BIOINFORMATION
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BIOMEDICAL INFORMATICS

www.bioinformation.net
Volume 18(5)

Research Article

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Variations in the shape of foramen magnum at the base of human skulls among Indians in Rajasthan

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Abstract:
Variations in the shape of foramen magnum can affect the normal anatomy of vital structures passing through it. Therefore, it is of interest to evaluate the various shapes of foramen magnum by using CT scans performed in patients of Indian population to establish clinical

correlation. A total of 314 CT images of human skull base obtained from the Department of Radio-diagnosis, Geetanjali Medical College and Hospital, Udaipur, Rajasthan were used in the present study. All the patients' CT scans were observed to determine the shape of foramen magnum. They were classified into one of the following shapes: Oval, round, tetragonal, egg shaped, hexagonal, pentagonal and irregular. The shapes of the foramen magnum in CT scans were oval in 39.09%, round in 22.61%, tetragonal in 12.10%, hexagonal in 10.51%, irregular in 7.96%, pentagonal in 5.41% and egg shaped in 1.59% CT images. Data shows that it is easy to operate at the base of skull in case of round, oval and hexagonal shape foramen magnum, as the working space is more in these shapes.

Keywords: Radiological study, CT Image, variations, shape, foramen magnum

Abbreviations: FM (Foramen Magnum), CT (computed tomography)

Background:
In modern era of clinical medicine, CT scan has evolved as a powerful and widely used diagnostic imaging tool. [1] The newest and most advanced Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) methods can evaluate anatomical variations of living human subjects. [2] Knowledge of the incidence of symmetric in variations of foramina of human skull is helpful in diagnostic evaluation of radiologic film. [3] Variations in shape of foramen magnum can affect the normal anatomy of vital structures passing through it. [4] Therefore, it is of interest to evaluate the various shapes of foramen magnum by using CT scans performed in patients of Indian population to establish clinical correlation.

Materials and Methods:
Present study was done in the Department of Anatomy, Geetanjali Medical College and Hospital, Udaipur, Rajasthan after obtaining institutional ethical approval. Total 314 patients' CT images of human skull base obtained from the Department of Radio-diagnosis, Geetanjali Medical College and Hospital, Udaipur, Rajasthan were used in the present study. The CT images belong to the patients who had undergone CT scan evaluation for head and neck region for different clinical indications between the year of 2013 and 2018. All the patients' CT scans were visually assessed to determine the shape of FM and was classified into one of the following seven shapes - oval, round, tetragonal, egg shaped, hexagonal, pentagonal and irregular (Figure 1). The findings of the present study were statistically analyzed by using Microsoft Office Excel 2019.

Table 1: The frequency of various shapes of foramen magnum in CT scans in present study

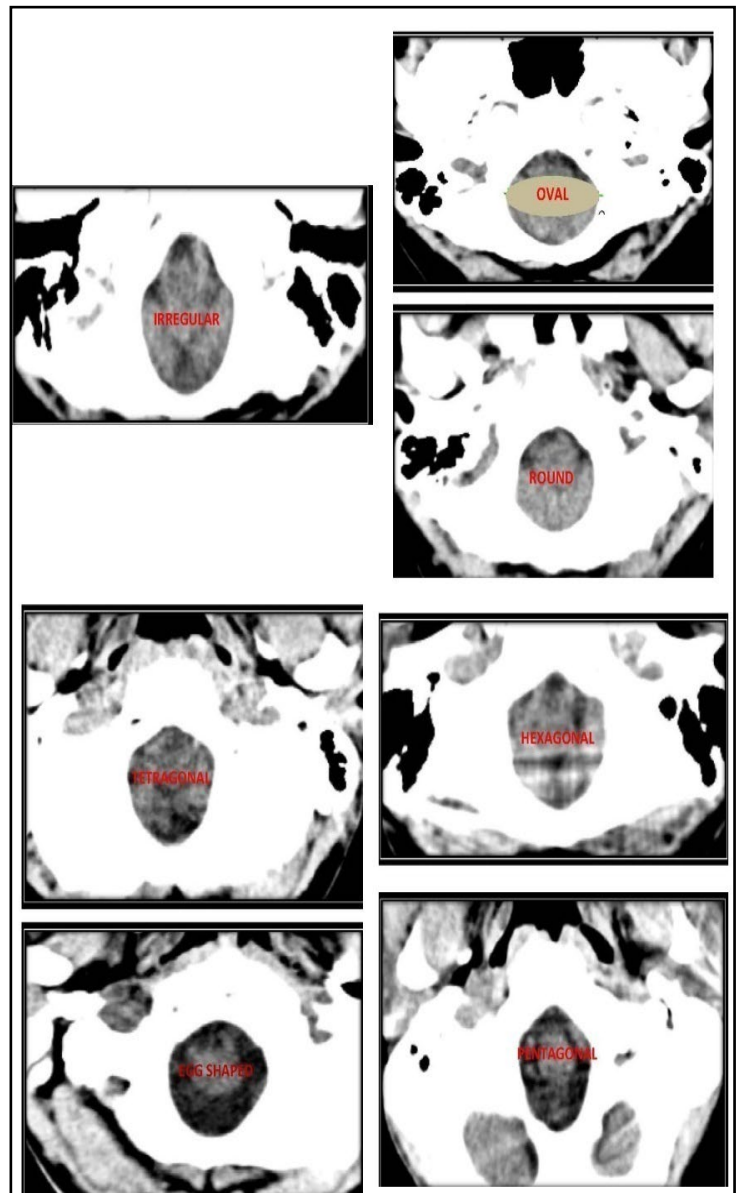| Shape of foramen magnum	CT scan	
	N=314	%
Oval	125	39.09
Round	71	22.61
Irregular	25	7.96
Tetragonal	38	12.10
Pentagonal	17	5.41
Hexagonal	33	10.51
Egg	05	1.59

Figure 1: CT images showing the various shapes of foramen magnum; Oval, Round, Tetragonal, Egg shaped, Hexagonal, Pentagonal, Irregular
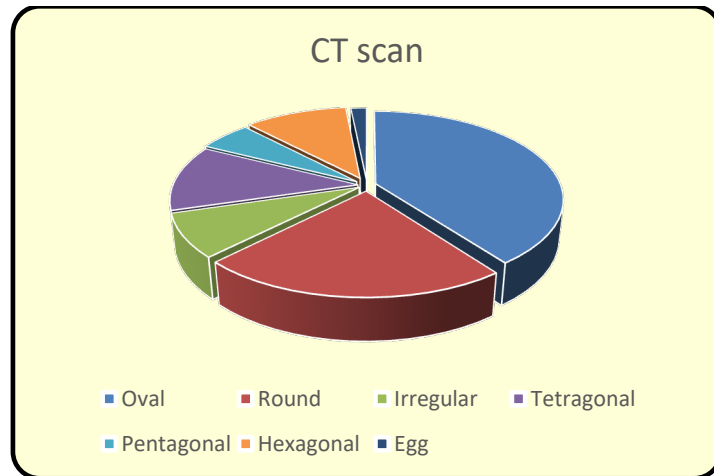
Figure 2: Pie chart showing the frequency of various shapes of foramen magnum in CT Scans in the present study

Results & Discussion:
The various shapes of the foramen magnum in CT images found in current study are oval in 39.09%, round in 22.61%, tetragonal in 12.10%, hexagonal in 10.51%, irregular in 7.96%, pentagonal in 5.41% and egg shaped in 1.59% cases. (Table 1, Figure 2) Evaluation of the different shape of skull base foramina by using computed tomography scans of patients has gained importance in clinical medicine. Most common shape of foramen magnum observed in the present study was oval, which was present in 39.09% cases. This value is lower as compared to the observations by Ganapathy *et al.* [5] (2014) (**Table 2**), who found oval shaped foramen magnum in 66% CT images. Furtado *et al.* [4] (2010) (Table 2) in 9.6 %, Sarthak *et al.* [6] (2016) (Table 2) in 18.2%, Edwards *et al.* [7] (2013) (Table 2) in 24.4% and Aghakhani *et al.* [8] (2016) (**Table 2**) in 35% CT images noticed oval shaped FM, which are lower than the findings of the present study. Round shape of foramen magnum was observed in 22.61% CT images. Edwards *et al.* [7] (2013) in 26% and Sarthak *et al.* [6] (2016) in 35.4% CT images observed round shape of foramen magnum, which are higher than the present value. The findings of following Authors are less than the present values: Furtado *et al.* [4] (2010) in 4.6%, Ganapathy *et al.* [5] (2014) in 9% and Aghakhani *et al.* [8] (2016) in 8% CT images. This may be due to variation in the categorization of oval and round shapes because percentages of oval shape foramen magnum has decreased and reciprocal increase in the percentage of round shape foramen magnum. In the present study, the foramen magnum was tetragonal shape in 12.10% CT

images. Furtado *et al.* [4] (2010) observed tetragonal shape of foramen magnum in 19.04% CT images in his study, which is greater than the present value. Ganapathy *et al.* [5] (2014) in 9%, Edwards *et al.* [7] (2013) in 6%, Aghakhani *et al.* [8] (2016) in 4.4% Sarthak *et al.* [6] (2016) in 8% CT images observed tetragonal shape of foramen magnum, which are lower than the current study. In the present study the foramen magnum was hexagonal shape in 10.51% CT images. Furtado *et al.* [4] (2010) in 19.04 %, Edwards K *et al.* [7] (2013) in 16.4% and Aghakhani *et al.* [8] (2016) in 23% CT images in their study, which is greater than the present value whereas Ganapathy *et al.* [5] (2014) observed hexagonal shape of foramen magnum in 10 % CT images in their study, which is less than present value. In the present study the foramen magnum was of irregular shape in 7.96 % CT images. The findings of following authors were higher than the present value: Ganapathy *et al.* [5] (2014) in 16%, Sarthak *et al.* [6] (2016) in 25.8%, Edwards *et al.* [7] (2013) in 15% and Aghakhani *et al.* [8] (2016) in 12.4% CT images. In the present study, the foramen magnum was of pentagonal shape in 5.41% CT images. Furtado *et al.* [4] (2010) in 9.6 %, Sarthak *et al.* [6] (2016) in 11.8%, Edwards *et al.* [7] (2013) in 8.4 % and Aghakhani *et al.* [8] (2016) in 13% CT images observed pentagonal shape of foramen magnum. These values are greater than the present value. In the present study, the foramen magnum was egg shaped in 1.59% cases. Furtado *et al.* [4] (2010) in 9.5 % and Edwards *et al.* [7] (2013) in 9.5% CT images observed egg shape of foramen magnum in their study, which is higher than the present value. The difference in percentages of various shapes of foramen magnum could be due to study done on different population or inter-observer variation or genetic variation. Anatomical values obtained by different authors are nearly the same, which is not correct with regards to the values of the radiologic study [9-14].

Conclusion:
Data shows that the oval shape is the most common, round is the second most common and egg shape is the least most common shape of foramen magnum in CT images of Indian population. Data also shows that it is easy to operate at the base of skull in case of round, oval and hexagonal shape foramen magnum, as the working space is more in these shapes.
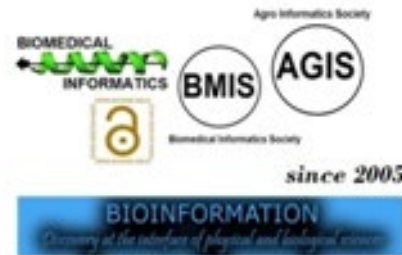
Table 2: Comparison between present study and other authors' studies about percentage of various shapes of FM in CT scans

S. No	Authors	Sample size	Round	Oval	Irregular	Tetragonal	Hexagonal	Pentagonal	Egg shaped
1	Furtado *et al.* [4]	21	4.6	9.6		19.04	19.04	9.6	9.5
2	Ganapathy *et al.* [5]	100	9	66	16	9	10	N.A	N.A
3	Sarthak *et al.* [6]	93	35.4	18.2	25.8	8	N.A	11.8	N.A
4	Edwards *et al.* [7]	250	26	24.4	15	6	16.4	8.4	9.5
5	Aghakhani *et al.* [8]	100	8	35	12.4	4.4	23	13	N.A
6	Current study	314	22.61	39.09	7.96	12.11	10.51	5.4	1.59

[*N.A. - Not applicable]

References:

[1] Patel PR *et al. InStatPearls [Internet]* 2022. StatPearls Publishing. [PMID: 33620865]

[2] Van Beek EJ & Hoffman EA. *Clinics in Chest Medicine.* 2008 **29**:195 [PMID: 18267192]

[3] Nakashima J & Duong H. *InStatPearls* [Internet] 2021. StatPearls Publishing.[PMID: 31985938]

[4] Furtado SV *et al. Acta neurochirurgica.* 2010 **152**:221 [PMID: 19672553]

[5] Ganapathy A *et al. Int J Cur Res Rev.* 2014 **6**:11 [https://ijcrr.com/uploads/728_pdf.pdf]

[6] Sarthak J & Batham IK. *International Journal of Medical Research and Review.* 2016 **4**:357 [https://ijmrr.medresearch.in/index.php/ijmrr/article/view/483/935]

[7] Edwards K *et al. Journal of Forensic Radiology and Imaging.* 2013 1:186 [https//doi.org/10.1016/j.jofri.2013.06.004]

[8] Aghakhani K *et al. International Journal of Medical Toxicology and Forensic Medicine.* 2016 **6**:29 DOI: [https://journals.sbmu.ac.ir/ijmtfm/article/view/IJMTFM -9503/5]

[9] Vinutha SP *et al. Anat Res Int.* 2018 2056291 [PMID: 30356386]

[10] Kamath VG *et al. Anat Res Int.* 2015 459428. [PMID: 26346917]

[11] Raikar NA *et al. J Forensic Dent Sci.* 2016 **8**:180 [PMID: 28123285].

[12] Sunar M *et al. Asian J Neurosurg.* 2019 14702 [PMID: 31497088]

[13] Natsis K *et al. Surgical and Radiologic Anatomy.* 2013 **35**:925 [PMID: 23620089]

[14] Zdilla MJ *et al. J Craniovert Jun Spine* 2017 **8**:205 [PMID: 29021672]