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Research Article

FORAMEN MAGNUM AND MANDIBULAR DIMENSIONS AS AN AID IN GENDER DETERMINATION: A RETROSPECTIVE CONE BEAM COMPUTED TOMOGRAPHY (CBCT) STUDY

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A B S T R A C T

Background and objectives:- Gender determination becomes the first priority in the process of identification of a person by a forensic investigator. The Foramen magnum and mandible show sexual dimorphism and can be imaged using CBCT. Gender determination being population specific, the present study aimed to assess the utility of foramen magnum and mandibular osteometric measurements on CBCT images of a subset of Indian population for gender determination.
Methods:- The CBCT images of 150 subjects were retrieved from the archival records and assessed. Four foramen magnum measurements and six mandibular measurements were measured. All the measurements were subjected to direct discriminant function analysis and their reliability in gender determination was assessed.
Results:- All the Foramen magnum and mandibular measurements showed significant differences between males and females. The predictive accuracy in gender determination was 66.7% on combining all the four foramen magnum measurements and 86.7% on combining all the six mandibular measurements. On combining both the foramen magnum and mandibular measurements, the overall predictive accuracy in gender determination was 83.3%.
Interpretation & Conclusion:-Foramen magnum and mandibular measurements can be used for gender determination with good predictive accuracies.

INTRODUCTION

Personal identification of individuals is an important task in forensics which has significant social and psychological implications (Shamim T. 2012). Determination of age, gender, stature, and ethnicity are the four important features in personal identification (Kanchan T *et al.*2013). Gender determination is the easiest and becomes the first priority in the process of identification of a person by a forensic investigator (Reynolds R *et al.* 1996). Gender identification can be performed from various bones or skeletal remains. If the whole skeleton is available, gender determination can be performed with 99%-100% accuracy (Kerley ER.1978). Next to pelvis, the skull is the part of the skeleton which helps in gender determination with 92% accuracy (Geunay Y *et al.* 1997).

The foramen magnum is an important anatomic landmark in the skull base. Various foramen magnum measurements have found to be useful in gender determination (Ukoha U *et al.* 2011).

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Similarly various metric and non metric parameters of the mandible have been used in gender determination (Sikka A *et al.* 2016; Ilguy D *et al.* 2014). Foramen magnum and mandible can be clearly visualized on advanced imaging modalities like CT scans and CBCT scans (Caravlho SPM *et al.* 2009).

CBCT scans are quite frequently used by dental surgeons for diagnosis and management of a number of maxillofacial disorders and these scans are becoming a part of dental records of the patients. These images can be archived and retrieved at any point of time (Jaju PP *et al.* 2014).CBCT scans can be used for measuring various anatomic landmarks in the maxillofacial region. They provide accurate and reliable linear measurements of anatomic structures (Ilguy D *et al.*2014).

Sexual dimorphism is population specific and gender determination in the human cranium is based on population differences in the size and built of the bony structures (Gapert R *et al.* 2009).Studies in Indian population have used either foramen magnum or mandibular measurements alone for gender determination (Vinay G *et al.* 2013; Kanchan T *et al.*2013). Most of these studies were done using dry skulls. A very few studies have been done using CT/CBCT images (Ilguy D *et al.* 2014; Uthman AT *et al.* 2012; Jaitley M *et al.*

2016). With this background, the present study aimed to assess the utility of foramen magnum and mandibular osteometric measurements on the CBCT images of a subset of Indian population for gender determination.

MATERIALS AND METHODS

The present study was a retrospective CBCT study conducted in the Department of Oral Medicine and Radiology, DAPMRV Dental College, Bengaluru in collaboration with Oral 3D diagnostic centre, Bengaluru. Before the commencement of the study, approval was obtained from the institutional ethical committee.

CBCT images of subjects of 18years and above were assessed in the study. CBCT images with pathologies, fractures involving the skull base and the mandible and those with errors and artifacts that obscure the visualization of foramen magnum and the mandible were excluded from the study.

Method of collection of data

The images of the subjects who had undergone a CBCT examination of the skull were retrieved from the archival records of a CBCT centre in Bengaluru and assessed. 150 CBCT images of the subjects who had given prior written consent for usage of their CBCT images for future research and publication purposes were included in the study.

The CBCT images were obtained using a 3D KODAK 9300C CBCT machine at the diagnostic centre with a 360 degree scan. The exposure parameters used were:-Tube voltage of 180kVp, Tube current of 10mA, Exposure time of 14seconds, Cylindrical shaped large field of view (FOV) measuring 14x17mm and Voxel size of 200microns.

All the images were assessed using CS 3D imaging software after the orientation of the images prior to the measurements and under optimal viewing conditions.

Foramen Magnum measurements (Figure 1)

A line passing from the anterior to posterior border of the FM was oriented parallel to the horizontal plane in the sagittal section in oblique slicing. Four FM measurements were assessed. The foramen magnum sagittal diameter (FMSD), foramen magnum transverse diameter (FMTD) and the circumference (FMC) were measured as shown in the figure 1. The area (FMA) was calculated using the formula given by Teixeria (Teixeira WRG. 1982).

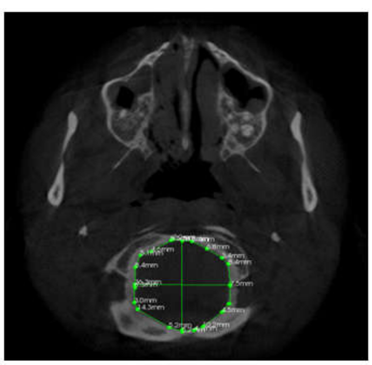

Figure 1 Axial section of CBCT image showing FMSD, FMTD and FMC measurements

FMSD is the greatest antero posterior dimension of the foramen magnum, FMTD is the greatest width of foramen magnum and FMC is measured after tracing the bony margin of the foramen magnum on the CBCT image.

Mandibular measurements (Figure 2,3&4)

For the mandibular measurements, the Frankfort plane was held parallel to the horizontal plane on the lateral view. Six mandibular measurements; gonial angle (Go-Angle), ramus length (R-length), minimum ramus breadth (Min R breadth), gonion-gnathion length (Go-Gn) (figure 2), bigonial breadth (Bi-Go) (figure 3) and the bicondylar breadth (Bi-Co) (figure 4) were measured.

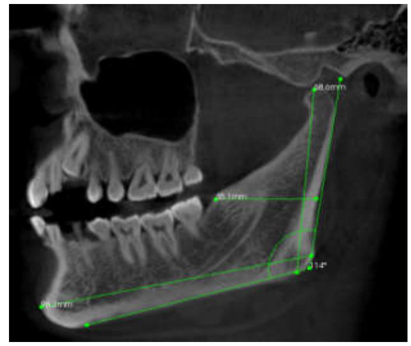

Figure 2 Sagittal section of CBCT image showing R-Length, Min R Breadth, Go-Angle & Go-Gn length measurements

R-length is the distance between the condylion and gonion,Min R breadth is the perpendicular line drawn from the inferior most part of the ascending ramus to the posterior border of the ramus, Go-Angle is the angle formed between the tangent to the lower border of the mandible and the tangent to the posterior border of the ramus and the distance between the Gonion and Gnathion gives the Go-Gn.

Figure 3 Axial section of CBCT image showing Bi-Go breadth measurement

Bi-Go is the distance between two gonions.

Figure 4 Axial section of CBCT image showing Bi-Co breadth measurement

Bi-Co is the distance between two condylions.

The 150 images were evaluated in a darkened quiet room. The images were assessed by two examiners independently. The first observer, after evaluating the complete set of images, evaluated 50 images for the second time after an interval of 1week. The second observer evaluated 30 images. The results obtained were tabulated and subjected to statistical analysis.

Statistical tests were done using SPSS software version 21.0. Student t test was used to determine the differences in the FM and mandibular measurements between males and females. To determine inter and intra observer variability, Intraclass Coefficient Test programme was used. To determine the correlation between the right and left mandibular measurements, Pearson correlation coefficient was used. In order to discriminate between males and females using the FM and mandibular measurements, direct discriminant function analysis was used. Equations were derived for the combination of measurements by discriminant function analysis.

RESULTS

A total of 150 full skull CBCT images were assessed in the present study out of which 77 (51.3%) were that of males and 73 (48.67%) were that of females. The Intraclass coefficient (ICC) values showed that there was perfect intraobserver (ICC value >0.8) and perfect interobserver (ICC value >0.8) agreement for the measurements in the present study.

Table 1 summarizes the comparison of FM measurements between males and females. All the four FM measurements were more in males as compared to females in the present study and the difference was statistically significant (FMSD p=0.000, FMTD p=0.001, FMC p=0.000 and FMA p=0.000).

Table 1 Gender wise comparison of foramen magnum measurements

	Males		Females		p value
	Range	Mean± SD	Range	Mean± SD	
FMSD (mm)	31.1-46.3	38.02 ± 2.8	30.4- 41.3	35.58 ± 2.8	0.000*
FMTD (mm)	24.6-39.3	31.85 ± 2.95	25.2- 39.5	30.37 ± 2.9	0.001*
FMC (mm)	90.8-143.9	112.94 ± 9.79	91.5- 130.2	107.46 ± 9.53	0.000*
FMA (mm^2)	619.84- 1388.04	962.8 ± 139.27	635.23- 1246.6	857.67±136.73	0.000*

*p <0.05

Table 2 Gender wise comparison of mandibular measurements

	Males		Females		p value
	Range	Mean± SD	Range	Mean± SD	
Go-Angle (°)	113 - 149	128.12 ± 5.8	118 - 143	130.23 ± 6.05	0.032*
R-Length (mm)	49.9 - 75.4	63.96 ± 6.44	45.3 - 75.7	58.5 ± 6.43	0.000*
Min R Breadth (mm)	18 - 31.9	25.66 ± 3.51	15.9 - 31.8	21.85 ± 3.5	0.000*
Go-Gn length (mm)	64.1 - 93.6	79.18 ± 6.79	59.9 - 84.4	71.9 ± 6.83	0.000*
Bi-Go (mm)	43.6 - 60.1	51.55 ± 4.41	36.8 - 56.7	47.19 ± 4.56	0.000*
Bi-Co (mm)	68.4 - 96.3	81.44 ± 5.26	70 - 96.5	79.6 ± 5.19	0.029*

*p <0.05

Right and the left mandibular measurements showed high positive correlation on pearson correlation coefficient (p=0.000).

There was no significant difference between the mandibular measurements on the right and the left sides. Therefore for the purpose of statistical analysis, the mandibular measurements on the left side were considered.

Table 2 summarizes the comparison of mandibular measurements between males and females. All the mandibular measurements except the Go-Angle were greater in males than in females, while the Go-Angle was greater in females. These findings were found to be statistically significant (Go-Angle p=0.032, R-Length p=0.000, Min R Breadth p=0.000, Go-Gn length p=0.000, Bi-Go p=0.000 and Bi-Co p=0.029).

Table 3 summarizes the findings of the Discriminant function analysis. The measurement with least value for Wilk's lambda was considered to be having the best predictive value in gender determination. Among the FM measurements the most reliable single predictor in gender determination was FMSD, followed by FMA, FMC and FMTD. Among the mandibular measurements, the most reliable single measurement in gender determination was Min R Breadth followed by Go-Gn length, Bi-Go breadth, R-Length, Bi-Co breadth and Go-Angle. On combining the four FM measurements or the six mandibular measurements or using all the 10 measurements, the predictability in gender determination was increased as compared to individual measurements. The six mandibular measurements combined had the most discriminating ability.
The discriminant equations derived are as follows.

For the four FM measurements: D= -25.628 + 0.830(FMSD) + 0.436(FMTD) - 0.068(FMC) - 0.012(FMA)

For the six mandibular measurements: D= -27.871 + 0.059(Go-Angle) + 0.077(R-Length) + 0.172(Min R Breadth) + 0.079(Go-Gn) + 0.118(Bi-Go) - 0.005(Bi-Co).

For the combined FM and mandibular measurements: D= -19.872 - 0.172(FMSD) - 0.256(FMTD) + 0.034(FMC) + 0.007(FMA) + 0.055(Go-Angle) + 0.071(R-Length) + 0.145(Min R Breadth) + 0.082(Go-Gn) + 0.087(Bi-Go) - 0.016 (Bi-Co).

Table 3shows a sectioning point for all the measurements derived from the group centroids obtained from the discriminant function analysis. On substituting the measurements into the equation, those with values above the sectioning point was considered as male and those below the sectioning point as female. Table 3 shows the predictive accuracy of all the FM and mandibular measurements.

Table 3 Discriminant function analysis

	Wilk's Lambda	Group Centroid		Sectioning point	Correctly classified			p value
		Male	Female		Males	Females	Overall	
FMSD	0.806	0.475	-0.501	-0.013	66.2%	65.8%	66%	0.000*
FMTD	0.933	0.259	-0.273	-0.007	54.5%	65.8%	60%	0.001*
FMC	0.917	0.292	-0.308	-0.008	61%	67.1%	64%	0.000*
FMA	0.851	0.405	-0.427	-0.011	63.6%	69.9%	66.7%	0.000*
Go-Angle	0.969	-0.172	0.182	0.005	50.6%	56%	53.3%	0.032*
R- Length	0.818	0.457	-0.482	-0.0125	67.5%	69.9%	68.7%	0.000*
Min R Breadth	0.699	0.634	-0.669	-0.0175	71.4%	78.1%	74.7%	0.000*
Go-Gn length	0.717	0.607	-0.640	-0.0165	72.7%	80.8%	76.7%	0.000*
Bi-Go	0.768	0.531	-0.561	-0.015	70.1%	74%	72%	0.000*
Bi-Co	0.968	0.175	-0.185	-0.005	57.1%	65.8%	61.3%	0.029*
4 FM variables	0.787	0.504	-0.531	-0.0135	70.1%	63%	66.7%	0.000*
6 Mandibular variables	0.489	0.989	-1.044	-0.0275	81.8%	91.8%	86.7%	0.000*
All 10 variables	0.580	0.770	-0.928	-0.079	79.3%	88.2%	83.3%	0.000*

*p <0.05

The overall predictive accuracy was 66.7% on combining all the four FM measurements and 86.7% on combining all the six mandibular measurements. On combining all the four FM and six mandibular measurements, the overall predictive accuracy in gender determination was 83.3% with 79.3% of males and 88.2% of females being correctly identified.

DISCUSSION

While applying discriminant functions for gender identification, the population under study is critically important. Discriminant functions applied to populations other than the reference population have shown an error between 32 to 48% in determining gender (Catalina-Herrera CJ. 1987). It is therefore necessary to study sexual dimorphism of various cranial structures in as many geographically diverse populations as possible.

A study comparing measurements of various anatomic landmarks in dry skulls and in CBCT images showed almost perfect agreement between the two methods and concluded that reconstructed images in CBCT provide true linear measurements between the anatomic landmarks of the skull and hence are comparable clinically (Periago DR *et al*. 2008).

Foramen Magnum measurements

The FM has a regular structure and is located in an area that is less prone to injury (Routal RR *et al*. 1984).There are no muscles acting upon the shape and size of the FM and hence it is considered to be a stable anatomical structure (Vinutha SP *et al*. 2016).FM attains its adult size early in childhood and is not affected by significant secondary sexual changes. Osteometric measurements in FM have shown to be greater in males than in females and hence FM measurements can be used in gender determination (Ilguy D *et al*. 2014).

In the present study, all the four FM measurements were greater in males than in females and this difference was statistically significant. Study done in Europe using 3D CT images has shown statistically significant differences for FMSD and FMTD between males and females with the values being greater in males (Burdan F *et al*. 2012). A study done in Brazilian population has found the mean FMA to be greater in males than in females (Teixeira WRG. 1982). A study done in Turkey (Ilguy D *et al*. 2014) and another study in Indian population (Jaitley M *et al*. 2016) using CBCT images have found that all four FM measurements were significantly greater in males as compared to females.

Foramen magnum is one of the primary centers of ossification on the cranial base during growth and development. The dimorphism exhibited by FM is related to the post natal development of FM. The anterior and the posterior borders of FM are delineated by the anterior and posterior intraoccipital synchondroses. The final length of the FM is determined by the anterior intraoccipital synchondrosis since it fuses at a later age as compared to the posterior synchondrosis. The anterior synchondrosis in turn is connected to the basilar part of the occipital bone through the sphenooccipital synchondrosis. The disappearance of the spenooccipital synchondrosis by around 18 to 20 years of age forms the actual clivus which connects the FM and the dorsum sellae. The distance between the dorsum sellae and the anterior aspect of the FM is found to be more in females resulting in small size of the FM in females (Burdan F *et al*.2012).

The other related factors contributing to gender dimorphism of FM include the stature, dimensions of the vertebral canal and the spinal cord. The dimensions of the vertebral canal and the spinal cord correlate with the number of motor and the sensory neuronal fibres passing through it, which in turn is related to the body size. It has been shown that the spinal cord mass is indirectly related to the body length, more than to body weight. Therefore the larger dimensions of FM measurements in males can also be attributed to the evolutionary trend of humans where in the male species is found to have larger built when compared to female species (Burdan F *et al*.2012).

Mandibular measurements

In the present study, all the mean mandibular measurements except the Go-Angle were greater in males as compared to females, with the Go-Angle being greater in females. This difference in the mean measurements between males and females was statistically significant. An Indian study using dry skulls has found all the mandibular measurements except the Go-Angle to be greater in males than in females (Kumar MP *et al*. 2013).A study done in Turkey using CBCT images has also found that all the mandibular measurements except Go-Angle were significantly greater in males as compared to females (Ilguy D *et al*. 2014). Studies using CBCT images in Brazil (GambaTde O *et al*. 2016) and China(Dong H. 2015) have also drawn similar conclusions.

Mandible is considered to be the most dimorphic bone in the skull which is reflected in its size and shape (Vinay G *et al*. 2013). In general, overall size and bone thickness of the male skeleton is more than that of females (Taleb NSA *et al*. 2015). Mandibular ramus is a potential site associated with morphological changes in size and remodeling during growth (Indira AP *et al*.2012). The forces exerted by the masticatory muscles onto the ramus are another major factor influencing its size and shape. Generally males exhibit greater masticatory forces than females and hence have larger bone size and shape with prominent muscle attachment sites (Sikka A *et al*. 2016). Hence males have greater R-Length and Min R Breadth when compared with that of females due to their large size of the mandibular ramus.

There is a forward rotation of the mandible in males where as a slight downward and backward rotation of the mandible is noted in females (Pecora NG *et al*. 2008).By about second decade of life, the gonion and the symphysis are pointed more downwards in males as compared to females. Moreover the mental region shows a downward positioning in males against a superoinferior and upward positioning in females (Rosas A*et al*. 2002). It was also found that the posterior border of the ramus shows an anterior flexion in males while a pronounced posterior flexion of ramus is seen in females (Alarcon JA *et al*. 2016).These features are responsible for a larger Go-Angle in females as compared to males. These features along with large skeletal built and stature in males contribute to greater Go-Gn length in males as compared to females.

The increased Bi-Go and Bi-Co breadths in males could be attributed to the well developed gonial regions and a distinct gonial flaring in males as compared to females. Moreover, males exhibit eversion of the mandibular angle while inversion is a characteristic in the mandibular angle of females (Kumar MP *et al*. 2013). Mandibular condyles are found to be smaller in females. This smaller diameter of the condyle in females may also be related to the lesser Bi-Co breadths in females than in males (Kumar MP *et al*. 2013).

Gender predictive accuracies of FM and mandibular measurements using Discriminant function analysis

In the present study, among the FM measurements, FMSD was found to be the most reliable single predictor of gender. This was in accordance with a study done in Turkey using CBCT images (Ilguy D *et al*. 2014).The overall predictive accuracy in the present study using FM measurements was 66.7%, which was almost in accordance with the results of the studies done in Britain (70.3%) (Gapert R *et al*. 2009) using dry skulls and another study in India (72%) (Jaitley M *et al*. 2016) using CBCT images. These findings suggest that FM measurements may provide comparable accuracies in gender determination.
In the present study, among the mandibular measurements, Min R Breadth was found to be the most reliable single predictor of gender. This was in accordance with a study done in India (Indira AP *et al*.2012). On combining all the six mandibular measurements, the overall gender predictive accuracy was 86.7%.

A study in Turkish population using CBCT images for mandibular measurements has shown an overall predictive accuracy of 83.2% (Ilguy D *et al*. 2014). A CBCT study in Chinese population using mandibular measurements has shown an overall predictive accuracy of 82.4% (Dong H. 2015).Various Indian studies using dry skull measurements and digital radiographic measurements showed an overall predictive accuracy of 75 to 81% (Sikka A *et al*. 2016; Kumar MP *et al*. 2013; Indira AP *et al*.2012). On comparison with these studies, the overall predictive accuracy in the present study was slightly higher indicating that mandibular measurements on CBCT images may be used in gender determination with good predictive accuracies.

In the present study, on combining all the four FM and six mandibular measurements, an overall predictive accuracy of 83.3% was noted. Results of the present study was in accordance with a study done in Turkey using CBCT images showing predictive accuracy of 83.2% (Ilguy D *et al*. 2014). From the present study, it could be concluded that CBCT images provide accurate and reliable measurements and FM and mandibular measurements can be used for gender determination with good predictive accuracies in Indian population.

References

1. Alarcon JA, Bastir M, Rosas A. Variation of mandibular sexual dimorphism across human facial patterns. *J Comp Human Biol* 2016 ;67(3):188-202.
2. Burdan F, Szumiło J, Walocha J, Klepacz L, MadejB, Dworzański W *et al*. Morphology of the foramen magnum in young Eastern European adults. Folia Morphol 2012; 71(4):205-16.
3. Caravlho SPM, Silva RHA, Lopes Jr C, Sales-Peres A. Use of images for human identification in forensic dentistry. Radiol Bras 2009; 42(2): 125-30.
4. Catalina-Herrera CJ. Study of the anatomic metric values of the foramen magnum and its relation to sex. ActaAnat (Basel)1987; 130(4):344-7.
5. Dong H.Sexual dimorphism of the mandible in a contemporary Chinese Han population. Forensic SciInt 2015; 255:9-15.
6. GambaTde O, Alves MC, Haiter-Neto F. Mandibular sexual dimorphism analysis in CBCT scans. *J Forensic Leg Med* 2016; 38:106-10.
7. GapertR, Black S, Last J. Sex determination from the foramen magnum: discriminant function analysis in an eighteenth and nineteenth century British sample. *Int J Legal Med* 2009; 123:25-33.
8. Geunay Y, Altinkeok M, Cagdir S, Kirangil B. Sex determination with skull measurements. *J Forensic Med* 1997; 13:13-9.
9. Ilguy D, Ilguy M, Ersan N, Dolekoglu S, Fisekcioglu E. Measurements of foramen magnum and mandible in relation to sex using CBCT. *J Forensic Sci* 2014; 59(3):601-5.
10. Indira AP, Markande A, David MP. Mandibular ramus: An indicator for sex determination - A digital radiographic study. *J Forensic Dent Sci* 2012; 4(2): 58-62.
11. Jaitley M, Phulambrikar T, Kode M, Gupta A, Singh SK. Foramen magnum as a tool for sexual dimorphism: A cone beam computed tomography study. *Indian J Dent Res* 2016; 27:458-62.
12. Jaju PP, JajuSP. Clinical utility of dental cone-beam computed tomography: Current perspectives. ClinCosmetInvestig Dent 2014; 6:29-43.
13. Kanchan T,Gupta A,KrishanK.Craniometric Analysis of Foramen Magnum for Estimation of Sex. *Int J Med Health Pharm Biomed Eng* 2013;7(7):166-8.
14. Kanchan T, Krishan K. Personal identification in forensic examinations. Anthropol 2013; 2:114.
15. Kerley ER. Recent developments in forensic anthropology. YrbkPhysAnthropol 1978; 21:160-73.
16. Kumar MP, Lokanadham S. Sex determination & morphometric parameters of human mandible. *Int J Res Med Sci* 2013;1(2):93-6.
17. Pecora NG, Baccetti T, McNamara JA Jr. The aging craniofacial complex: A longitudinal cephalometric study from late adolescence to late adulthood. *Am J OrthodDentofacialOrthop* 2008; 134:496-505.
18. Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. Angle Orthod 2008; 78:387-95.
19. Reynolds R, Varlaro J. Gender determination of forensic samples using PCR amplification of ZFX/ZFY gene sequences. *J Forensic Sci* 1996; 41(2):279-86.
20. Rosas A, Bastir M, Martinez-Maza C, Bermudez de Castro JM. Sexual dimorphism in the Atapuerca-SH hominids: The evidence from the mandibles. *J Hum Evol* 2002; 42:451-474.
21. Routal RR, Pal GP, Bhagwat SS, Tamankar BP. Metrical studies with sexual dimorphism in foramen magnum of human crania. *J AnatSoc India* 1984;33: 85-9.
22. Sikka A, Jain A. Sex Determination of Mandible: A Morphological and Morphometric Analysis. *Int J Contemp Med Res* 2016; 3(7): 1869-72.
23. Shamim T. Forensic Odontology. J Coll Physicians Surg Pak 2012; 22(4): 240-5.

24. Taleb NSA, Beshlawy ME. Mandibular Ramus and Gonial Angle Measurements as Predictors of Sex and Age in an Egyptian Population Sample: A Digital Panoramic Study. *J Forensic Res* 2015; 6(5):308.
25. Teixeira WRG. Sex identification utilizing the size of the foramen magnum. *Am J Forensic Med Pathol* 1982;3(3):203-6.
26. Ukoha U, Egwu OA, Okafor IJ , Anyabolu AE, Ndukwe GU, Okpala I. Sexual Dimorphism in the Foramen Magnum of Nigerian Adult. *Int J Biol Med* Res 2011; 2(4): 878 - 81.
27. Uthman AT, Al-Rawi NH, Al-Timimi JF. Evaluation of foramen magnum in gender determination using helical CT Scanning. DentomaxillofacRadiol 2012; 41(3): 197-202.
28. Vinay G, Gowri MSR, Anbalagan J. Sex determination of human mandible using metrical parameters. *J ClinDiagn Res* 2013;7(12):2671-3.
29. Vinutha. S.P, Shubha. R. Morphometry and sexual dimorphism in foramen magnum: a study of human skull bones. *Int J Anat Res* 2016;4(3):2593-9.

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