Sudan University of Science and Technology

College of Graduate Studies

Measurement of Foremen Magnum in Adult Sudanese using Computed Tomography

قياس الثقبة العظمى لدى السودانين البالغين بإستخدام الأشعة المقطعية المحوسبة

A Thesis Submitted for Partial Fulfillment for the Requirements of

M.Sc. Degree in Diagnostic Radiologic Technology

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الآية

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

قال تعالى:

(وتعالي الله الملك الحق ولا تعجل بالقران من قبل أن يقضي اليك وحيه وقل ربي زدني علما)

"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**. **Afraa Siddig Hassan Omer** his supervision, guidance and valuable comments and support from the idea of this research until finishing.

Abstract

This was descriptive cross sectional study the problem of the study was that there is no specific characterization of the dimensions of the FM as standard in Sudanese population, study aimed to measure the foramen magnum in Adult Sudanese using computed tomography conducted in Northern State at Aldaman Hospital during the period from March to October 2022, The Data were collected from 100 patients using data collection sheet containing the following variables; age, gender, as well as the measurements relating to foramen magnum include FML and FMW and analyzed statistically by SPSS, their age (20-30) years (50%) males and (50%) females.

The results found that the mean of foremen magnum length was (35.05±3.11) mm, the mean of foremen magnum width was (29.15±2.52) mm, males average length was (35.4±2.32) mm and width was (29.51±2.72) mm, females average length was (34.71±3.73) mm and width was (28.79±2.27) mm, there was statistically insignificant correlation between gender and foremen magnum measurements (p-value = 0.268 and 0.153) and there was statistically insignificant correlation between age and foremen magnum measurements (p-value = 0.973 and 0.105), there was statistically insignificant difference in foremen magnum measurements between males and females (sigs. > 0.05); males measurements greater than females measurements. there was statistically insignificant difference in foremen magnum measurements between age groups (sigs. = 0.888 and 0.27), there was very weak linear relationship between age and foremen magnum length (R^2 = 0.0006), between age and foremen magnum diameter (R^2 = 0.0006) and weak positive linear relationship between age and foremen magnum width (R^2 = 0.025).

The study concluded that there was very weak linear relationship between age and foremen magnum length, between age and foremen magnum diameter and weak positive linear relationship between age and foremen magnum width.

المستخلص

تهدف إلى قياس الثقبة العظمى في السودانيين البالغين باستخدام التصوير المقطعي الذي تم إجراؤه في الولاية الشمالية – مستشفى الضمان خلال الفترة من مارس إلى أكتوبر 2022 ، تم اختيار 100 مريض بأعمار (20–30) سنة (50) ٪) ذكور و (50٪) إناث.

كانت هذه دراسة مقطعية وصفية مشكلتها الدراسة أنه لا يوجد توصيف محدد لأبعاد الثقبة العظمى كمعيار في السكان السودانيين، هدفت الدراسة إلى قياس الثقبة العظمى عند البالغين السودانيين باستخدام التصوير المقطعي الذي تم إجراؤه في الولاية الشمالية بمستشفى الضمان. خلال الفترة من مارس إلى أكتوبر 2022 ، تم جمع البيانات من 100 مريض باستخدام ورقة جمع البيانات التي تحتوي على المتغيرات التالية ؛ العمر والجنس وكذلك القياسات المتعلقة بماغنوم الثقبة تشمل طول وعرض الثقبة العظمى وتم تحليلها إحصائيا بواسطة الحزمة الاحصائية للعلوم الاجتماعية كانت أعمارهم (20–30) سنة (50٪) ذكور و (50٪) إناث.

ووجدت النتائج أن متوسط طول الثقبة العظمى (35.05±3.11) ملم، ومتوسط عرض الثقبة العظمى (29.15±2.52) ملم، كان متوسط قياسات الذكور الطول (35.4±2.32) ملم والعرض (29.51 ± 2.72) ملم وكان متوسط قياسات الإناث الطول (34.71 ± 3.73) ملم والعرض (28.79 ± 2.27) ملم ، ولم يكن هناك ارتباط معنوي إحصائيا بين الجنس وقياسات الثقبة العظمى (القيم الاحتمالية = 0.268 و 0.153) وكان هناك ارتباط غير ذي دلالة إحصائية بين العمر وقياسات الثقبة العظمى (القيمة الاحتمالية = 0.973 و 0.105)، وكان هناك علاقة غير ذات دلالة إحصائية الفرق في قياسات الثقبة العظمى بين الذكور والإناث (سيج = 0.289 و 0.11). قياسات الذكور أكبر من قياسات الإناث، لم يكن هناك فرق معنوي إحصائياً في قياسات الثقبة العظمى بين الفئات العمرية (سيج = 0.888 و 0.27)..

خلصت الدراسة إلى وجود علاقة خطية ضعيفة للغاية بين العمر وطول الثقبة العظمى ، بين العمر وقطر الثقبة العظمى ، وعلاقة خطية موجبة ضعيفة بين العمر وعرض الثقبة العظمى.

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List of abbreviations

FM	Foramen Magnum
CT	Computed 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

Introduction

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. (Mancall & Brock, (2011)

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. (Radhakrishnan, et. al, 2012)

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. 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. (Augustine, 2016)

Computed tomographic scan is noninvasive modality for the imaging the skull base. Since this procedure is widely done, this modality was preferred. 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. (Gopalrao, et al., 2013)

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 areas 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 dimensions of the FM as standard in Sudanese population.

1.3 Objectives of the study:

1.3.1 General objective:

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

1.3.2 Specific objectives:

- To measure the foramen magnum length and width.
- To determine the correlation between the FM size with gender and age.
- 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 recommendations followed by references and appendices.

Chapter two

Literature Review and Previous Studies

Chapter two

Literature Review and Previous Studies

2.1 Anatomy:

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. (Scanlon & Sanders, 2018)

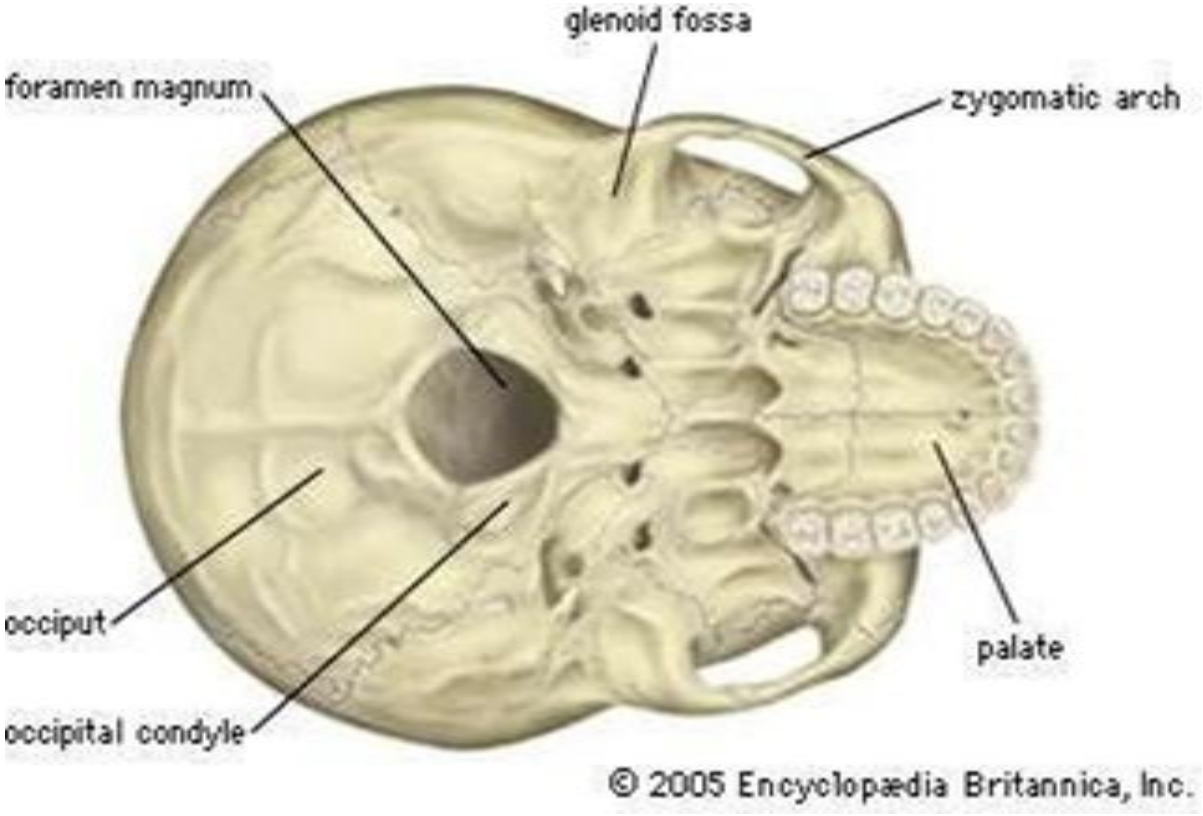

Figure (2.1): Shows anatomy of the skull (Scanlon & Sanders, 2018)

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. (Scanlon & Sanders, 2018)

2.2 Physiology:

The foramen magnum functions as a passage of the central nervous system through the skull connecting the brain with the spinal cord. On either side of the foramen magnum is an occipital condyle. These condyles form joints with the first cervical vertebra. (Scanlon & Sanders, 2018)

2.3 Pathology:

2.3.1 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. (Klaben, et al., 2018)

Figure (2.2): Shows CT image for Chiari malformations (Klaben, et al., 2018)

2.3.2 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 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. (Klaben, et al., 2018)

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. (Klaben, et al., 2018)

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. (Klaben, et al., 2018)

2.3.3 Occipital Dysplasia:

Enlargement of the foramen magnum and congenital shortening of C1, most often seen in toy breed dogs, has been called occipital dysplasia. 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.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. 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. No impairment of function could be attributed to the change. No brain or spinal cord anomalies were found. (Angelini & Pinzan, 2019)

2.4 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. 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. (Villarraga, et al., 2019)

2.4.1 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. (Maier, et al., 2018).

2.5 Previous studies:

Iqbal 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.

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. 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. 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. 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 methodological differences.

Almustafa 2018: found foramen magnum shapes were determined as a round shape in 17(17%) of the cases, oval in 53 (53%), irregular in 15(15%) and arrow head in 15(15%), the mean sagittal and transverse diameters of the foramen magnum were determined as 35.37±2.49 mm and28.57±2.48 mm respectively. 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 and resection of tumors.

Chapter three

Materials and Methods

Chapter three

Materials and Methods

3.1 Materials:

3.1.1 Study Type:

A descriptive cross sectional study.

3.1.2 Study Area and duration:

Conducted in Northern State Aldaman Hospital - Marawi during the period from March to October 2022.

3.1.3 Study population:

Patients subjected referred to the Radiology Department for CT Brian for different clinical indications

3.1.4 Sample size:

100 consecutive Sudanese patients (50 were males and 50 females age range between (20 – 30) years.

3.1.4.1 Inclusion criteria:

Patients who have sound health of adult age whose skeletal growth is complete.

3.1.4.2 Exclusion criteria:

Patients with previous trauma, surgery or pathology in the region of the FM and patients their age above 30 years and less than 20 years.

3.1.5 Instrumentation:

All patients examined on a multi-slice CT scanner (GE Optima 520, 16 slice).

3.2 Methods:

3.2.1 Technique used:

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 (GE Optima 520, 16 slice). (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 magnum to the opposite end of the lateral border of concavity more pronounced, with transverse direction (transverse diameter). The foramen magnum area and circumference, both area and foramen magnum were measured by tracing the bony border in the 3D volume rendering.

3.2.2 Data collection

The Data were collected using data collection sheet containing the following variables; age, Gender, as well as the measurements relating to foramen magnum include FML and FMW.

3.2.3 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 26).

3.2.4 Ethical consideration:

The data were collected from the patients who already came to CT brain with verbal agreement from them. No personal data were published; also the data kept in personal computer with personal password due to privacy and confidentiality.

Chapter four

Results

Chapter four

Results

Table (4.1): Shows frequency distribution of gender:

Gender	Frequency	Percent
Male	50	50%
Female	50	50%
Total	**100**	**100%**

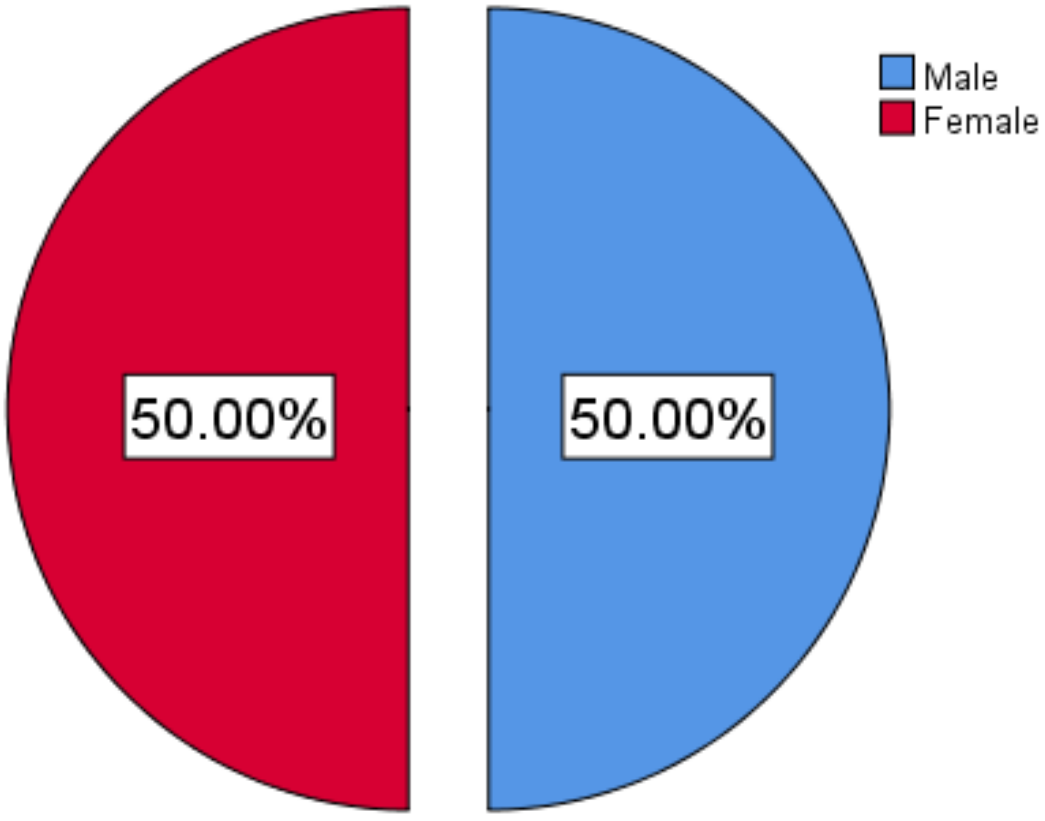

Figure (4.1): Shows frequency distribution of gender

Table (4.2): Shows frequency distribution of age group:

Age group	Frequency	Percent
(20-22)	29	29%
(23-25)	29	29%
(26-28)	20	20%
(>28)	22	22%
Total	**100**	**100%**

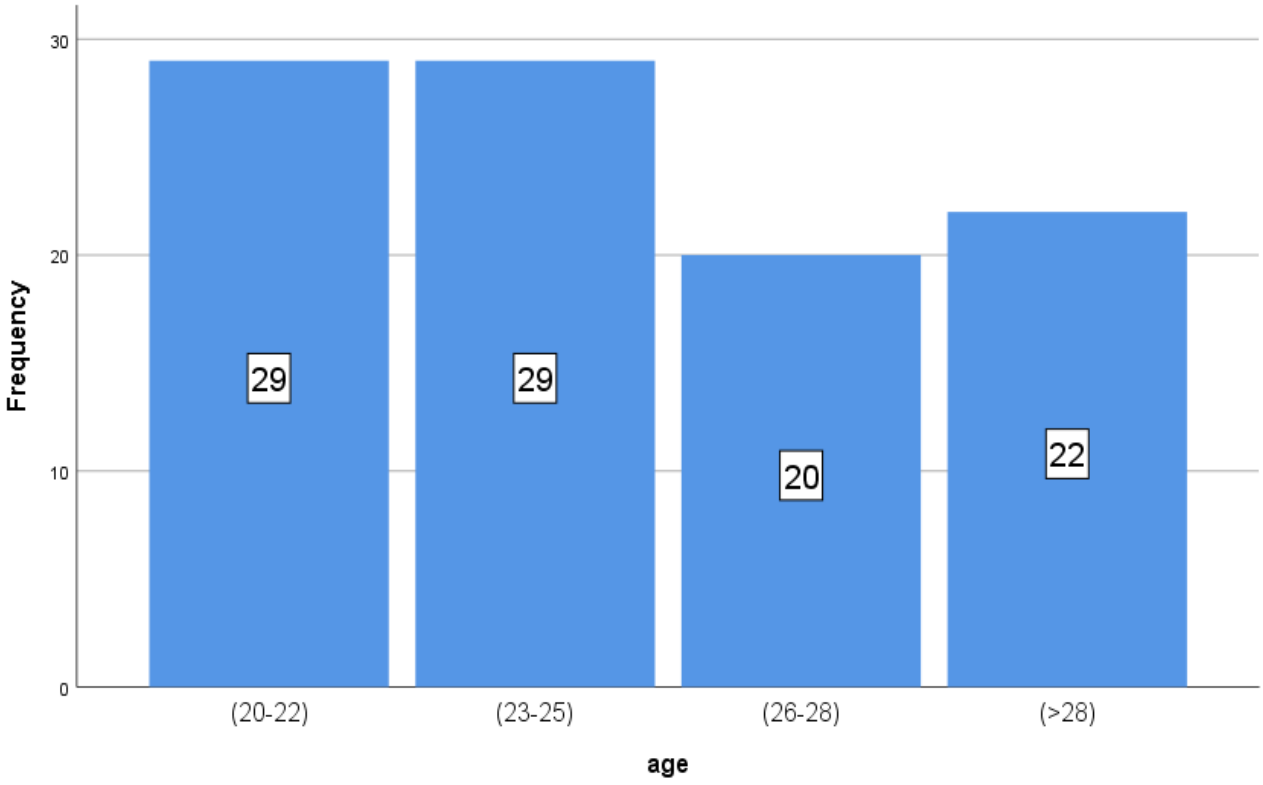

Figure (4.2): Shows frequency distribution of age group

Table (4.3): Shows descriptive statistics of age and foremen magnum measurements:

	N	Minimum	Maximum	Mean	Std. Deviation
Age	100	20	30	24.95	3.63
Foremen magnum length	100	30.5	55	35.05	3.11
Foremen magnum width	100	23.8	38.1	29.15	2.52

Table (4.4): Shows correlations age and gender with foremen magnum measurements:

		Gender	Age
Foremen magnum length	Pearson Correlation	-0.112	0.003
	Sig. (2-tailed)	0.268	0.973
	N	100	100
Foremen magnum width	Pearson Correlation	-0.144	0.163
	Sig. (2-tailed)	0.153	0.105
	N	100	100

Table (4.5): Shows comparing foremen magnum measurements between genders:

	Gender	N	Mean	Std. Deviation	Sig.
Foremen magnum length	Male	50	35.4	2.32	0.289
	Female	50	34.71	3.73	
Foremen magnum width	Male	50	29.51	2.72	0.110
	Female	50	28.79	2.27	

Table (4.6): Shows ANOVA test comparing foremen magnum measurements between age groups:

		Sum of Squares	df	Mean Square	F	Sig.
Foremen magnum length	Between Groups	6.29	3	2.1	0.212	0.888
	Within Groups	951.3	96	9.91		
	Total	957.61	99			
Foremen magnum width	Between Groups	25.03	3	8.34	1.328	0.270
	Within Groups	603.34	96	6.29		
	Total	628.37	99			

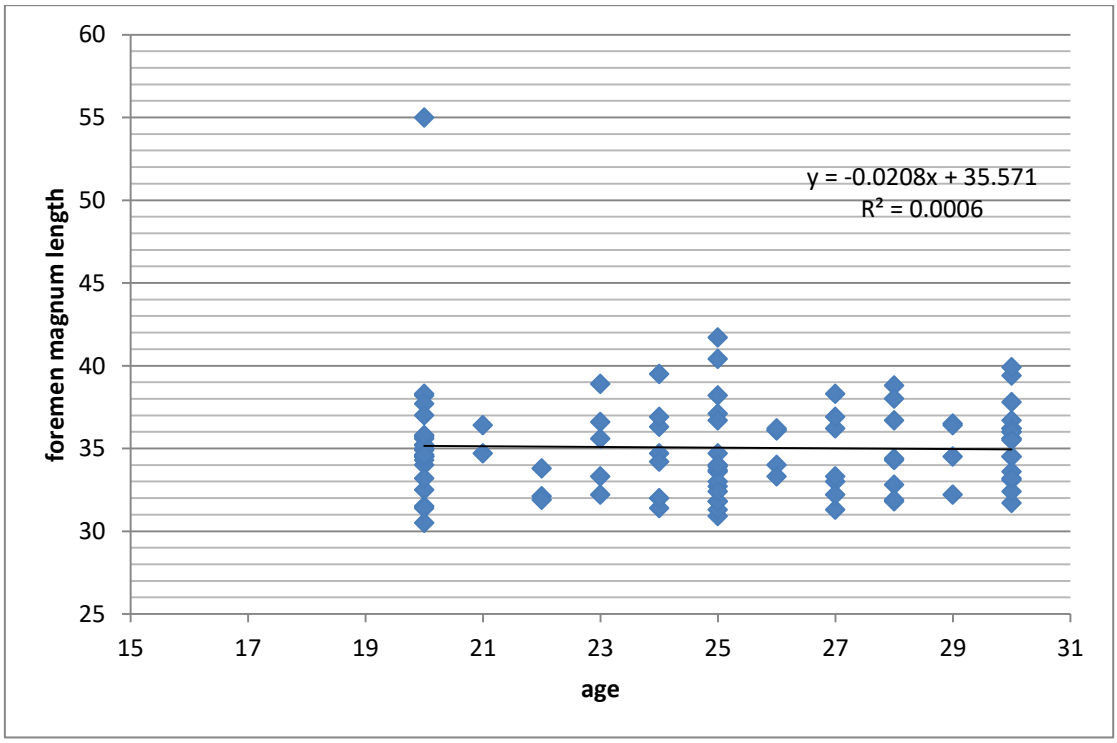

Figure (4.3): Scatter plot shows linear relationship between age and foremen magnum length

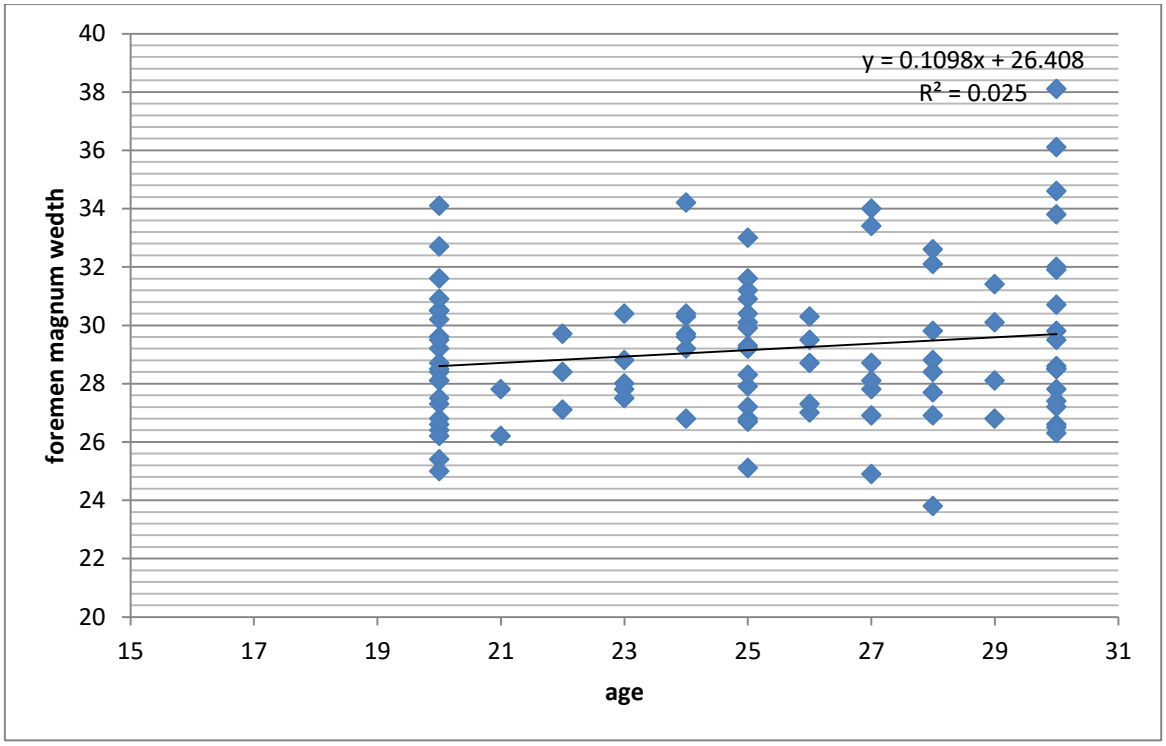

Figure (4.4): Scatter plot shows linear relationship between age and foremen magnum width

Chapter five

Discussion, Conclusion & Recommendations

Chapter five

Discussion, Conclusion & Recommendations

5.1 Discussion:

This was descriptive cross sectional study aimed to measure the foramen magnum in Adult Sudanese using computed tomography conducted in Northern State at Aldaman Hospital during the period from March to October 2022, 100 patients were selected their age (20-30) years (50%) males and (50%) females. Table, Figure (4.1).

The study showed (29%) in age group (20-22), (29%)in group (23-25), (20%)in group (26-28) and (22%) in group (>28). Table, Figure (4.2).

The results found that the mean of age was (24.95±3.63) years, the mean of foremen magnum length was (35.05±3.11) mm and the mean of foremen magnum width was (29.15±2.52) mm. Table (4.3).

The results found that there was statistically insignificant correlation between gender and foremen magnum measurements (p-value > 0.05) and there was statistically insignificant correlation between age and foremen magnum measurements (p-value > 0.05). Table (4.4).

The results found that there was statistically insignificant difference in foremen magnum measurements between males and females (sigs. > 0.05); males average measurements was foremen magnum length was (35.4±2.32) mm, foremen magnum width was (29.51±2.72) mm and foremen magnum diameter was (111.1±7.28) mm and females average measurements was foremen magnum length was (34.71±3.73) mm and foremen magnum width was (28.79±2.27) mm. males measurements greater than females measurements. Table (4.5). Agree with Iqbal et al, who found FM were larger in males compared to females and disagree with Tellioglu et al., who found all measured parameters, there is significant difference between the genders ($p < 0.05$)

Also the results found there was statistically insignificant difference in foremen magnum measurements between age groups (sigs. > 0.05). Table (4.6).

Finally the results found that there was very weak linear relationship between age and foremen magnum length ($R^2 = 0.0006$) and between age and foremen magnum diameter ($R^2 = 0.0006$) Figures (4.3) to (4.4).

5.2 Conclusion:

The study concluded that the mean of foremen magnum length was (35.05±3.11) mm, width was (29.15±2.52) mm, there was statistically insignificant correlation between gender and foremen magnum measurements, between age and foremen magnum measurements, statistically insignificant difference in foremen magnum measurements between males and females males measurements greater than females measurements, statistically insignificant difference in foremen magnum measurements between age groups, there was very weak linear relationship between age and foremen magnum length, between age and foremen magnum diameter and weak positive linear relationship between age and foremen magnum width.

5.3 Recommendations:

- Further studies should be done with large sample size.
- A few studies have been performed in different parts of the world on the size 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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Appendices

Appendix I

Data Collection Sheet

NO	Gender	Age	FML	FMW
1				
2				
3				
4				
5				
6				
7				
8				
9				
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Appendix II

CT image

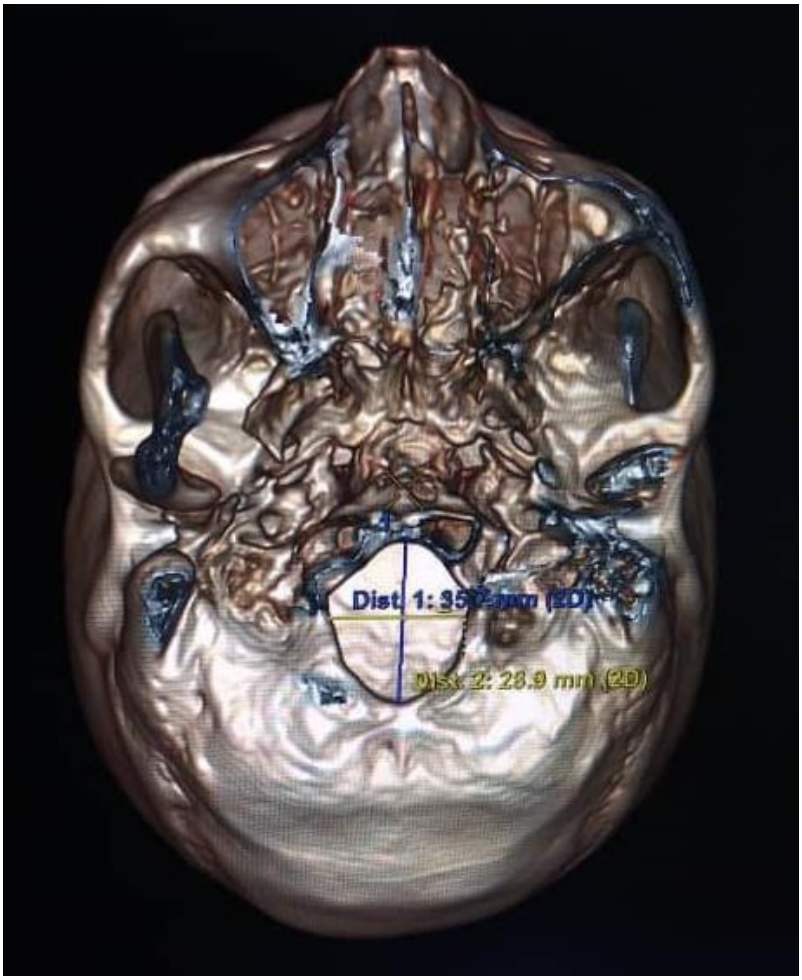

Image 1: CT Axial image for 30 years male patient foremen magnum measurements was L: 35.7mm and W: 28.9

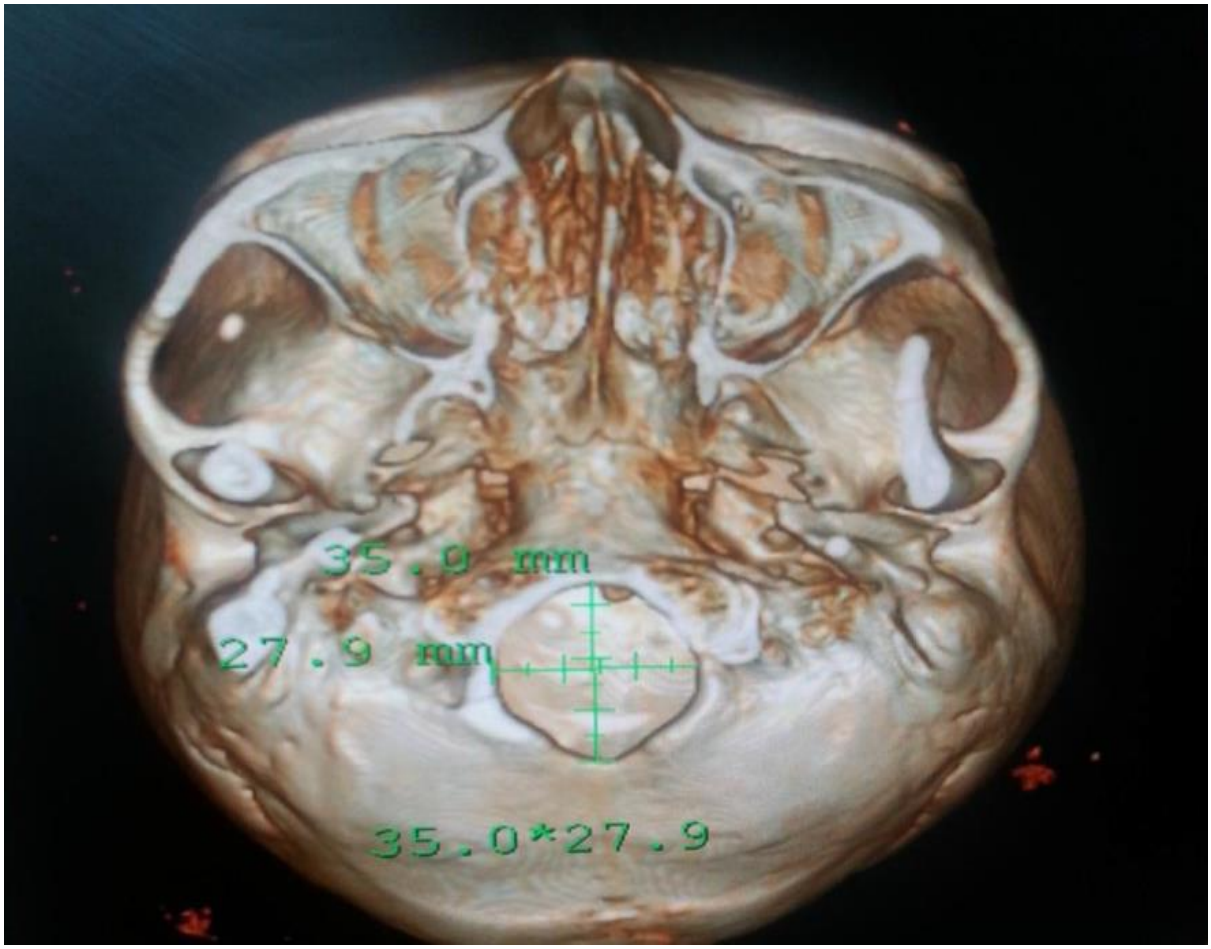

Image 2: CT Axial image for 29 years female patient foremen magnum measurements was L: 37.2 and W: 29.5