

# Sex Determination from Foramen Magnum Measurements - A Regional Study in Chennai, TN

T.Vedanayagam<sup>1,\*</sup>, V. Sathyamurthy<sup>2</sup>

<sup>1,2</sup>Associate Professor, Institute of Forensic Medicine, Madras Medical College, Chennai-600003

**\*Corresponding Author:**

E-mail: vedam810@gmail.com

## ABSTRACT

*The identification of sex from human remains is of fundamental importance in forensic medicine, especially in criminal investigations, in the identification of missing people and in anthropology for reconstructing the lives of ancient civilization. The technique of osteometry has been successfully used in the estimation of stature, age, sex and race in Forensic Medicine. The accuracy of determination of the sex from skeletal remains varies with the age of the subject, bones available, fragmentation and biological factors. The objective of this study is to measure the size of the foramen magnum and find out whether the sex of an individual can be made out from these measurements. The study sample consists of 420 human bodies which underwent autopsy, comprising of 260 male and 160 female bodies within the age group of 18-60 years. The age group of 18-60 years was selected because the sexual characteristics of the bone do not begin to manifest themselves until the stage of puberty is attained. Hence the lower limit of age was fixed as 18 years. Since all the sutures of the cranium get fused by the age of 60, the upper limit was fixed at 60 years. Based on the transverse diameter of the Foramen magnum, the sex determination can be done with 99.9% confidence limit. There is no statistically significant difference in the sagittal diameter.*

**Key Words:** Sex determination, Base of the Skull, Foramen Magnum, Sagittal and Transverse Diameter of Foramen Magnum.

## INTRODUCTION

Identification is the determination of the individuality of a person. The question of identification of a living person is mostly the concern of the police. The identification of a living person is based entirely on the known- fingerprints or birthmarks or several personal impressions with regard to characteristic gestures, movements or shape, features of the teeth, eyes, hair or voice.

The determination of sex is statistically the most important criterion, as it immediately excludes half the population. The identification of sex from human remains is of fundamental importance in forensic medicine especially in criminal investigations, in the identification of missing persons and in anthropology, in attempts at reconstructing the lives of ancient populations. The identification of a dead body is required in cases of sudden and unexpected death, fires, explosions, railway or aircraft accidents, mutilated or hidden decomposed bodies or foul play that often needs great medico-legal acumen. In India, owing to its rapid decomposition in the hot seasons or through damage caused by wild animals, the identification of a dead body sometimes becomes very difficult. Osteometry includes the measurements of the skeleton and its parts i.e. the measurements of the bones including the skull. Through this technique, a forensic scientist can study the variation in bony skeleton of different populations of the world. The technique has been successfully used in the estimation of stature, age, sex and race in forensic and legal sciences. These four parameters i.e. age,

sex, race and stature is considered as the "Big Fours" of forensic anthropology. Various studies have been conducted and are in progress in many parts of the world in this regard.

The accuracy of determination of the sex from skeletal remains varies with the age of the subject, the degree of available fragmented bones, fragmentation of the bones and biological variability<sup>1</sup>.

## AIM OF THE STUDY:

- 1) To Measure the Sagittal and Transverse diameters of the Foramen magnum intracranially during autopsy of south Indian population.
- 2) To study the possibility of sex determination in the south Indian population using these measurements.

## MATERIALS AND METHODS

The present study was conducted in the Institute of forensic medicine, Madras Medical College, Chennai during 2007-2008. The study was approved by the Institutional Ethical Committee, Govt. General Hospital & Madras Medical College, Chennai. The study sample consists of 420 human bodies comprising of 260 male and 160 female bodies in the age group of 18-60 years. On receiving requisition for autopsy from the concerned Investigating officer, the autopsies were conducted at the dissecting hall of the Madras Government General Hospital mortuary. The age group of 18-60 years was selected because the sexual characteristics of the bone do not begin to manifest themselves until the stage of puberty is attained. Hence the lower limit

of age was fixed as 18 years. Since all the sutures of the cranium get fused by the age of 60, the upper limit was fixed at 60years.

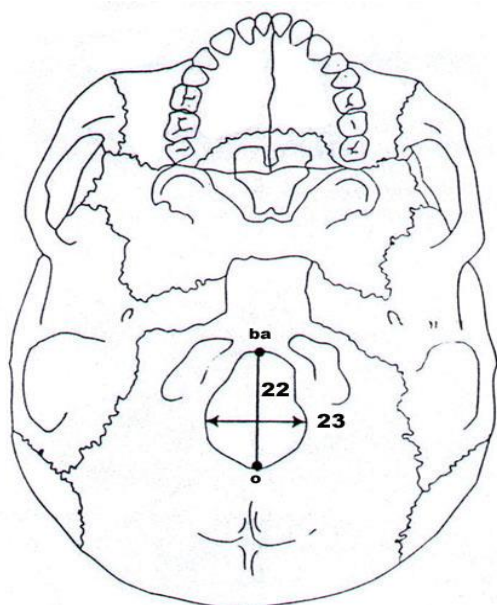
#### Inclusion Criteria

- Age group of 18-60 years.
- Without any fracture of the cranium

#### Exclusion Criteria

- Congenital anomalies
- Dwarfs.

**Measurement:** The intra cranial transverse and sagittal diameter of foramen magnum was measured using digital vernier caliper to the accuracy of 0.5 mm



22. Foramen Magnum Length (ba-o): direct distance from basion (ba) to opisthion (o)

23. Foramen Magnum Breadth: distance between the lateral margins of foramen magnum at the points of greatest lateral curvature.

#### RESULTS

The total cases included were 420 and out of which 260 were male bodies and 160 female bodies. This in percentage wise constitutes 61.9 % male and 38.1% female. All the cases taken in this study belongs to the south Indian population. The mean value of 420 cases for the sagittal diameter was  $18.1 \pm 0.9$  mm and the transverse diameter was  $25.8 \pm 3.2$  mm. The mean value for sagittal diameter of the male cases alone was  $18.4 \pm 0.7$ mm and the transverse diameter was  $28.2 \pm 0.6$ mm. In female cases the mean value of sagittal diameter was found to be  $17.6 \pm 1.0$ mm and the transverse diameter was  $21.8 \pm 0.7$ mm.

On statistical analysis the difference in the intracranial transverse diameter was found to be

significant and there was no statistically significant difference in the sagittal diameter

#### DISCUSSION

Sex of an individual can be identified accurately in 90% of the cases using pelvis alone, 80% of cases using skull alone and in 98% cases using pelvis and skull together<sup>2</sup>.

Sexing of the skull is predominantly done using non -metrical parameters, which are at best appropriate only in relative terms. When only skulls or fragmented jaws are available for sex determination, forensic experts may use methods that are based on the measurement of various bone parameters and analysis of cranial osteological traits like shape of the glabella, size of the mastoid process, orbital form, frontal profile, shape of the occipital protuberance or size of the foramen magnum. Identification of sex is done based on differences in shape and size of the morphological marks. The morphological marks are more subjective and sex determination depends on experience of the investigator, so visual methods of sexing skull are likely to be inaccurate when performed by an inexperienced worker. In sexing a skull the initial impression is often the deciding factor; a large and robust skull is generally male, a small and gracile skull is female. This subjective approach of sexing skull may sometimes produce misleading results. Methods based on measurements and morphometry are accurate and can be used in determination of sex from the skull. Discriminant function analysis of skeletal measurements is a reliable method that overcomes some of the problems inherent in subjective methods of sexing skulls. It is increasingly utilized for sex diagnosis from skeletal measurements<sup>3</sup>.

The average value of intra cranial transverse diameter of the foramen magnum for both male and female cases put together was  $25.7 \pm 3.2$  mm. The maximum and minimum values for the transverse diameter were 30mm and 27mm respectively in males. The maximum and minimum values for the transverse diameter were 23 mm and 20mm respectively in females. The mean transverse diameter in male group was  $28.2 \pm 0.6$ mm and in female group was  $21.8 \pm 0.7$ mm. This result is in close agreement with Catalina Herrera's anatomic study of the Foramen magnum in which the transverse diameter of Foramen magnum was found to be 30.3mm<sup>4</sup>. Testut and Latarjet obtained similar values<sup>5</sup>. The study values were also consistent with results obtained by Schmeltzer et al and Wackenheim Sendemirct et al study in which they obtained a mean value of 30mm for the transverse diameter of the Foramen magnum by C.T.image study<sup>5</sup>. Fischgold and Werenheim reported that the minimum radiographic value for the transverse diameter as

30mm. Another study conducted at Madurai, India by Muthukumar .N. Swami Nathan et al<sup>6</sup> reported a value of 27.9mm for the transverse diameter of the Foramen magnum. Khalil Awadh Murshed et al of Turkey in their study reported 40mm and 27mm as the maximum and minimum for male and 33mm and 24mm as the maximum and minimum values for females<sup>7</sup>.

According to Martin and Sellar, the difference in the measurements between the living and skeletal bones is because of drying up of the bones. He further says that in the skull all the dimensions differ by 1-2% only on drying. The small difference in the transverse diameter from the western studies could be explained by the difference in the skull size itself. Moreover the measurements were taken lower edge of the foramen magnum extra-cranially.

There is a difference of 6.4mm between the mean values of the transverse diameter of Foramen magnum of male and female. On statistical analysis the difference is found to be highly significant with the p- value of less than 0.001 by z-test. **Hence based on the transverse diameter of the Foramen magnum, the sex determination can be done with 99.9% confidence limit.**

The average value of intra cranial sagittal diameter of the foramen magnum for both male and female cases put together was 18.1±0.9mm. The maximum and minimum values for the sagittal diameter were 21mm and 17mm respectively in males. The maximum and minimum values for the sagittal diameter were 21 mm and 16mm respectively in females. The mean transverse diameter in male group was 18.4±0.7mm and in female group was 17.6±1.0mm. This value differ very much with Catalina Herrera's anatomic study of the Foramen magnum in which the sagittal diameter of Foramen magnum was found to be 35.3mm<sup>4</sup>. Testut and Latarjet obtained similar values. The study values were also differ with results obtained by Schmeltzer et al and Wackenheim Sendemir et al study in which they obtained a mean value of 27mm for the sagittal diameter of the Foramen magnum by C.T.image study<sup>5</sup>.

In the above quoted studies the measurements were taken at the lower edge of the foramen magnum extra cranially where as in the present study the measurements were taken at the upper edge of the foramen magnum intra cranially. This could be the reason for the large difference in the sagittal diameter between the present and above quoted studies or this could be due to the population difference.

There is a difference of 0.76mm between the mean values of the sagittal diameter of Foramen magnum of male and female. On statistical analysis the difference is found to be not significant with the

p- value by z-test. **Hence based on the sagittal diameter of the Foramen magnum, the sex determination cannot be done.**

## CONCLUSION

1. The intra cranial transverse diameter of the foramen magnum of male South Indian population is 28.2mm.
2. The intra cranial transverse diameter of the foramen magnum of female South Indian population is 21.8mm.
3. There is a difference of 6.4mm between the mean values of the transverse diameter of Foramen magnum of male and female. On statistical analysis the difference is found to be highly significant.
4. The Transverse diameter of the Foramen Magnum can be used to differentiate the sex with a 99.9% of confidence level.
5. The intra cranial sagittal diameter of the foramen magnum of male South Indian population is 18.4mm.
6. The intra cranial sagittal diameter of the foramen magnum of female South Indian population is 17.6mm.
7. There is a difference of 0.8mm between the mean values of the sagittal diameter of Foramen magnum of male and female. On statistical analysis the difference is found to be not significant.
8. The sagittal diameter of the Foramen Magnum cannot be used to differentiate the sex.

## REFERENCES

1. John G Clement and David L Ranson, Craniofacial identification in Forensic medicine Arnold press London second edition 2005. on first reprint 2006. P 53-54 P38-42.
2. P.C.Dikshit. Textbook of Forensic Medicine and Toxicology, Peepee Publishers New Delhi, First edition, 2007. P 66-67.
3. Werner U Spitz .Medicolegal Investigation of death, Charles C Thomas publishers, U.S.A. Fourth edition 2004. P210-213.
4. Catalina-Herrera CJ. Study of the anatomic metric values of the foramen magnum and its relation to the sex. Acta Anat 130: 344-7, 1987.
5. Schmeltzer A, Babin E, Wenger JJ. Measurement of the foramen magnum in children and adults. Neuroradiology 213: 162-3 1971.
6. Muthukumar N, Swaminathan Acta Neuro(wien) Madurai Tamilnadu 2005;147:889-95.
7. K.A. Murshed Turk J Med Ssi 33(2003) 301-306.