Sudan University of Science and Technology

College of Graduate Studies

Measurement of Foremen Magnum in Adult Sudanese using Computed Tomography

قياس الثقب العظمي لدي السودانين البالغين باستخدام الاشعة المقطعية المحوسبة

A thesis Submitted for partial fulfilment of the Requirements of Master Degree in Diagnostic Radiologic Technology

Presented by

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2018

الاية

قال تعالى :

{﴿فَتَعَالَى اللَّهُ الْمَلِكُ الْحَقُّ ۗ وَلَا تَعْجَلْ بِالْقُرْآنِ مِن قَبْلِ أَن يُقْضَىٰ إِلَيْكَ وَحْيُهُ ۖ وَقُل رَّبِّ زِدْنِي عِلْمًا ﴿114﴾}

صدق الله العظيم

سورة طه الاية 114

□

Dedication

To My mother

To My father

To my brothers

To my sister

To my friends

Acknowledgement

Grateful thanks and grace to Allah, the Almighty for guiding and helping me to finish this research.

I would like also to express sincere thanks and gratitude to my supervisor **Dr. Huseen Ahmed Hassan** for his supervision, guidance and valuable comments and support from the idea of this research until finishing.

Abstract

This Descriptive study was conducted at Radiology Department in the Modern Medical Centre, Khartoum, Sudan to measure the foramen magnum in Adult Sudanese using computed tomography 50 consecutive Sudanese patients (37 were males and 13 females age above 20 years, FM dimensions tend to stabilize after the second decade of life , were enrolled in the study , between October 2017 and April 2018. Use of reconstructed helical CT images .

The means of its length and width diameters were higher in females than in males. Statistically significant differences were found between males and females for all variables ($P < 0.05$). No statistically significant difference ($P > 0.05$)

was found between age groups for FM width. The round type was the most common, in 21.6% of the patients. The oval morphological types of FM substituted 30 (60%) of the sample and the rounded proceeded 20(40%). there is a significant differences between at least one group of age and other in FM width FM shape doesn't dependent on age or gender of participants.

CT/3D CT can be accurately used in further investigations to provide valuable information regarding FM and the measurements of its sagittal and transvers diameters and also its circumference may be reliably used for in anthropometric analysis and forensic medicine. The study recommended conducting of further studies should be performed in order to estimate differences among various ethnicity/races especially in Sudan and to establish the normal standard data in Sudanese population.

ملخص الدراسة

أجريت هذه الدراسة الوصفيه في قسم الأشعة في المركز الطبي الحديث بالخرطوم بالسودان لقياس الثقبة في السودانيين البالغين باستخدام التصوير المقطعي

أجريت في هذه الدراسة 50 مريض سوداني 37 منهم ذكور و13 إناث فوق سن 20 عاما، تم قياس أبعاد الثقب العظمية إلى االستقرار بعد العقد الثاني من الحياة، في الفترة بين اكتوبر 2017 و ابريل 2018 وقد استخدمت الدراسة الاشعة المقطعية. كانت مقايسس الثقبة العظمية أعلى في الإناث منه في الذكور .تم العثور على فروق ذات دلالة إحصائية بين الذكور والإناث لجميع المتغيرات .(P <0.05) لا يوجد فروق ذات دلالة إحصائية .(P> 0.05)كان الشكل البيضاوي لFM غالبا لدى 30 (60٪) من العينة و 20 مستدير (40٪) .هناك اختلافات كبيرة بين مجموعة واحدة على الأقل من العمر وغيرها في عرض FM بينما شكل FM لا يعتمد على عمر أو جنس المشاركين في هذه الدراسة. التصوير المقطعي ثلاثي الأبعاد يمكن استخدامها بدقة في مزيد من التحقيقات لتوفير معلومات قيمة بشأن قياسات FM مما يمكن من استخدامها استخدامها بشكل موثوق في التحليل الأنثروبومتري والطب الشرعي .وأوصت الدراسة بإجراء المزيد من الدراسات من أجل تقدير الفروق بين مختلف الأعراق /والأجناس خاصة في السودان ووضع البيانات المعيارية العادية لدى السكان السودانيين.

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Abbreviations

FM	Foramen Magnum
CT	Coputed Tomography
LFM	Length of Foramen Magnum
WFM	Width of Foramen Magnum
VA	Vertebral Arteries
CN	Cranial Nerve
CSF	Cerprospinal Fluid
MDCT	Multi Detector Computed Tomography
MIR	Magnetic Resonance Imaging
OC	Occipital Condyle
SFM	Shape of Foramen Magnum

Chapter one

Introduction

Chapter One

1.1 Introduction

The most prominent feature in the floor of the posterior cranial fossa is the foramen magnum in the occipital bones, this wide communication between the posterior cranial fossa and the vertebral canal, vertebral arteries and the spinal accessory nerve. Anteriorly the apical ligament of the dense and membrane tectoria are in it. Its wider posterior part contains the medulla oblongata and spinal cord continued. Anterior to its transverse diameter it is narrowed by the two occipital condyles. (Standring. et. al, 2008)

Foramen magnum (FM) is the oval shape opening located at the base of the skull, and bordered by the basilar, squamous, and two lateral parts of the occipital bone. The FM, as a transition zone between spine and skull, plays a vital role as a landmark because of its close association to key structures such as the brain and the spinal cord.(Boni. et. al, 2009)

Since the FM includes specific neuroanatomical structures and their lesions in that region which require particularly microsurgical intervention, choosing and establishing the most suitable surgical techniques need a careful planning mainly based on the FM size to refrain from any neurological injury. (Venkatesh. et. al, 2005). Moreover, intradural and extradural tumors, common congenital abnormalities such as FM syndrome produced by atlanto-occipital assimilation, and cerebellar tissue herniations which invaginated into the FM may lead to neural compression and even death are commonly met pathological disorders in this region. (Fatma Hayat Erdil .et al, 2010) Computed tomographic scan is noninvasive modality for the imaging the skull base. Since this procedure is widely done, this modality was preferred. (Surwase, et. al., 2013).

Because of the dense bone of the base of skull beam-hardening artifacts are often seen in images of the posterior fossa, thin slices can help to reduce these artifacts and produce high spatial rsolution.

Reviewing published literature, identified many study concerning CT measurements of the foramen magnum in unidentified skulls, and reported studying 3D CT measurements of the foramen magnum with a resultant sex discriminant.

The cranial base is such a complex structure that it is only studied morphometrically. The sites where a number of vital structures have their entrance or exits are very important for clinical application. Therefore the assessment of these morphometrics is helpful for surgical approaches for reaching lesions in the middle and posterior part of cranial base. (Cicekcibasi, et al, 2004)

The study of diameters of foramen magnum is interesting due to the important relations of the foramen magnum and also its contents.

Dimensions of the foramen magnum have clinical importance because the vital structures that pass through it may suffer compression. It has also been noted that longer antero-posterior dimension of foramen magnum permitted greater contralateral surgical exposure for condylar resection.So, anatomic and radiologic values of foramen magnum dimensions and their relation to gender have been the objectives of several studies. (Murshed et al,2003).

The anatomic and radiologic values have been the objectives of several studies. (Murshed et al, 2003). Recent advances in microsurgical technique and more wide spread use of the operating microscope have now enabled surgeons to approach previously in operable deep seated lesions of the skull base. It is therefore necessary that the clinicians should have athorough knowledge of anatomy of this region for evaluation of various disease processes affecting this region (Laine FJ, et al 1990).

FM evaluations are very significant in not only to establish the most suitable operational procedures, but also to find valuable data for unidentified sex assessment and determination and individuality in forensic medicine.(Fatma Hayat Erdil .et al, 2010).
Determining the biological sex of unknown skeletal remains is an important aspect of medico-legal investigations seeking to establish the identity of a deceased individual. (Gapert, et al 2008).

Anthropologists are often faced with the task of assigning sex to remains that are incomplete, fragmented or damaged as may result from incidents such as mass disasters, airplane crashes, fire, explosions or physical violence (Teixeira,1982).

Comprised remains will affect the accuracy of sex estimation and thus necessitate the development of reliable sexing criteria based on isolated bony elements (Holland 1986).

The foramen magnum has attracted considerable interest for the purposes of sex determination (Uthman, et al., 2012).

The robusticity of the occipital bone and the relatively protected anatomical position of the foramen magnum beneath adepth of soft tissue may make it less vulnerable to fragmentation, or to the effects of inhumation and taphonomic processes in comparison to other cranial and facial bones.(Holland 1989)

1.2 Problem of the study:

The FM clinically importance since vital structures that pass through it which may suffer compression; such as in cases of FM achondroplasia and FM brain herniation as well as in a transcondylar surgical approach to the FM, when resection of tumors; removal of bony structures such as the occipital condyle (OC) may result in injury to the vascular structures and lower cranial nerves and result in craniocervical instability. Hence, knowledge of FM area‘s anatomy is of extreme importance for treating lesion and help the surgeon regarding selection best surgical approach and expected changes in the anatomy of these critical structures.

There is no specific characterization of the morphology and dimensions of the FM as standard in Sudanese population; so this study is obtain to study the anatomical variation of the FM for forensics, anthropologic and surgical purposes.

1.3 objectives:

1.3.1 General objectives:

To measure the foramen magnum in Adult Sudanese using computed tomography.

1.3.2 Specific objectives

- To measure the foramen magnum size and dimensions.
- To characterize the foramen magnum shape and contour.
- To determine the correlation between the FM shape and size with gender.
- To find out an index for the FM for Sudanese compared to the other populations

1.4 Overview of the study:

The study consist of chapter one include the introduction, chapter two include the previous study and literature review ,chapter three include the material and method chapter four contains the results ,chapter five consist of discussion, conclusion and recommendation.

Chapter two

Literature Review and background studies

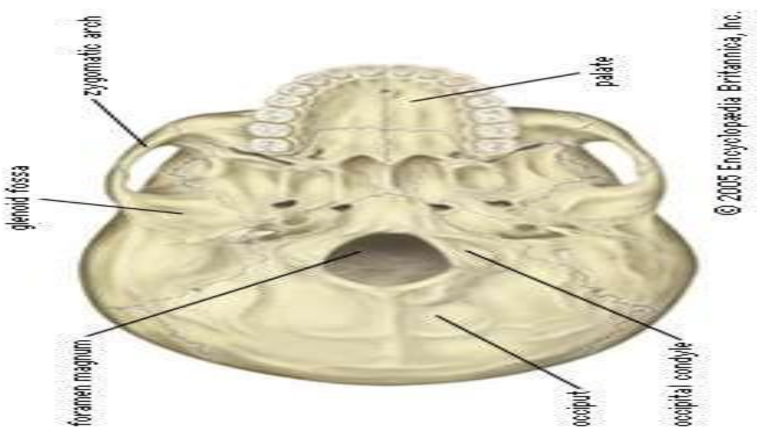
Chapter two

Literature review

2.1 Anatomy

2.1.1 SKULL

Skull The skull consists of 8 cranial bones and 14 facial bones. Also in the head are three small bones in each middle ear cavity and the hyoid bone that supports th0e base of the tongue. The cranial bones form the braincase (lined with the meninges) that encloses and protects the brain, eyes, and ears. These are the frontal bone, parietal bones (two), temporal bones (two), and occipital bone. The sphenoid bone and ethmoid bone are part of the floor of the braincase and the orbits (sockets) for the eyes. The frontal bone forms the forehead and the anterior part of the top of the skull. Parietal means “wall,” and the two large parietal bones form the posterior top and much of the side walls of the skull. Each temporal bone on the side of the skull contains an external auditory meatus (ear canal), a middle ear cavity.(Valerie C et al., 2007)



2.1.2 foramen magnum

The foramen magnum is an uncommon location for lesions which require an anterior approach. Foramen magnum meningiomas are the most common tumor we have addressed via this approach. It is often used in conjunction with other approaches for chordomas. We have also resected a recurrent posterior fossa hemangioblastoma and performed a vertebral artery aneurysmorrhaphy via this approach. The medial condyles and hypoglossal canals create the lateral borders for this approach. Once again, routine monitoring of the XII nerve is valuable. In our experience, resection of the medial half of the condyle (as is the case with the lateral half) does not result in occipitocervical instability. Nevertheless, these patients should be followed long term to ensure that they do not develop delayed instability.

The foramen magnum has an oval shape with a large anterior–posterior diameter of about 3.5 cm and a width of 3 cm. It provides a wide communication between the cranial cavity and the vertebral canal.

It contains lower end of the medulla oblongata, two accessory nerves (spinal roots) ,two hypoglossal nerves ,two vertebral arteries and veins ,anterior spinal artery , two posterior spinal arteries and spinal vein.

The technique for the foramen magnum has more of an effect on the vascular con-tents than on the nerves. This maneuver is indicated for all vertebrobasilar circulatory insufficiencies. We also use it for circulatory problems of the inner ear. (Valerie C et al., 2007)

2.2pathology:

2.2.1 Chiari malformations (CMs)

Chiari malformations (CMs) are structural defects in the cerebellum. They consist of a downward displacement of the cerebellar tonsils through the foramen magnum (the opening at the base of the skull), sometimes causing non-communicating hydrocephalus as a result of obstruction of cerebrospinal fluid (CSF) outflow. The cerebrospinal fluid outflow is caused by phase difference in outflow and influx of blood in the vasculature of the brain. The malformation is named for Austrian pathologist Hans Chiari. A type II CM is also known as an Arnold–Chiari malformation in honor of Chiari and German pathologist Julius Arnold.

CMs can cause headaches, difficulty swallowing (sometimes accompanied by gagging), choking and vomiting, dizziness, nausea, neck pain, unsteady gait (problems with balance), poor hand coordination (fine motor skills), numbness and tingling of the hands and feet, and speech problems (such as hoarseness).

Less often, people with Chiari malformation may experience ringing or buzzing in the ears (tinnitus), weakness, slow heart rhythm, or fast heart rhythm, curvature of the spine (scoliosis) related to spinal cord impairment, abnormal breathing, such as central sleep apnea, characterized by periods of breathing cessation during sleep, and, in severe cases, paralysis.(Peach et al ,1964)

2.2.2 Foramen magnum meningiomas

Foramen magnum tumors, the least common of the posterior fossa meningiomas, are located anterior or anterolateral to the cervicomedullary junction, and are usually intimately involved with the lower cranial nerves (IX–XII), the cervicomedullary junction, and the vertebral artery and its branches (especially PICA). The typical clinical syndrome consists of suboccipital and neck pain (usually in the C2 dermatome), ipsilateral upper extremity dysesthesias, contralateral dissociated sensory loss, progressive limb weakness beginning in the ipsilateral upper extremity and progressing in a counterclockwise fashion, and wasting of the intrinsic muscles of the hand (DeMonte & Al-Mefty 1993b). Since the traditional posterior approach to meningiomas in this location does not address the anterior location of the tumors, the transcondylar or far lateral approach has been devised (Sen & Sekhar 1990; DeMonte & Al-Mefty 1993b)

The tumor capsule is opened carefully, particular care being given to avoid injury to the cranial nerves or blood vessels, and debulked. It may be detached from its clival base to decrease the vascularity. Careful separation of the tumor from the medulla and upper cervical spinal cord, the lower cranial nerves, and the vertebral artery may be accomplished by dissection in the arachnoidal plane surrounding the tumor. The area of dural attachment is removed, as is any hyperostotic bone, and the dura is closed in a watertight manner to prevent CSF leakage. If the entire occipital condyle has been removed, an occipital–cervical fusion should be performed. Postoperatively, the patient is managed in either a stiff collar or a halo-thoracic brace, depending on the nature of the fusion construct. Injury to the lower cranial nerves, the main cause of operative morbidity, has led to the routine use, in some centers, of electromyographic monitoring of the muscles supplied by the vagus, accessory, and hypoglossal nerves (DeMonte et al 1993).

Dysfunction of the lower cranial nerves is the primary cause of postoperative morbidity. Hence, careful assessment of the patient's ability to protect the airway is mandatory, and, in some cases, early tracheostomy may be warranted to avoid the complication of aspiration pneumonitis.(Samer Ayoubi et al 2012)

2.2.3 Occipital Dysplasia

Enlargement of the foramen magnum and congenital shortening of C1, most often seen in toy breed dogs, has been called occipital dysplasia.246,247 Concomitant hydrocephalus has been observed. In severe cases, the cerebellum and brainstem are exposed, making these structures vulnerable to compression and causing secondary syringohydromyelia akin to Chiari malformation .248 The clinical signs reported included pain at the craniocervical junction, personality change, and cerebellar ataxia. Often the clinical signs are more related to hydrocephalus. Many dogs remain asymptomatic. The diagnosis is confirmed MRI of the cranium and cervical vertebrae. Other causes of the signs should be pursued because many normal animals have an enlarged foramen magnum.249 An apparent correlation of the larger opening and brachycephalic skulls has been noted. Marked variation in the shape of the foramen magnum was found in a study of 48 beagle skulls.250 No impairment of function could be attributed to the change. No brain or spinal cord anomalies were found.(Michael D et al ,2011)

2.3 Computed Tomography (CT)

Also called Computed Axial Tomography (CAT), can be used for medical imaging, imaging methods employing tomography created by computer processing and mechanical imaging system to provide sectional anatomic images in axial, sagittal and coronal planes. (Bhatt,2008). CT scan can be used to study all parts of your body organs, such as the liver, pancreas, intestines, kidneys, bladder, adrenal glands, lungs, and heart, it also can study blood vessels, bones, and spinal cord. (Bhatt, 2008).

2.3.1 CT System Component

CT scanner containing rotating X-ray device to create cross sectional images of the body, CT scanner is a large square machine like hole in the center contains a gantry, X- ray tubes and detectors, gantry rotate and the X-ray tube moves around the patient's body to produce the required images, X-ray detectors also rotate around the patient at all times opposite to the X-ray tubes, X-ray beams pass through the body part being examined at different angles, detector convert X-ray energy into light which is convert into electrical energy and then sent to a special computer that uses special algorithms to reconstruct an image in cross section. (Priya et.al 2009).

2.4 previous studies:

Showkathali el at., 2017 found that age of the patients were ranged between 18 and 70 years with the mean age of 41.22 ± 13.93 years. The dimensions of the posterior fossa and FM were larger in males compared to females. The mean height of the posterior fossa was 38.08 (±4.718) mm (*P* = 0.0001), and the mean volume of the posterior fossa was 157.23 (±6.700) mm3 (*P* = 0.0001). The mean AP, transverse diameter, and the surface area of the FM were 33.13 (± 3.286) mm, 29.01 (± 3.081) mm, and 763.803 (±138.276) mm2, respectively.

The normal dimensions of the posterior fossa and FM were less in females than males and were useful to radiologists and neurosurgeons to better their diagnostic inferences, as well as to determine the proper treatment options in Chiari malformation type I (CMI) and other posterior fossa anomalies. The posterior fossa tissue volume can be reliably measured in patients with CMI using our method. More studies were required because there were variations in dimensions among individuals of different races in different regions of the world.

Uthman et al., 2012 studied 88 patients (43 males and 45 females; age range, 20–49 years) were selected for this study. FM sagittal diameter, transverse diameter, area and circumference were measured and data were subjected to discriminant analysis for gender using multiple regression analysis.

FM circumference and area were the best discriminant parameters that could be used to study sexual dimorphism with an overall accuracy of 67% and 69.3%, respectively. By using multivariate analysis, 90.7% of FM dimensions of males and 73.3% of FM dimensions of females were sexed correctly.It can be concluded that the reconstructed CT image can provide valuable measurements for the FM and could be used for sexing when other methods are inconclusive .

Tellioglu et al., 2015 noted that the foramen magnum provides a transition between fossa crania posterior and canalis vertebralis. Medulla oblongata, arteria vertebralis and nervus accessorius spinal part pass through the foramen magnum. In this study, we aimed to make the morphometric measurements of the foramen magnum on computed tomography (CT) and to determine the feasibility of sex determination based on these measurements. Besides sex determination, from a clinical aspect, it is important to know the measurements of the foramen magnum in the normal population in terms of diseases characterised by displacement of the posterior fossa structures through foramen magnum to upper cervical spinal canal such as Chiari malformations and syringomyelia.

Materials and methods: All the data for our study was obtained retrospectively from 100 patients (50 males, 50 females) who had a CT scan of the head and neck region in Adnan Menderes University Hospital, Department of Radiology. To examine the foramen magnum in each and every occipital bone, we measured the foramen magnum's anteroposterior diameter, transverse diameter, the area of the foramen magnum and its circumference.

Results: We found that men have a higher average value than women in our study. According to Student's t-test results; in all measured parameters, there is significant difference between the genders ($p < 0.05$). When multivariate discriminant function test is performed for all four measurements, the discrimination rate is 64% for all women, 70% for all men and 67% for both genders.

Conclusions: As a result of our study, the metric data we obtained will be useful in cases where the skeletons' sex could not be determined by any other methods. We believe that, our study may be useful for other studies in determining of sex from foramen magnum. Our measurements could give some information of the normal ranges of the foramen magnum in normal population, so that this can contribute to the diagnosis process of some diseases by imaging.

Sendemir el at., 1994 assessed the metric values of the foramen magnum (FM) were studied both by dry skull measurements and tomographic measurements. Anteroposterior (AP) and transverse diameters of 88 skulls in three different groups were taken into consideration. The mean AP value for the 38 skulls of the first group (Late Byzantine Era, A.D. 13th century) was 35.6 +/- 2.3 mm, while the mean transverse value was 29.9 +/- 2.1 mm. Twenty-seven skulls of the 20th century had the mean values of 35.1 +/- 2.8 and 28.7 +/- 2.2 mm for AP and transverse measurements, respectively. The third group consisted of computed tomography (CT) measurements of 23 outpatients in the radiology department. Their mean AP value was 36.4 +/- 2.8 and the mean transverse value was 30.0 +/- 1.4 mm. When the measurements of 88 skulls of the three groups were considered together, the mean AP value was 35.6 +/- 2.7 and the transverse value was 29.5 +/- 2.1 mm. There is no significant difference between the total mean value of the present study and that of other authors. However, if the three groups are considered separately, the mean transverse value shows significant differences, especially that of the second group. Also the radiographic and tomographic measurements of other authors have higher results than the present results, perhaps due to methodologic differences.

Chapter three

Methodology

Chapter three
Materials and Methods

3.1 Subject and study sample

A prospective study of 50 consecutive Sudanese patients (37 were males and 13 females age range between 20 - 32 years, FM dimensions tend to stabilize after the second decade of life , were enrolled in the study , between October 2017 and April 2018.

They were referred to the Radiology Department in the Modern Medical Centre ,Khartoum, Sudan, in which the patients subjected to CT Brian for different clinical indications. Patients with previous trauma, surgery or pathology in the region of the FM were excluded, because disorders involving skull base may distort the normal Anatomy of skull base, and patient who have sound health of adult age whose skeletal growth is complete were included.

All patients examined on a multislice CT scanner (Brilliance Philips 64 slice). The scan is performed with the patient in the supine position, It is very important to ensure that there is no rotation or tilt of head in order to demonstrate any bilateral asymmetry, the protocol used for routine head scanning from base of skull through apex, 28 with kVp of 120 and 200 mAs, slice thickness is depending on the structure being scanned, thin data and bone require slice thickness of 5mm and 2mm for reformatted images. Because of the dense bone of the base of skull beam-hardening artifacts are often seen in images of the posterior fossa, thin slices can help to reduce these artifacts.

Helical mode is primarily used for studies that require 3D reformations.

All FM measurements were taken from reformatted images (3D volume rendering), by the measurement function available in the CT system (brilliance Philips 64 slice).

3.2 Data collection

The Data were collected using the following variables:

age, Gender, as well as the measurements relating to foramen magnum.

All measurements, of the Foramen Magnum(FM) and in

(mm) were taken as follows :

Foramen Magnum(FM) measurements : Length of the foramen magnum (LFM): is the distance taken in a straight line from the end of the anterior border (basion) through the center of the foramen magnum until the end of the posterior border toward the median sagittal plane(Antero posterior diameter)

Width of foramen magnum (WFM) - is the distance in a straight line from the end of the border right side, with the concavity stronger through the center of the foramen 29 magnum to the opposite end of the lateral border of concavity more pronounced, with transverse direction (transverse diameter).

The of foramen magnum area and circumference, both area and foramen magnum were measured by tracing the bony border in the 3D volume rendering.

3.3 Statistical analysis

The data obtained were analyzed statistically by computing descriptive statistics like Mean, ± SD values and Percentages, with an independent Test,ANOVA test, and by correlation analysis using an IBM SPSS Statistics software package (Inc., Chicago, Illinois version 16

3.4 Technique

- Patient supane head first
- Arms along the sides of the body
- Head immobilized in head holder
- Support is placed under head

Chapter four

Results

Chapter four
Results

Table 4.1: distribution of participants with respect to gender:

Gender	Frequency	Percent
Male	37	74.0
Female	13	26.0
Total	**50**	**100.0**

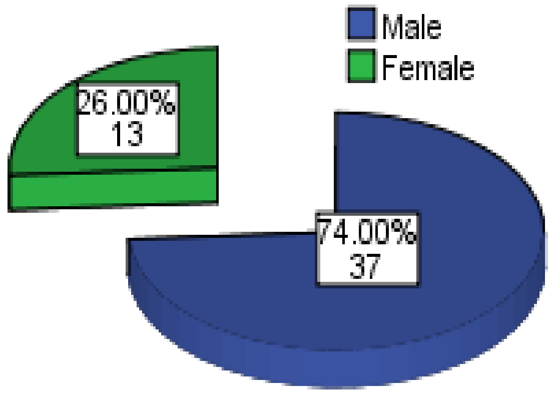


Figure 4.1: distribution of participants with respect to gender

Table 4.2: distribution of participants with respect to age:

Age	Frequency	Percent
20-24 years	12	24.0
25-28 years	23	46.0
29-32 years	14	28.0
More than 32 years	1	2.0
Total	**50**	**100.0**

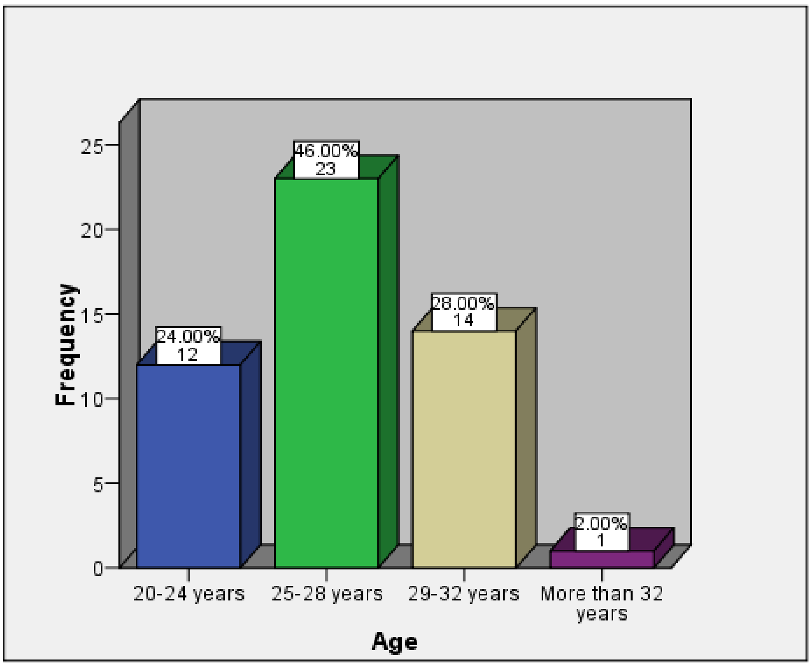


Figure 4.2: distribution of participants with respect to age

Table 4.3: Mean FM (width, length) for two groups (Male and Female):

	Gender	Mean	Std. Deviation
Width	Male	27.62	5.340
	Female	28.54	3.045
Length	Male	48.08	20.970
	Female	55.46	23.440

Table 4.4: t-test for Equality of Means of two groups:

	t-test for Equality of Means				
	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
Width	-0.584	48	0.562	-0.917	1.570
Length	-1.059	48	0.295	-7.380	6.969

Table 4.5: Mean FM (width, length) for age groups:

		Mean	Std. Deviation
Width	20-24 years	23.75	4.731
	25-28 years	28.13	4.635
	29-32 years	31.00	2.542
	More than 32 years	27.00	.
Length	20-24 years	44.50	22.786
	25-28 years	47.43	21.792
	29-32 years	60.21	18.585
	More than 32 years	32.00	.

Table 4.6: ANOVA table for difference between age groups in mean of FM (width and length):

		Sum of Squares	Df	Mean Square	F	Sig.
Width	Between Groups	343.161	3	114.387	6.554	.001
	Within Groups	802.859	46	17.453		
	Total	1146.020	49			
Length	Between Groups	2298.991	3	766.330	1.707	.179
	Within Groups	20649.009	46	448.892		
	Total	22948.000	49			

Table (4.7): Chi-square test for association of FM shape and age:

			Age				
			20-24 years	25-28 years	29-32 years	More than 32 years	Total
Shape	Oval	Count	6	13	10	1	30
		%	50.0%	56.5%	71.4%	100.0%	60.0%
	Round	Count	6	10	4	0	20
		%	50.0%	43.5%	28.6%	.0%	40.0%
Total		Count	12	23	14	1	50
		%	100.0%	100.0%	100.0%	100.0%	100.0%

(4.8): Chi-square test for association of FM shape and gender:

			Gender		Total
			Male	Female	
Shape	Oval	Count	23	7	30
		%	62.2%	53.8%	60.0%
	Round	Count	14	6	20
		%	37.8%	46.2%	40.0%
Total		Count	37	13	50
		%	100.0%	100.0%	100.0%

Chapter five

Discussion, Conclusion &

Recommendations

Chapter five

5.1 Discussion

Table (4.3) provides useful descriptive statistics for the two groups that we compared, where the mean width is (27.62±5.34) for males compared to (28.54±3.045) for females, while the mean length is (48.08±20.97) for males compared to (55.46±23.44) for females

t-test results will tell us if the Means for the two groups were statistically different (significantly different) or they were relatively the same.

We can see that the group means are not significantly different because the values in the "**Sig. (2-tailed)**" = (0.562 and 0.295) respectively for width and length are greater than 0.05. Looking at the **Distributions of two groups table (4.3) above**, we can conclude that there is no statistically significant difference in the mean FM (width and length) for males and females.

Table (4.5) provides useful descriptive statistics for different groups that we compared, where the mean width is (23.75±4.73) for 20-24 years compared to (28.13±4.64) for 25-28, (31±2.54) for 29-32 and (27) for more than 32 years, while the mean length is (44.5±22.79) for 20-24 years compared to (47.43±21.79) for 25-28, (60.21±18.59) for 29-32 and (32) for more than 32 years.

Table (4.6) shows the results of the 1-Way between Subjects (age groups) ANOVA that be conducted. We take a look at the Sig. values in the last column these values determine if the different age groups were relatively give the same FM (width and length) or if they were significantly different from one another. The Sig. value is 0.001 for width and 0.179 for length, and we can conclude that there is a significant differences between at least one group of age and other in FM width, while the differences in FM length are likely due to chance.

Notes from the table (4.7) above, that the most of FM were oval shaped for all age groups. The probability of the chi-square test statistic (chi-square =2.422) was (Sig. = 0.49), which is greater than the alpha level of significance of 0.05. Thus hypothesis that differences in “FM shape” are related to age is not supported and FM shape doesn’t dependent on age.

Notes from the table (4.8) above, that the most of FM were oval shaped for both males and females. The probability of the chi-square test statistic (chi-square =0.277) was (Sig. = 0.599), which is greater than the alpha level of significance of 0.05. Thus hypothesis that differences in “FM shape” are related to gender is not supported and FM shape doesn’t dependent on gender.

5.2 Conclusions

The dimensions of FM have clinical importance because the vital structures that pass through it may suffer compression as in cases of FM achondroplasia.

To conclude, the present study regarding morphometry of foramen magnum shows diameters of foramen magnum were greater in females than in males.

FM measurements are valuable in studying sex dimorphism in forensic investigations with high significant difference was observed between sexes. However, it should be noted that sex differences in the dimensions of the FM and the variations should be taken into concern during the performance of clinical and radiological diagnostics and during surgical approach.

Current study results show the shape of the foramen magnum is not indicative of a specific ancestral group; and gender; however, the oval shape is predominated and followed by round one.

The radiological and anatomical measurements indicated that the radiological assessment greatly helps to organize the preoperative preparation.

Computed tomographic scan is noninvasive modality for the imaging the skull base. Since this procedure is widely done, this modality was preferred.

CT/3D CT can be accurately used in further investigations to provide basis for anthropometric and forensic issues. Current study findings may consider as reference for Sudanese, and the measurements may describe the normal morphological variants of FM for Sudanese. Since the anatomy of the FM is of interest to many radiological fields.

The radiologists must have knowledge of normal anatomy of skull base to determine the presence of abnormality and to help in surgical planning.

The information gained from the present study will be of useful to all of the medical and radiological fields.

5.3 Recommendations

- Large sample size studies for future.
- A few studies have been performed in different parts of the world on the size and shape of FM reporting different findings about it, there is no documented data regarding anatomical characteristics of FM in the Sudanese population.
- Further studies should be performed in order to estimate differences among various ethnicity/races especially in Sudan and to establish the normal standard data in Sudanese population.

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Title Foramen magnum - an overview | ScienceDirect Topics Article Title Foramen magnum Date Accessed ,2018

Appendices

Appendix I

DATA COLLECTION SHEET

NO	gender	Age	LFM	WFM	Shape
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Appendix II

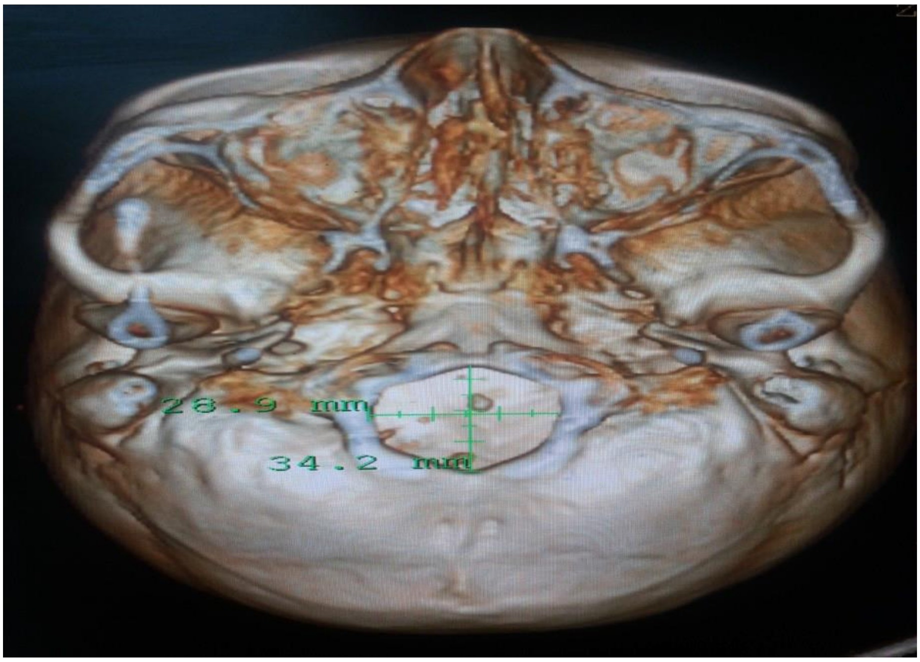

Figure A1: 38y male his FM measurement LFM 34.2 an WFM 28.4

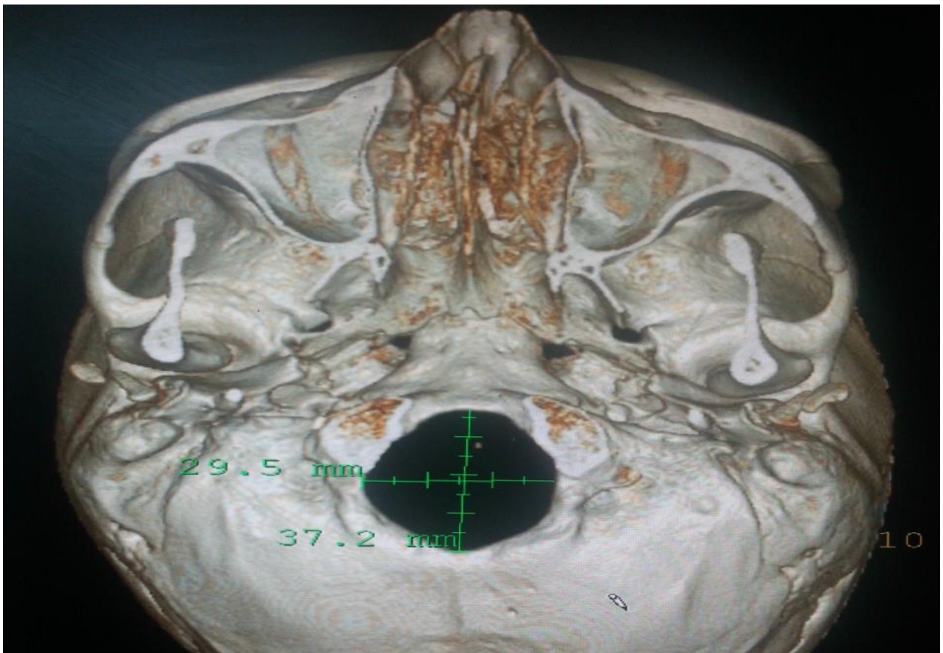

Figure A2 : 50y mail his FM measurement LFM 37.2 and WFM 29.5

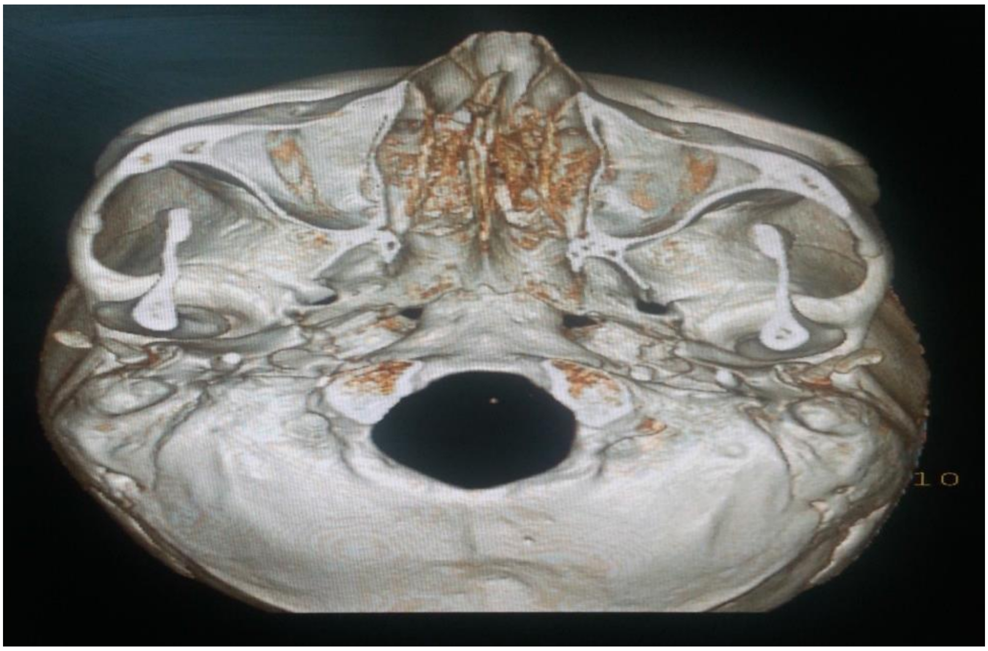

Figure A3: 25y female have FM round in shape

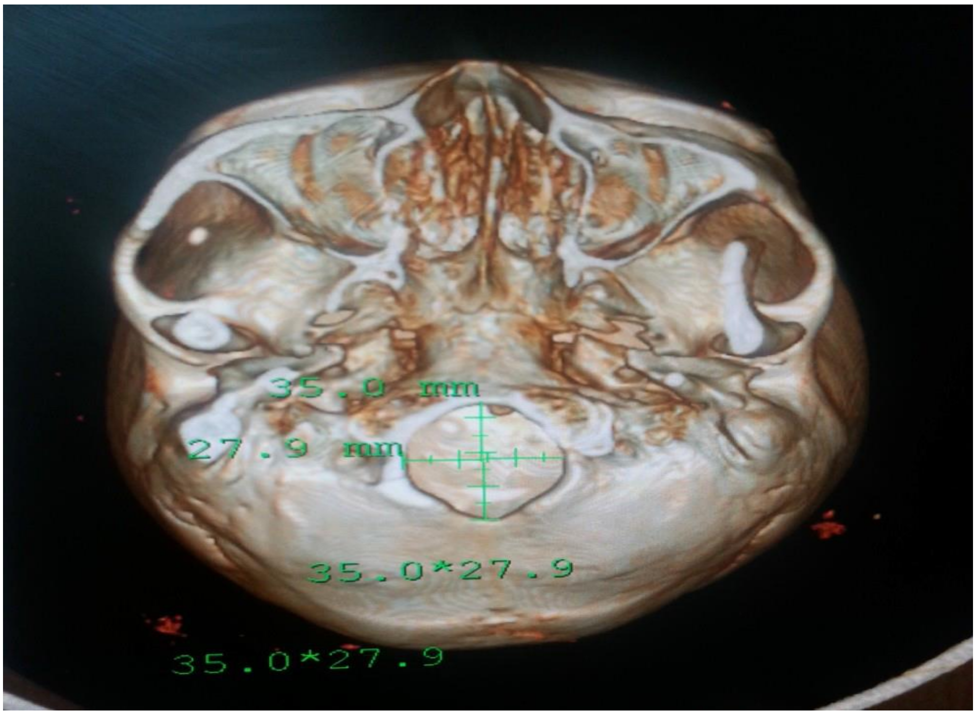

Figure A4: 49y female her FM measurement is LFM 37.2 and WFM 29.5