Sex determination using foramen magnum: A study on computerized tomographic images of normal Libyan adults

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Abstract:

The purpose of this research is to study the sexual dimorphism of the sagittal diameter (SD) and transverse diameters (TD) of the foramen magnum (FM) among healthy Libyan adults. The study sample included a computerized tomography (CT) images of 46 individual (27 male, 19 female) their age ranged from (18 to 75). The length (SD) and the width (TD) of the 46 individuals was measured using FM was measured. The obtained data (sex, age, SD of FM. TD of FM) was then entered and analyzed using Statistical Package for Social Sciences (SPSS). The result showed a statistically significant different in FM parameters between both sexes, For SD, (P value=0.000), For TD (P value=0.007). The mean sagittal diameter was (3.89cm) for males, and (3.46cm) for females. The mean transverse diameter was (3.29cm) for males, and (3.00cm) for females. The study thus demonstrates that there is a statistically significant different in the foramen magnum dimension between both sexes in the Libyan population. Which can be helpful in sex determination in forensic medicine.

Introduction:

The foramen magnum (FM) lies in the center of the posterior aspect of the cranial fossa formed by the occipital bone, it is the largest foramen of the skull. It allows the passage of the medulla, the meninges, the spinal roots of the accessory nerve, and the vertebral [1]. In wars, fires, explosions and any other mass disasters, identification of an individual may be extremely difficult due to skeletal fragmentation. Determining an individual's sex by skeletal remains is an important aspect of a medicolegal inspection [2]. Due to the fact that the size and shape of the skull bones vary between males and females, the FM was one of the structures that has been attracting interest for sex determination in forensic medicine [3,4]. Nevertheless, the morphometry of the FM seems to differ among different ethnic groups [5], so it may be also of importance in determining the ethnicity of an individual. The aim of this research is to assess the measurements of the FM of normal Libyan individuals using Computed tomography (CT) to provide data that could be useful for sex and ethnicity determination.

Methods and Material:

CT scans of 46 neurologically normal Libyan adults (27=males, 19=females) were used in this study, an adult in this paper represents people that are aged 18 and older. The data was collected from Ibn-Sina clinic, in Benghazi, Libya. Patients from both sexes that were less than 18 years old, or had a disorder or an injury that can cause a deformity to the base of the skull (e.g. fractures, FM herniation, Foramen magnum meningiomas ...etc.) were excluded. The CT scans were obtained from reformatted axial sections using helical CT scan (Somatom Emotion, Siemens, AG, Erlangen, Germany). The measurements collected were of the length of the FM (**the sagittal diameter),** and the width of the FM magnum (**the transverse diameter).** The sagittal diameter represents the distance between the anterior and posterior ends of the foramen magnum wall, and the transverse diameter represented the distance between the inner lateral ends of the foramen magnum wall. The data was collected using a record sheet that included the sex, the age, the sagittal diameter of the FM, and the transverse diameter of the FM. The obtained data was then entered and analyzed using Statistical Package for Social Sciences (SPSS) version 23 software for windows. Descriptive statistics were applied as mean, standard deviation and presented in tabular and graphical forms to show the data's general information. Analytical statistics were applied, using t-test for to compare means of the parameters according to gender. Probability less than 0.05 is considered to be significant. In addition, the interrelation among the research variables has been studied.

Results:

A total of 46 individual were studied, 27 males (58.7%), and 19 female (41.3%) Figure 1. Age group were (18 to 75) Figure 2. Both transverse and sagittal measurements were significantly greater in males. Descriptive statistics between both genders showing the different distribution of the 2 genders according to the sagittal diameter is presented in Figure 3. For males the minimum value for the sagittal diameter of the FM was 3.45cm and the maximum value was 5.45cm, with a 95% confidence of it being between 3.74cm and 4.06cm. As for females, the minimum value for the sagittal diameter of the FM was 2.85cm and the

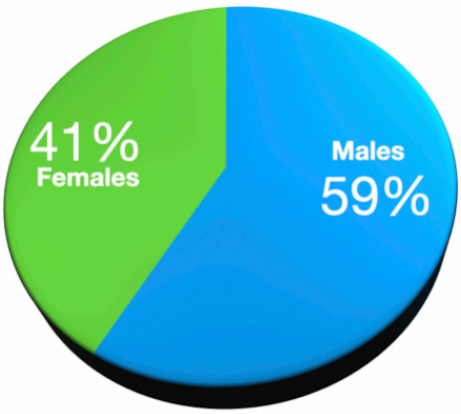

Figure 1: sample distribution according to gender

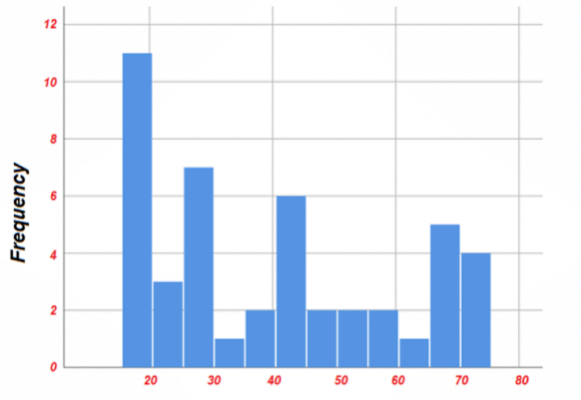

Figure 2: sample distribution according to age

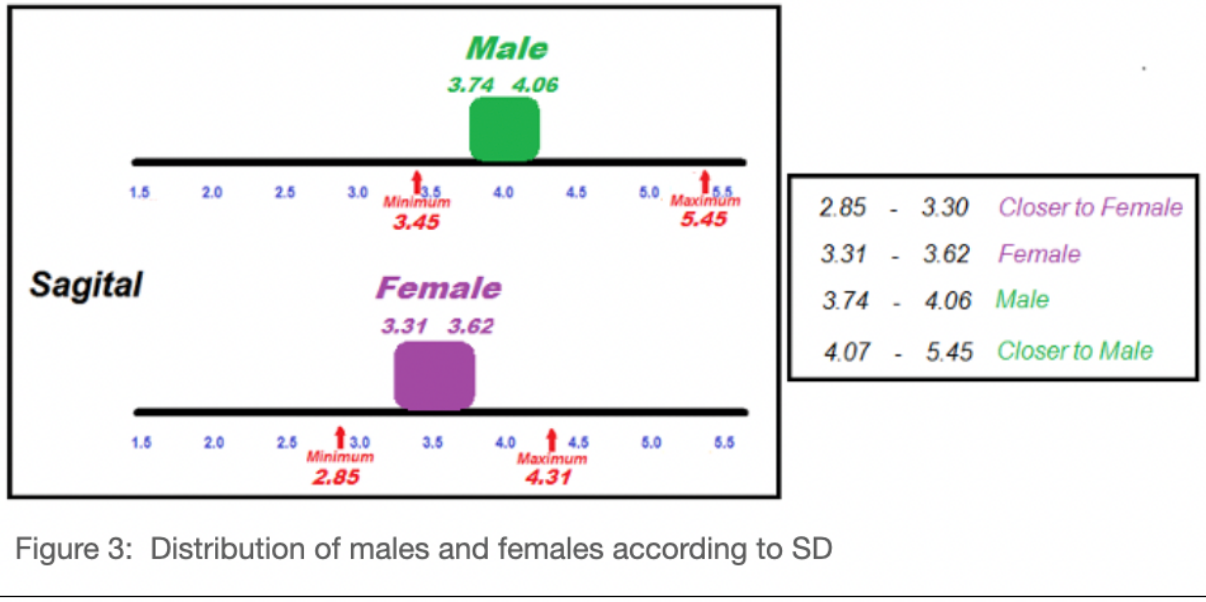

Figure 3: Distribution of males and females according to SD

maximum value was 4.31cm, with a 95% confidence of it being between 3.31cm and 3.62cm. The two-sample t-test tested the null hypothesis that the average sagittal diameter for males equals the average sagittal diameter for females. After applying the test, the P value was equal to (0.000) (Table 1), which is highly significant and lower than 0.05, thus the null hypothesis was rejected and the alternative hypothesis that state that the average sagittal diameter of the FM for males doesn't equals the average sagittal diameter of the FM for females, was accepted. As for the transverse diameter of the FM descriptive statistics between

both genders is presented in Figure 4. For males the minimum value for the transverse diameter of the FM was 2.71cm and the maximum value was 4.31cm, with a 95% confidence of it being between 3.16cm and 3.44cm. As for females, the minimum value for the transverse diameter of the FM was 2.42cm and the maximum value was 4cm, with a 95% confidence of it being between 2.83 and 3.18cm. The two-sample t-test tested the null hypothesis that the average transverse diameter of the FM for males equal the average transverse diameter of the FM for females. After applying the test, the P value turned out to e.

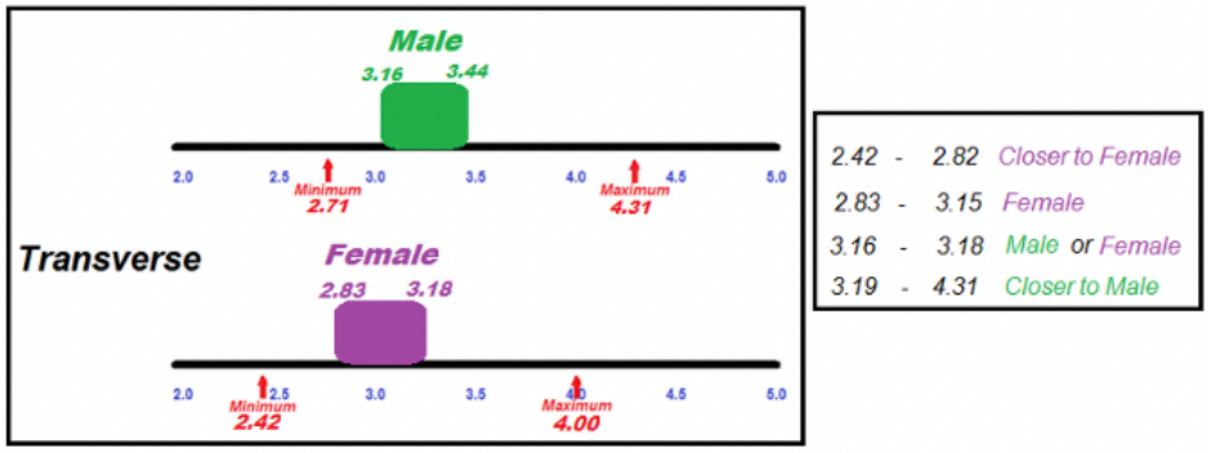

Figure 4: Distribution of males and females according to TD

Table 2: Descriptive statistics of the transverse diameter of the FM according to sex

Two-Sample T-Test (Transverse according to *Sex*)					95% Confidence Interval		*P. Value*
Sex	**N**	**Mean**	**S. Dev**	**Percentage**	**Lower**	**Upper**	
Male	27	3.298	0.345	58.7 %	3.161	3.435	0.007*** Difference is Significant
Female	19	3.002	0.360	42.3 %	2.829	3.176	
Overall	***46***	***3.176***	***3.774***	***100%***	***3.063***	***3.288***	

qual 0.007 (Table 2), which is significant and lower than 0.05, thus the null hypothesis was rejected, and the alternative hypothesis that states that the average transverse diameter of the FM for males doesn't equals the average transverse diameter of the FM for females, is accepted. The interrelation among the research variables has been introduced through a

correlation matrix (Table 3), there was a strong direct relation between the sagittal and transverse diameters of the FM. Also, the sagittal diameter of the FM has a stronger converse relation with the sex of the person than the transverse diameter has, and both of them have slightly converse relation with the age.

Table 1: Descriptive statistics of the sagittal diameter of the FM according to sex

Two-Sample T-Test (Sagittal according to *Sex*)					95% Confidence Interval		*P. Value*
Sex	N	Mean	S. Dev	Percentage	Lower	Upper	
Male	27	3.899	0.409	58.7 %	3.737	4.061	0.000*** Difference is Significant
Female	19	3.467	0.320	42.3 %	3.312	3.621	
Overall	***46***	***3.176***	***3.774***	***100%***	***3.063***	***3.288***	

Table 3: correlation matrix showing the interrelation among the research variables

	Sex	Age	Transverse	Sagittal	
Sex	1	1			
Age	.428**	.428**	1		
Transverse	-.390**	-.390**	-.369*	1	
Sagital	-.502**	-.502**	-.321-*	.740**	1

Discussion:

In this study we show that the transverse and the sagittal diameters of the FM differ significantly between both sexes, and that both of the diameters are significantly greater in

males, which goes in accordance with the bulk of previous studies. We also establish that the sagittal diameter of the FM gets affected more depending on the sex of the individual than the transverse diameter does, and that the size of both diameters is smaller in older individuals, this finding suggests that the older the person gets the narrower their FM will be. The comparison of the morphometric analysis obtained in this present study from a Libyan population and comparing it with other ethnic groups showed the following results: The average sagittal diameter of the foramen magnum for a Libyan male was (3.89cm) which is higher than Switzerland's[6] (3.81cm) , the Saudi Arabian's[7] (3.72cm), the Bulgarians[8] (3.66cm), and the Indian's[9] (3.56cm). And the average sagittal diameter of the foramen magnum for Libyan females was (3.46cm) which is only higher than the Indian's[9] (3.25cm) , and lower than Switzerland's[6] (3.66cm) , the Saudi Arabian's[7] (3.61cm) , and the Bulgarians[8] (3.61cm). As for the transverse diameter of the foramen magnum, for a Libyan male the average diameter was (3.29cm) and comparing it to to other ethnic groups, we found that it was higher than the Indian's[9] (2.89cm), the Saudi Arabian's[7] (3.16cm) , and the Bulgarians[8] (3.14cm) , and lower than Switzerland's[6] (3.30cm). As for the average Libyan female's transverse diameter of the foramen magnum it was (3.00cm) , which is higher than the Bulgarians[8] (2.92cm), and the Indian's[9] (2.81cm) , and lower than Saudi Arabian's[7] (3.06cm) and the Switzerland's[6] (3.13cm). Our study findings are considered one of the highest when compared to previous studies made on different ethnic groups, especially that of the average sagittal diameter of the Libyan male's foramen magnum, being (3.89cm) which is greater than the findings of studies made on other ethnic groups.

Conclusion:

It is to conclude that both measurements taken (SD & TD) are significantly higher in males than in females from a statistical perspective. Also, that the dimensions of the FM can vary from one ethnic group to another. Lastly, the foramen magnum should be considered in sex determination in forensic investigations.

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