



ORIGINAL RESEARCH PAPER

Forensic Medicine

SEX DETERMINATION FROM FORAMEN MAGNUM MEASUREMENTS – AN AUTOPSY BASED STUDY IN NORTH KERALA POPULATION

KEY WORDS: Sex determination; Skull; Foramen Magnum; Sagittal diameter; Transverse diameter

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ABSTRACT

Establishing identity from fragmented skeletal remains is difficult when compared to other techniques available. In cases like natural disasters, bomb explosions etc. where only few fragmented remains of the body are present, then forensic anthropology can be used to establish the identity. Even though determination of sex from skull is possible, if skull fragments are only available then the importance of foramen magnum for determination of sex comes into consideration if occipital bone is present. The current study was done to find the possibility of sex determination in North Kerala population using the measurements of foramen magnum. The sagittal and transverse diameters of foramen magnum were measured using digital Vernier callipers and the values were analysed and was found that sagittal diameter of foramen magnum can be used to differentiate the sex in the present study and that the sex of an individual cannot be determined based on transverse diameter of Foramen Magnum in the given population.

INTRODUCTION:

Only fragments of bones may be available for examination in severe disruptive injuries. (Tanuj Kanchan et al., 2013) Studying skeletal remains from past populations and estimating the age and sex are fundamental steps for establishing the biological profile of an individual for forensic anthropologists and bio anthropologists. (Aurore Schmitt, PhD et al., 2006) Skull is the single most studied bone in physical anthropology, and much of our knowledge about human evolution is based on cranial remains. (Krogman, 2013) Foramen magnum is an important land mark on base of skull, due to the protection afforded by its location. (Maharjan et al., 2018) Due to the thickness of the cranial base and its relatively protected anatomical position the foramen magnum can withstand both physical insults and inhumation somewhat more successful than many other areas of the cranium. (Ch & SLokanadham, 2013)

Even though determination of sex from skull is possible, if skull fragments are the only available pieces of human remains, then the importance of foramen magnum for determination of sex comes into consideration as the occipital bone is well preserved when compared to other skull parts. This study focuses on establishing whether there is a correlation between measurements of foramen magnum and sex determination.

MATERIALS AND METHODS:

A cross sectional study was done in a total sample size of 196. Cases were selected using the inclusion and exclusion criteria from the cases brought to the Department of Forensic Medicine, Government Medical College, Kozhikode for autopsy. A brief history of the case and personal data regarding place of birth, native place as per documents submitted by police or relatives were recorded.

The cases included were natives of North Kerala of age group 18-65 years. The cases having fractures involving the base of the cranium, cases with congenital deformities and bodies where sex could not be determined from morphological features, were excluded.

Sampling procedure:

An incision is put on scalp just behind the left ear, extending in a semicircular fashion over the parietal bones and ends in region of right ear, then the scalp is reflected in front upto the orbital region and back upto the occipital protuberance and the temporal muscles are cut. After that the skull cap is

removed by sawing and the dura is examined and removed. Then the brain is removed frontal lobes are gently pulled backward, the nerves are cut close to dura of skull, tentorium is slit with scalpel, then cervical part of spinal cord is cut, brain is completely removed. The remnant dura on base will be stripped off. The intracranial sagittal and transverse diameters of foramen magnum will be taken using a digital vernier caliper, since the vernier caliper cannot directly be used for the measuring the sagittal and transverse diameter of the foramen magnum, a divider was used to take the measurements (Fig 1).



Fig 1: Measurement of diameters of foramen magnum

Data analysis:

After data collection data was entered into MS EXCEL 2016 and analysis was done using appropriate statistical software, using SPSS version 18. Sensitivity and specificity will be analysed from the area under ROC curve.

DISCUSSION:

Devadas et al conducted a study to determine the sex of the skull based on the morphometric analysis of foramen magnum. They measured the anteroposterior diameter and the transverse diameters of foramen magnum and calculated index of the foramen magnum, the circumference of the foramen magnum & surface area of the foramen magnum, and got the average anteroposterior diameter was 36.7mm in males and 32.1mm in females, the average transverse

diameter was 29.7mm in males and 26.1mm in females and they thus proved a significant difference between male and female skulls. Statistically, a significant difference was observed between male and female skulls. (P et al.,2017)

The values of sagittal diameter of foramen magnum were close to the values of study done by Vedanayagam et al (Tamil Nadu), which was 18.1±0.9mm together, and 18.4±0.7mm in males and 17.6±1.0 mm in females.(T.vedanayagam, Sathyamurthy, 2015) But was different from the values obtained by other authors.

Jaitley et al (Madhya Pradesh) calculated the SD for males as 37.30 ± 2.61 mm, while for females it was 35.95 ± 2.38 mm, using CBCT(Cone Beam Computed Tomography) and when males and females were compared, it was moderately significant (P = 0.014). (Jaitley et al.,2016)

(8)The difference in values obtained in other studies may be due to the studies done in dry skulls where the diameters are measured from outside the cranium. In this study the dimensions are measured intracranially from the upper edge similar to the method adopted by Vedhanayagam et al.

Saleh et al , studied the length and breadth of foramen magnum through CT and they found that there is statistical significance in the expression, and they found through logistic regression that foramen magnum length was more accurate than breadth.(Saleh et al., 2019) Abo El Atta et al (2020), in study in Egyptian population found that the mean sagittal diameter (SD) in males as 36.8±3.3mm and that of females as 35.7±3.3mm using Multislice CT, was found to have sexual dimorphism in 52 Egyptian population. (Abo El-Atta et al., 2020) Another study in Egyptian population by Saleh et al.(2019) found that mean length of foramen magnum was 3.22mm which was larger in males than in females (33.53mm). Here the values were calculated using radiographic methods which may be reason for the difference. (Saleh et al.,2019)

The value for transverse diameter obtained was smaller when compared to other studies. The TD of males was larger when compared to females in the study population. Study conducted at Manglore by Radhakrishnan et al gives value of 28.63mm in males and 26.59mm in females.(Radhakrishna S.K. , Shivarama C.H. , Ramakrishna A. , Bhagya B., 2012) Most of the Indian studies in males showed a value between 27 – 37mm in males and 21-27mm in females.

The female mean diameters in Indian population are smaller when compared to studies done in other countries. And in present study both males and females showed lesser value, but was comparable with that of study done in South Indian population, which implies that ethnicity has an impact on the dimensions. Jaitley et al (Madhya Pradesh), got the TD as 37.1±3.61mm in males and 29.51±2.77 in females through CT, and was found to be highly significant. (Jaitley et al., 2016)

Wani HA et al (2019) in a study of cross-sectional area of foramen magnum on NCCT in the axial plane in Jammu and Kashmir (India) population , showed largest sagittal dimension, they found that no statistically significant difference (p-value 0.7804) was seen in mean age and range of the two gender groups. (Wani et al.,2019)

RESULTS:

The sex distribution in the present study was 50% male and 50% female, so out of the total 196 samples taken 98 were males and 98 were females. The Mean age in present study was 42.49 with a standard deviation of 13.96.

The minimum age taken was 18 years and maximum age was 63 years. Among the age group of 18-65 years the majority were of age group of 51-60 years (34.2%). The age group 18-30 years was 25% of the total population. (Fig2)

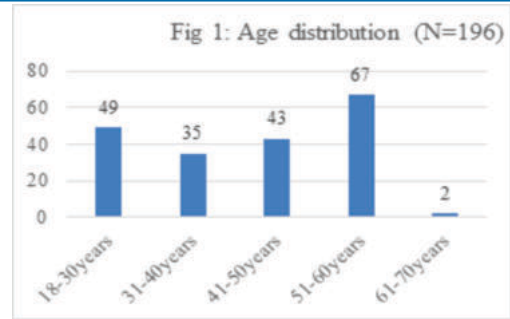


Fig 2: Age distribution:

The mean sagittal diameter (SD) was 17.1 +/- 3.0 mm. In males it was 17.9 +/- 3.0 mm and 16.02 +/- 2.5 mm in females. The maximum and minimum values for the sagittal diameter in males were 27.1mm and 8.9mm and among females were 9.7mm and 22mm. And was larger in males when compared to females, was statistically significant with a p value of 0.04.

The mean Transverse diameter of the Foramen magnum was 21.0 +/- 3.2mm. It was 21.0 +/- 3.2mm in males and 20.1 +/- 2.8m in females. The maximum and minimum values for the transverse diameter in males were 13.9mm and 35.6mm and among females were 9.6mm and 30mm. It was not statistically significant. (Table1).

Table 1: Comparison of Sagittal diameter and transverse diameters in males and females

Parameters	Male	Female	P value
Sagittal diameter (mm)	17.9 +/- 3.0	16.02 +/- 2.5	0.04
Transverse diameter (mm)	21.0 +/- 3.2	20.1 +/- 2.8	0.28

CONCLUSION

The Sagittal diameter of foramen magnum can be used to differentiate the sex in the present study. The sex of an individual cannot be determined based on transverse diameter of Foramen Magnum in the given population. In this study the intracranial dimensions of foramen magnum on wet specimens were taken, while in most of the studies were carried out in dry skull. And also by aids of CT or other scanning techniques where inbuilt software's are used for measuring various dimensions which may be the reason for the wide variation in the values obtained in the present study. The studies on wet specimens were limited. The difference in ethnicity and the population studied and the sample size, may have resulted in the difference in values when compared with other studies. The studies were limited in the given population and further studies need to be carried out.

Conflicts Of Interest:

None.

ABBREVIATIONS:

- APD- Anterio posterior diameter
- CBCT- Cone Beam Computed Tomography
- NCCT- Non Contrast Computed Tomography
- SD -Sagittal diameter
- SPSS -Statistical Package for Social Sciences
- TD- Transverse diameter

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