Original Research Article

Morphometric investigation of foramen magnum for determination of sex in Northern India region

Anuj Ram Sharma[1*], Aruna Arya[2], Rakesh Kumar Agarwal[3], Vinay Sharma[4], Vishnu Gupta[5]

[1]Associate Professor, Department of Anatomy, Muzaffar Nagar Medical College & Hospital, Beghrajpur, Muzaffar Nagar, U.P, India
[2]Assistant Professor, Department of Anatomy, Muzaffar Nagar Medical College & Hospital, Beghrajpur, Muzaffar Nagar, U.P, India
[3]Professor, Department of Anatomy, Maharashi Markendeshwar Medical College & Hospital, Kumarhatti, Solan, H.P, India
[4]Professor, Department of Anatomy, Muzaffar Nagar Medical College & Hospital, Beghrajpur, Muzaffar Nagar, U.P, India
[5]Professor &Head, Department of Anatomy, Muzaffar Nagar Medical College & Hospital, Beghrajpur, Muzaffar Nagar, U.P., India

Received: 28-04-2021 / Revised: 23-05-2021 / Accepted: 03-07-2021

Abstract

Introduction: The basic components of a biological profile are: sex, age, height and ancestry. Among these four components, the first thing that is determined, is the sex of an individual. The aim of this study was to assess the Morphometry of foramen magnum for determination of sex in Northern India region. **Materials and Methods:** This study was conducted on 96 human adult skulls. Skulls were collected from museum of anatomy department of MMC, Muzaffarnagar and also from adjacent medical colleges of same geographical area. The region of foramen magnum was used since it is a regular structure and less likely to major morphological changes. A total of 12 measurements were taken from each intact cranial base with a digital verneiercaliper . Each measurement was taken in millimeters (mm) to an accuracy of 0.5 mm. *P* <0.001values were accepted as statistically significant. **Results:** The value of WIDTH OF FORAMEN MAGNUM ranged from minimum 29.9mm to maximum 30.5 mm with mean value of 30.3 mm and SD of ±0.2. In females the value of LENGTH OF FM ranged from minimum 27.2mm to maximum 36.9 mm with mean value of 31.3 mm and SD of ±2.08. **Conclusion:** In incomplete skeletons, metric analysis of the foramen magnum may provide a statistically useful indication as to sex of the unknown skull.

Keywords: Skeletons, metric analysis, foramen magnum, skull, Gender

Introduction

There are two osteological techniques used to determine the sex of an individual; the first is visual assessment to evaluate the morphological sex traits and second is the metrical, in which the skeletal assessment relies on methods based on osteometric measurements. This method reduces theexaminer's subjective judgment and has highreproducibility but need well preserved bones andwell defined measuring landmarks and techniques[1].

Sex determination from skull morphology is important in medico-legal cases. In most of the forensic studies the skeleton will be incomplete and makes gender identification difficult. The foramen magnum (FM) is one of the primary centers of ossification on the cranial base during growth and development, and is located inferior to the sagittal suture, on the cranial base. The foramen magnum area is one of the primary centers of ossification on the cranial base during growth and development, and is located inferior to the sagittal suture, on the cranial base. The FM is an important landmark of the skull base that's why it has been a particular interest in anthropology, anatomy, forensic medicine and other medical fields. Catalina Herrera[2] indicated that the sagittal and transverse dimensions of the FM were significantly higher in human male than in human female skulls.

*Correspondence
Dr. Anuj Ram Sharma
Associate Professor, Department of Anatomy, Muzaffar Nagar Medical College & Hospital, Beghrajpur, Muzaffar Nagar, U.P, India
E-mail: dranujlatasharma@gmail.com

Zaidi and Dayal[3] classified a sample of Indian skulls according to the shape and dimensions of the FM, reporting gender differences which were similar to those reported among Brazilian skulls[4].

Sexual dimorphism using Foramen Magnum have been established by direct metric measurements on the skull (Suazo et al, 2009, &Gapert et al, 2009)[5,6] and also by using computed tomographic images of skull as well as living individuals[5,6].

Variations of the shape of FM have got diagnostic, clinical and radiological importance[7]. Anatomical variance of the foramen magnum may have some impact on certain surgical procedures such as vertebral artery and posterior inferior cerebellar artery aneurysm repairs, foramen magnum meningioma resections, and foramen magnum decompression[8].

Significant differences exist in the measurements of FM between males and females in different geographical regions[9]. The FM is an important landmark of the skull base and is of important interest in anthropology, anatomy, forensic medicine, and other medical fields. It is a three-dimensional (3D) circular or oval aperture within the occipital bone centrally.

The primary goal of this research is to document and analyze the foramen magnum morphometrically to establish a normal base- line values of this region and to investigate its reliability in sex prediction which constitute the biological profile of an individual.

Materials and Methods

This study was conducted on 96 human adult skulls. Skulls were collected from museum of anatomy Department of Muzaffarnagar

Medical College, Muzaffarnagar and also from adjacent medical colleges of same geographical area.

The study group includes adult skulls of 50 males and 46 females as determined by visual assessment of non-metrical parameters for sex determination of skull. Only those skulls having full cranial base with foramen magnum for measurements to be taken were included. Skulls showing any kind of anomalies and skulls with partial damage to foramen magnum area of cranial base were not included. Morphometry (Anterioposterior diameter (APD) & Transverse diameter (TD)) of the foramen magnum was measured using Vernier Caliper. Each measurement was taken in millimeters (mm) to an accuracy of 0.5 mm to allow for instrument error.

Foramen magnum length

Maximum internal length of the foramen magnum along the midsagittal plane, from opisthion to basion[10].

Foramen magnum width

Maximum internal width of the foramen magnum along the transverse plane[10].

Each foramen magnum was classified into one of the four shapes, oval, round, tetragonal, pentagonal. APD of the foramen magnum is the distance 16 between opisthion to basion along the midsagittal plane. while TD is the maximum distance along the transverse plane. Differences in length and width of foramen magnum between males and females were assessed by t-test.

P <0.001values were accepted as statistically significant. For each measurement, the minimum and maximum diameters were obtained and mean values with standard deviations for both sexes.

Results

In males the value of LENGTH OF FM ranged from minimum 35.9mm to maximum 36.9 mm with mean value of 36.3 mm and SD of± 0.27. The value of WIDTH OF FORAMEN MAGNUM ranged from minimum 29.9mm to maximum 30.5 mm with mean value of 30.3 mm and SD of ±0.2

In females the value of LENGTH OF FM ranged from minimum 27.2mm to maximum 36.9 mm with mean value of 31.3 mm and SD of ±2.08.The value of WIDTH OF FORAMEN MAGNUM ranged from minimum 26.2mm to maximum 31.5 mm with mean value of 28.9 mm and SD of ±1.72.Oval shape was the most common followed by round, tetragonal and pentagonal in both males and females.

Table-1 Showing the measurements of foramen magnum in male skulls (Male n=50)

S.N.	Parameter	Min	Max	Mean	SD
10	LENGTH OF FM	35.9	36.9	36.3	±0.27
11	WIDTH OF FM	29.9	30.5	30.3	±0.2

Table-2 Showing the measurements of foramen magnum in female skulls (FEMALE n=46)

S.N.	Parameter	Min	Max	Mean	SD
10	LENGTH OF FM	27.2	36.9	31.3	±2.08
11	WIDTH OF FM	26.2	31.5	28.9	±1.72

A Student's t-test was conducted to determine if there were significant differences between male and female parameters. There is non-significant difference in length of foramen of male and female (p>.001). There is non-significant difference width of foramen magnum of male and female (p>.001)

Table-3 Showing the comparison of measurements of foramen magnum between male and female skull

M=50	Minimum		Maximum		Mean ±SD	
Female=46	M	F	M	F	M	F
LENGTH OF FM	35.9	27.2	36.9	36.9	36.3 ± 0.27	31.3 ±2.08
WIDTH OF FM	29.9	26.2	30.5	31.5	30.3 ± 0.2	28.9 ± 1.72

Discussion

The sex determination procedure is easy when the skeletal integrity is complete, whereas it may be extremely difficult while handling fragmented bones.

Giles and Elliot have remarked that "next to the pelvis, the skull is the most easily sexed portion of the skeleton" (Giles & Elliot, 1963)[11]. The factors decreasing our accuracy rates may be due to probable methodological differences. Also we have to keep in mind that there are some intermediate characteristics in each sex with social and populational differences as well. The study of Catalina-Herrera et al, (1987)[12] has revealed significant differences between sagittal and transverse diameters of the foramen magnum with these parameters being larger in male than in female skulls. Previous work by Holland suggests that the measurements of the region of occipital condyles and the foramen magnum are useful for determining the sex, with an accuracy of 70–90% (Holland 1986)[10].

The comparison of the morphometric analysis obtained in this study with the results of other studies showed that the length of the foramen magnum (male) in the present study is (36.3 ±0.27) as compared to South Indian male skulls(34.04±2.36) (Radhakrishna et al 2012)[13] and the Indian population (Routal etal,1984)[14] (35.5 ± 2.8).

Similarly length of foramen magnum of female skulls of present study (31.3±2.08) as compared to the South Indian population (31.72±2.14) (Radhakrishna et al 2012)[13] Regarding the width of the foramen magnum, in present study male skulls(30.3±0.2) as compared to values of the South Indian male skulls (28.63± 1.89) (Radhakrishna et al 2012[13].

The same measure for the female skulls of the present study (28.9±1.72) as compared to the South Indian population (26.59±1.64) (Radhakrishna et al 2012[13], Sayee et al 1987)[15]. These results demonstrate that sexual dimorphism is present in the foramen magnum. In incomplete skeletons, metric analysis of the foramen magnum may provide a statistically useful indication as to sex of the unknown skull. There was a statistically significant difference between males and females for both length (mean: 22.8mm for males and 20.8 mm for females) and width (mean:12.5 mm for males and 11.8mm for females) of right condyle and width of the foramen magnum (mean:30.8mm for males and 28.9mm for females) (p<0.001). All dimensions were larger in the male, as compared to females, same is true for our study (Uysal et al, 2005)[16].

Conclusion

In conclusion, this study provides new population specific craniometric standards for identification of sex in Northern India and will also help in the process of sex identification where fragmentary skulls are found. In applying these discriminant functions, some difficulties may come owing to the small sample size and unequal ratio of males and females. In incomplete skeletons, metric analysis of the foramen magnum may provide a statistically useful indication as to sex of the unknown skull. Although these results may provide new standards for this population, precaution is necessary for

applying it to a forensic sample, as the true nature of sexual variation in a population may not be fully revealed in a relatively small sample. However, in case of highly fragmentary remains, where no other skeletal remains are preserved, metric analysis of the basal region of the occipital bone may provide a statistically useful indication as to the sex of an unknown skull.

Since the present study was based on a limited sample, it is suggested that further research based on larger samples of documented Indian skulls should be undertaken to check the reliability of morphometric measurements of foramen magnum in sex determination.

References

1. MacLaughlin SM, Bruce MF. (1990): The accuracy of sex identification in European skeletal remains using the Phenice characters. J Forensic Sci: 35:1384–92.
2. Catalina-Herrera, C. J. (1987). Study of the anatomic metric values of the foramen magnum and its relation to sex. Cells Tissues Organs, 130(4), 344-347.
3. Zaidi, S. H., &Dayal, S. S. (1988). Variations in the shape of foramen magnum in Indian skulls. AnatomischerAnzeiger, 167(4), 338-340.
4. Manoel, C. C., Prado, F. B., Caria, P. H. F., &Groppo, F. C. (2009). Morphometric analysis of the foramen magnum in human skulls of Brazilian
5. Suazo GIC, Russo PP, Zavando MDA, Smith RL. (2009): Sexual dimorphism in foramen magnum dimensions. Int J. Morphol: 27(1):21-23.
6. Gapert, R., Black, S., and Last, J. (2009): "Sex Determination from the Occipital Condyle: Discriminant Function Analysis in an Eighteenth and Nineteenth Century British Sample." American Journal of Physical Anthropology: 138(4):384-394.
7. Chethan P, Murlimanju B v., Prashanth K u., Prabhu LV, Krishnamurthy A, Somesh M s., et al. Morphological analysis and morphometry of the foramen magnum: an anatomical investigation. Turkish Neurosurgery [Internet]. 2011 [cited 2019 Aug 27]; Available from: http://www.turkishneurosur gery.org .tr/summary_en_doi.php3?doi=10.5137/1019- 5149.JTN.4297-11.1
8. Ficke J, Varacallo M. Anatomy, Head and Neck, Foramen Magnum. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 [cited 2019 Aug 27]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK526041/
9. Kamath VG, Asif M, Shetty R, Avadhani R. Binary logistic regression analysis of foramen magnum dimensions for sex determination. Anat Res Int2015;2015:459428.
10. Holland TD. (1986): Sex determination of fragmentary crania by analysis of the cranial base. Am J Phys Anthropo: l70:203–208.
11. Giles E, Elliot O. (1963): Sex determination by discriminant function analysis of crania. Am J PhysAnthropol: 21:53–68.
12. Catalina-Herrera CJ. (1987): Study of the anatomic metric values of the foramen magnum and its relation to sex. ActaAnat: 130:344–347
13. Radhakrishna SK, Shivarama CH, Ramakrishna A, Bhagya B. (2012):Morphometric analysis of foramen magnum for sex determination in south Indian population. Nitte University Journal of Health Science: 2(1):20-22
14. Routal RR, Pal GP, Bhagwat SS, Tamankar BP. (1984): Metrical studies with sexual dimorphism in foramen magnum of human crania. J AnatSoc India: 33(2):85–89.
15. Sayee R, Janakiram S, Thomas IM. (1987): Foramen magnum measurements of Crania from Karnataka .J AnatSoc India: 36:87-89.
16. Uysal, S., Gokharman, D., Kascar, M., Tuncbilek, I., and Kosar, U. (2005): Estimation of Sex by 3D CT Measurements of the Foramen Magnum. "Journal of Forensic Science: 50 (6):1-5.

Conflict of Interest: Nil Source of support: Nil