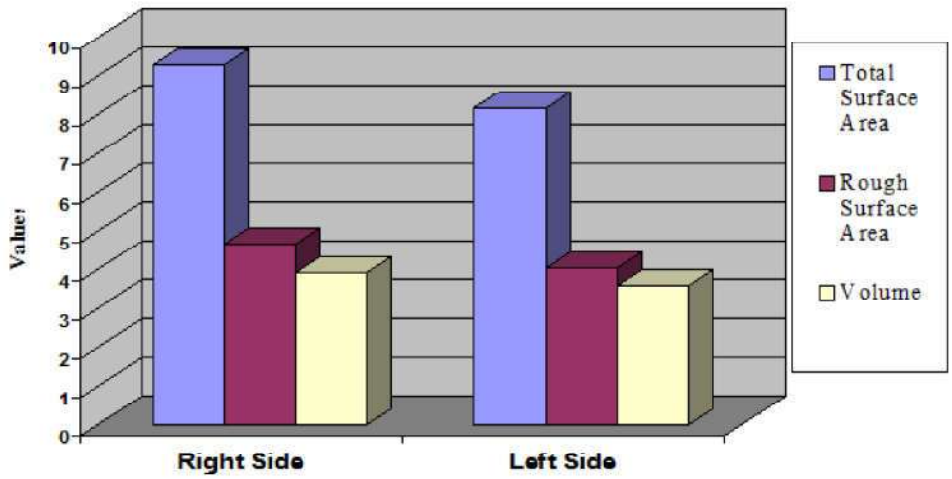
Fig. 4: Clay mould formation for estimation of volume of mastoid process

Table 4: Measurement of Surface Area (sq cm) and Volume (cubic cm)

	Right			Left		
	Max	**Min**	**Avg**	**Max**	**Min**	**Avg**
Total Surface Area	14	6	9.25	13	5	8.15
Rough Surface Area	7	2.5	4.65	6	2	4.03
Volume (CC)	6.2	2.0	3.90	6.0	1.0	3.58

Table 5: The Right Sided Dominance of the Parameters

Parameters	Right	Left
Mastoid breadth	3.2 cms	3.08 cms
Mastoid height	3.63 cms	3.47 cms
Total surface area	9.25 sq cms	8.15 sq cms
Rough surface area	4.65 sq cms	4.03 sq cms
Volume	3.9 cc	3.58 cc



Graph 1: Showing Right Sided Dominance of all the Parameters of Mastoidprocess

Fig. 5: Absent mastoid foramen

All the parameters showed right sided dominance. (Table 5 and Graph 1).

Mastoid foramina were absent in 6 mastoid process. 3 on left side and 3 on right side. (Fig. 5)

Fig. 6: Showing Enlarged foramen, deep notch and mastoid air cells

One skull had deep notch, an enlarged foramen was seen above external acoustic meatus, mastoid air cells was found to be extending up to the tip of mastoid process in one skull. (Fig. 6).

Discussion

Mastoid process is absent in new born and develops in 2nd year, when the child holds the head upright by the pull of sternocleidomastoid. The air cells gradually extend into it and by 4th year, they are well formed. Mastoid air cells may fill the mastoid process even to its tip. There are varieties of mastoid process: Pneumatic, Sclerotic and Mixed [2] In 20% of skulls, the mastoid process has no air cells at all [1]. More episodes of otitis media influences the mastoid pneumatization which further leads to

asymmetry [4]. When comparative evaluation done between the present and ancient populations, the otitis media is a common condition [5].

Many studies have been made on sex determination using anthropometric methods, but very few literatures were found on different shapes of mastoid process. Tomohito study concludes that it would not be safe to use mastoid process measurements for sex determination [6]. We have focused our study on the dimensions and shapes of Mastoid process. Descriptive statistics demonstrated pattern of social dimorphism in the mastoid region. The quantitative analysis provides greater consistency in identification than the qualitative features of the mastoid region [7]. This study was conducted to provide information on bilateral morphology and morphometric differences in mastoid process. We observed mainly 4 types of shapes of mastoid process in our study. Ovoid, Globular, Conical and Bifid. Ovoid shaped process was found in majority of skulls. (47 on right and 61 on left side). (Table 1). The observation on the shapes makes our study distinctive from the other available literature.

In our study, average measurement of height (length) showed 3.63 cms on right side when compared to left which has 3.47 cms. In previous studies, mastoid length was measured from a point on Frankfurt's plane to the tip of mastoid process and concluded that mastoid length is utilised to determine the sexes [8]. But Tomihito concluded that this method of measurement is not practical in anthropological and forensic context [6]. The study conducted by Hoshi in 1962 shows differences in mastoid process length and categorised into Male (M), neutral (N) and females (F). Length was found more in male in Japanese skulls [9]. Rajendrakumar et al studied mastoid length and their measurement was 2.4 to 3.7 cms which is correlating with our study [10]. A correlation coefficient was calculated which shows that the height of mastoid process is independent of other variables [11].

Surface area using square reticule was found to be 9.25 sq cm on right and 8.15 sq cm on left which was lesser when compared to studies done by Marco [12]. Temporal bone implants require storage space which is the cavity created by a canal wall up mastoidectomy [13].

An attempt is made to measure the volume of the mastoid process by water displacement method using clay modelling of mastoid process and found to be 3.9 cc on right side and 3.58 cc on left side which showed less values when compared to previous studies. CT measurement showed mastoid volume ranging from 5.5 to 72.4 cc [12]. Numerous studies showed that mastoid air cell system (MACS) volume is indirectly related to the predisposition of the middle ear to certain pathological conditions like otitis Media and cholesteatoma [14].

Recent studies shows the importance of surface area to volume ratio in gas exchange, as ratios appears to be somewhat constant [15]. The mastoid surface area and the volume measured in adult Brazilians follows a linear correlation [12].

Strong correlation between measurement of each side (bilateral symmetry) indicates significant genetic contribution. Weak correlation between these measurements (bilateral asymmetry) are suggestive of predominantly environmental contribution to the assessed structures [12]. The present study provide information on bilateral morphologic and morphometric differences on mastoid process, which showed strong correlation. (Table 5, Graph 1).

Mastoid foramen has a distinguished ancestry with a surgical important structure, primitive jugular vein [16]. We report absent mastoid foramen in 6 skulls. (3% incidence rate) whereas Boyd GI reported 31.9% absent mastoid foramen bilaterally and unilaterally absent in 33.7% [17]. Kim et al found 1.4% absent mastoid foramen bilaterally and 10.3% unilaterally [18]. Our study showed lesser percentage than the previous study.

An enlarged foramina on upper part of external acoustic meatus was observed. Ali Z Syed reported a case of an enlarged mastoid foramen on the right mastoid region of temporal bone by CT scan [19]. If this variant was not recognised would have potentially led to an incorrect diagnosis or caused iatrogenic life threatening bleeding during attempted surgery in the region of mastoid [20]. We found a deep notch on the posterior aspect of mastoid process. (Fig. 6) The success of mastoid operation, both simple and radical is so dependent on exposing the antrum that a definite knowledge of its location and parameters are of paramount importance [21].

Conclusion

An important finding from this study is regarding the right sided dominance of measurements on mastoid process and various mastoid shapes. The Anatomical knowledge about shape and surface area is important for the otologist during

implant surgeries. Mastoid surgeries should be carried out carefully to avoid damage to the surrounding structures.

Acknowledgement

My sincere thanks to 1st year MBBS students for providing skull bones for my study. Dr. J.H. Sharieff, Professor, for guiding us in this study.

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