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CASE STUDY

ROLE OF MASTOID PROCESS IN GENDER DETERMINATION-A RETROSPECTIVE ANALYSIS USING COMPUTED TOMOGRAPHY

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ABSTRACT

Aim & Objectives: To assess the role of mastoid process in gender determination by analyzing its dimensions in a computed tomographic image.
Methodology: Sample size of 100 CT images was determined, considering a confidence level of 95% and an error rate of +/-5%. Radiographic linear measurements were made using customized DICOM software to accurately analyze the dimensions of mastoids in CT images.
Statistics analysis: Z test and Interval estimation was performed.
Results: Dimensions of mastoids in CT images of males were found to be higher when compared to females.
Conclusion: The results of our study indicated that mastoids are one of the tools for gender identification, yielding a good level of accuracy by using computed tomographic images.

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INTRODUCTION

The gender determination from human skeletal material is of fundamental importance for any forensic investigator (Franklin *et al*., 2007) when the crime investigation is found to be challenging. The accuracy of the sex estimation from skeletal remains varies according to bones and their fragmentary condition and the maximum accuracy is obtained when the whole skeleton is available for the purpose (Mehta *et al*., 2015). In absence of any soft tissues, skeletal material is usually analyzed to construct the individual's biological profile, which includes informations about genetic ancestry, sex and stature (Petaros *et al*., 2015). In mass disasters, forensic recognition of the mortal remains was challenging hence newer methods to facilitate the identification became necessary (de Oliveira Gamba *et al*., 2014). Human skull remains highly resistant to physical damage and has numerous technique to measure the complex structure. (Sukumar *et al*., 2013; Galdames *et al*., 2008) In which different craniofacial components have different caliber in Gender identification. Skull and pelvis assume great importance in establishing sex of an individual. (Rattanasalee *et al*., 2014; Lalwani *et al*., 2012) In oral cavity, teeth may be used for gender determination with the aid of odontometric analysis were mandibular canines presented the greatest sexual di-morphism amongst all the teeth (Jindal *et al*., 2013; Srivastava, 2010). Hsiao *et al*. (1996), Rosas and Bastir (2002), and Franklin *et al*. (2004, 2005), found that measurements such as bizygomatic breadth and those capturing the size and shape of the glabellar region and the frontal bone are the most effective sex discriminators. (Jantz *et al*., 2013) In general, mandibular morphology was found to be a poor discriminator of recent human groups (Nicholson and Harvati, 2006). Hence skull remains a better sex determinant of which we have chosen, mastoid process that shows good reliability in gender identification through its triangular dimensions and field of view. Mastoid process shows greater dimorphic trait with females having smaller mastoid than males (Passey *et al*., 2015). As measurement in 3 dimensions is possible in computed tomographic images, CT plays vital role in Forensic Anthropology. Our study is to determine the role of mastoid process in gender identification by using computed tomography images.

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MATERIALS AND METHODS

A Retrospective collection of 100 CT images (50 males and 50 females) was done and samples were under 25 to 50 above age groups. Images with developmental anomalies, Gross Artifacts, Fractures were excluded from the study. These images were taken under 130kv in 45 seconds, which were converted into 3D reformatted volume rendering technique

(VRT) images. Nine Craniometrical points of mastoid process shown in Table 1, were located and linear measuremenst were made bilaterally on the CT images (Figures-a,b,c,d) by using DICOM software. All these measured images were saved under JPEG image format and the results were tabulated using R- software.

RESULTS

Z- test and Interval estimation of our study showed the mean value of 1677.6 ± 342.6mm^2 for male patients which was found to be higher when compared to female patient 1143.23 ± 169.71mm^2 with P value of 0.001 at 95% level of confidence in all 9 dimension as shown in Table 2&3. The contributions of variables in gender determination were shown in Flow chart 1.

DISCUSSION

Mastoid process plays an important role in Gender identification because of its field of view and its triangular dimension. Many studies on mastoid process were done in different population with different methods which includes CBCT images and manual dry skull method.

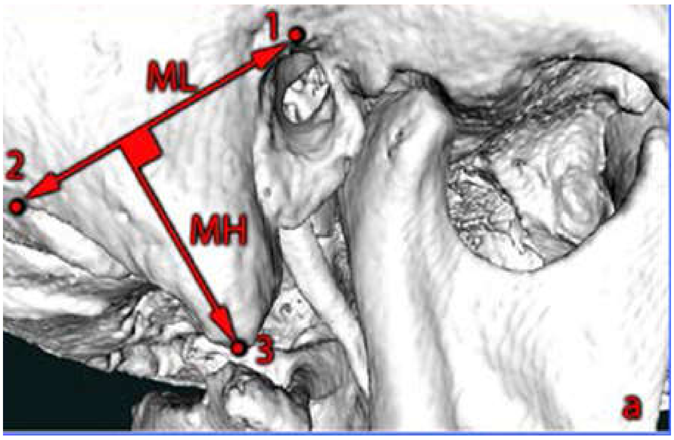


Figure a shows 3D illustrated Anatomical landmarks of the skull, and the points represents as follows. (1) the posterior end of incisura mastoidea, (2) and the mastoidale, (3) the view is also showing the line joining the two points 1 and 2, representing the mastoid length ML; and a perpendicular line from 3 on the 1-2 line, representing the mastoid height MH

Table 1. Description of the Distance in Craniometrical measurements of Mastoid process

Acronyms	Abbreviation	Description
Mastoid height	MH	The height of the mastoid process measured from its tip (the mastoidale) and perpendicular to a line between porion (top of the external auditory meatus) and the posterior end of incisura mastoidea (the groove medial to the mastoid process from which the digastric muscle originates).
Mastoid length	ML	Antero–posterior diameter, the length of the mastoid process measured from porion to the posterior end of incisura mastoidea.
Mastoid width	MW	Medio-lateral diameter, the distance between the highest point on the surface of mastoid process within the digastric fossa to the most protruding point on its lateral surface.
Intermastoidale distance	IMD	Distance between right and left mastoidale, the lowest point on the tip of the mastoid process.
Intermastoid lateral surface distance	IMLSD	Distance between the most prominent point on the convex lateral surface of left and right mastoids.
Mastoid flare	MF	Average distance between the tip of mastoid and the most prominent point on its convex lateral surface.
Mastoid Medial Convergence Angle	MMCA	The angle formed between the line starting from the most laterally prominent point on the mastoid right surface, passing through the right mastoidale and a similar line on the left side.
Mastoid size	MS	Size of the mastoid process = (MH*ML*MW)/100
Mastoid surface area	SA	Surface area of a cone =π(ML/2)*MH

Table 2. Statistical data of mean and standard deviation of mastoid process (n=100)

Dimension	Mean (male)	Stdev (male)	Mean (female)	Stdev (female)	Z-value	P-value
MH	22.58	2.97	18.02	2.26	7.63	0.000
ML	30.3	4.31	23.31	3.05	8.25	0.000
MW	22.47	2.56	19.87	2.9	4.26	0.000
MF	18.04	1.96	16.89	1.9	2.65	0.001
IMD	105.53	4.3	101.95	4.2	3.75	0.000
IMLSD	128.44	7.12	116.49	8.79	6.71	0.000
MMCA	104.53	3.84	100.92	6.05	3.23	0.001
MS	158.04	49.58	84.13	19.59	8.51	0.000
SA	1087.66	266.04	662.93	121.16	8.95	0.000

Table 3. Statistical result of confidence interval for mastoid process (n=100)

	Male	Female
Dimension	95% Confidence Interval	95% Confidence Interval
MH	(21.692, 23.468)	(17.292, 18.748)
ML	(29.012,31.588)	(22.327, 24.293)
MW	(21.705, 23.235)	(18.936, 20.804)
MF	(17.454, 18.626)	(16.278, 17.502)
IMD	(104.245, 106.815)	(100.597, 103.303)
IMLSD	(126.312, 130.568)	(113.658, 119.322)
MMCA	(103.382, 105.678)	(98.971, 102.869)
MS	(143.221, 172.859)	(77.818, 90.442)
SA	(1008.143, 1167.177)	(623.890, 701.97)

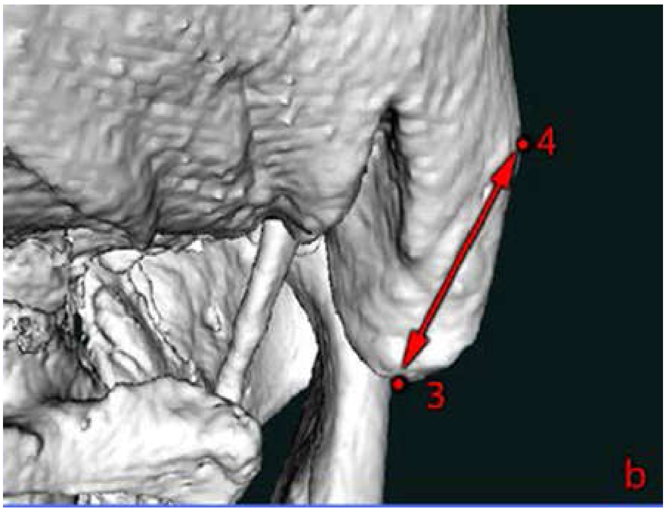


Figure b shows the view is also showing the line joining the two points 1 and 2, representing the mastoid length ML; and a perpendicular line from 3 on the 1-2 line, representing the mastoid height MH, (4) the view is also showing the line joining points 4 and 3, the mastoidale

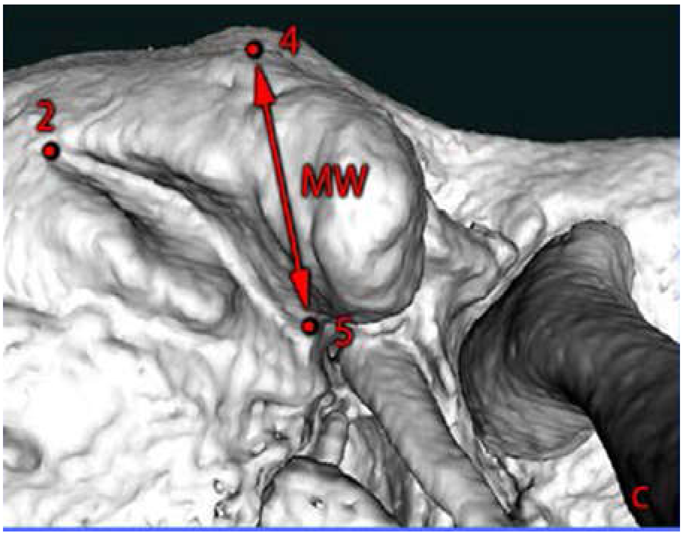


Figure c shows mastoidale the view is also showing the line joining points 4 and 3, the mastoidale; (5) the view is also showing the line joining points 4 and 5representing the mastoid width MW

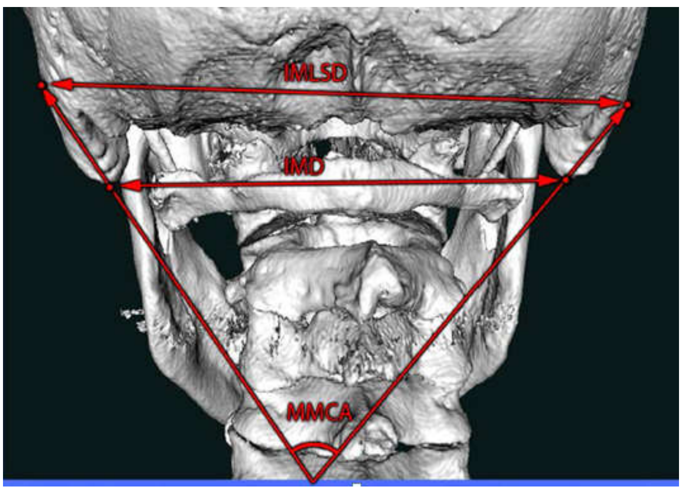
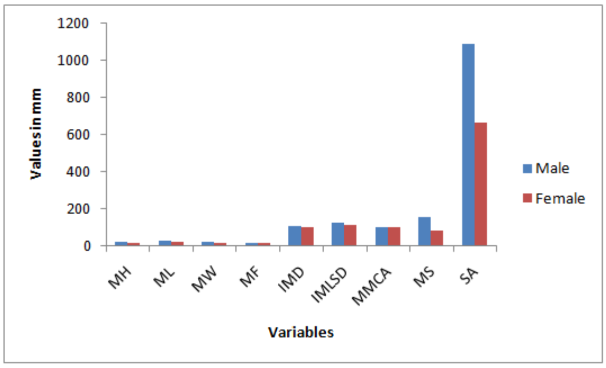


Figure d shows Intermastoid lateral surface distance (IMSLD), Mastoid medial convergence angle (MMCA), Intermastoidale distance (IMD)



Flow chart 1 shows contribution of variables in Gender determination

According to Keen (1950) (Hoshi, 1962) the shape of mastoid process can be consider in gender determination and reported that when a skull is placed on a plain surface, the male samples rest on mastoids process and the female sample rest on the occipital condyles. When Kristen A. Bernard (Bernard, 2009), measured all dimension in both male and female dry skull by manual method and he found that the Mastoid radius (MR) is the accurate tool for the sex determination whereas our study showed all dimensions to be significant and Mastoid surface (MS) showed values higher in male samples than female samples when compared to all other dimensions. Deepali jain *et al*. (2013), Ariane kemkes *et al*. (2006), Marco segre *et al*. (2003) stated that osteometric measurement in mastoid process of different population showed mastoid surface area of male samples to be higher than female samples in accordance to our study. Nagaoka T at al reported that the measurement methods need to be carefully determined and executed to achieve reliable results of sex determination using the mastoid process. (Nagaoka *et al*., 2008) Amin W *et al* determined that the gender discrimination also done by using CBCT images (Amin *et al*., 2015) and also reported similar results in agreement to our study. Mastoid processes are continuously providing high classification accuracies among studied population and hence can be recommended for gender identification.

Conclusion

The present study concluded that all the 9 dimensions showed male samples with higher values than female samples at 95% level of significance, which made an attempt to appropriate the role of mastoid process in sexual dimorphism by using CT Image. Amongst the sex discriminatory function of nine mastoid related variables, Mastoid surface proved to be the best sex identifiers. Furthermore this study can be improved by increasing sample size and standardization of methods significantly.

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