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Sudan University of Science &Technology

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Characterization of foramen magnum for the Sudanese Using Computed Tomography

توصيف الثقب الغزالي للسودانيين بإستخدام الاشعة المقطعية

A Thesis Submitted for the partial fulfillment of the requirement of the M.Sc Degree in Diagnostic Radiological Technology

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June 2016

الآية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال تعالى (وَلَوْ أَنَّمَا فِي الْأَرْضِ مِنْ شَجَرَةٍ أَقْلَامٌ
وَالْبَحْرُ يَمُدُّهُ مِنْ بَعْدِهِ سَبْعَةُ أَبْحُرٍ مَا نَفِدَتْ
كَلِمَاتُ اللَّهِ إِنَّ اللَّهَ عَزِيزٌ حَكِيمٌ)

سورة لقمان الآية (27)

Dedication

To

My Family

My Teachers

My Friends

Acknowledgement

This work was carried out under the Will of Allah.

I am extremely grateful to many people who supported me during the preparation of this study.

I would like to express my deep gratitude to my supervisor **Dr. Ikhlas Abdalaziz** for his support and guidance.

My thanks also go to the staff of radiology department of **Abdoon SidAhmed Diagnostic Center**

Finally, I would like to sincerely thank my family for their support.

List of Tables:-

List of Figures:-

List of abbreviations:-

FM	Foramen magnum
BS	Bass of Skull
PF	Posterior fosse
CT	Computed Tomography
MRI	Magnetic Resonance Image
CAT	Computed axial tomography
MIP	Maximum intensity projection
MPR	Multiplaner reconistracture
3D	Three Dimension
C1	First cervical vertebra (atlas)
C2	Second cervical vertebra
NF2	neurofibromatosis type 2
IGS	**Image-guided surgery**
CM	Centimeter
APD	Anterior posterior diameter
TD	Transverse diameter
AP	Antero-posterior
Fig	Figure

Contents

Abstract

The study was done to characterize foramen magnum using CTs and effect of diameter of base of the skull and height of patient on the diameter of foramen magnum.

50 patients (60% males and 40% females) were selected all the diagnosis as normal cranial CTs.

This study was done in Abdoon SidAhmed Diagnostic Center and Alfaisal Specialized Hospital during the period from January to Marsh 2016.

This study found the mean anterior posterior diameter FM in male subjects as 37.41mm (±3.27) and that of the female subjects 35.8mm (±2.88) width of the foramen magnum in male subjects was 30.93mm (±2.95) and that of the female subjects was 28.8mm (±1.96)result that the FM 0f males the graeter than females. The results showed that there was a weak correlation between foramen magnum and base of skull dimension the R^2=0.177.

The results also showed that there was a weak correlation between foramen magnum and high of patients the R^2=0.023.

The study, as well, showed that there was a weak correlation between foramen magnum and both bass of skull and high of patients although the correlation between the foramen magnum and bass of skull is relatively stronger than between foramen magnum and high of patients.

ملخص البحث

أجريت هذه الدراسة لتوصيف الثقب الغزالي للسودانيين بإستخدام الأشعة المقطعية للرأس ودراسة تأثير قاعدة الرأس وطول المرضى علي هذه القياسات.

تم إختيار 50 مريض معافى الرأس، منهم 30 ذكور و 20 من الإناث،

أجريت الدراسة في مركزعبدون سيد احمد التشخيصي ومستشفي الفيصل التخصصي في الفترة من يناير الي مارس عام 2016.

وجد أن متوسط أبعاد الثقب الغزالي على النحو الأتي: الطول للذكور (3,27±37,41) سم وللإناث(2,88±35,8) سم

اما العرض للذكور (2,95±30,93)سم وللإناث (1,96±28,8) سم ونتيجة لهذه النتائج وجد أن متوسط أبعاد الثقب الغزالي للذكورأكبر من الإناث.

أوضحت الدراسة أن هنالك إرتباطا ضعيفا بين أبعاد الثقب الغزالي وقاعدة الرأس لأن $R^2=0.177$ وهنالك أيضا إرتباط ضعيف بين أبعاد الثقب الغزالي وارتفاع المرضى $R^2=0.02$

وأوضحت الدراسة أن الإرتباط بين أبعاد الثقب الغزالي وقاعدة الرأس وارتفاع المرضى إرتباط ضعيف الا أن الإرتباط بين أبعاد الثقب الغزالي وقاعدة الرأس أقوي نسبيا من الإرتباط بين أبعاد الثقب الغزالي وارتفاع المرضى.

Chapter One

Chapter One

Introduction

1.1 Introduction

The foramen magnum (Latin: great hole) is a large opening in the occipital bone of the human skull.

It is one of the several oval or circular openings (foramina) in the basss of skull the spinal cord, an extension of the medulla, passes through the foramen magnum as it exits the cranial vault apart from the transmission of the medulla oblongata and its membranes, the foramen magnum transmits the vertebral arteries, the anterior and posterior spinal arteries, the tectorial membranes and alar ligaments It also transmits the spinal component of the accessory nerve into The skull (Dikman 1998).

Configuration and size of the foramen magnum play an important role in the pathophysiology of various disorders of craniovertebral junction (Wang etal 1987).

Stenosis of foramen magnum causes brainstem compression manifested by respiratory complications, lower cranial nerve dysfunctions, upper and lower extremity paresis, hypo- or hypertonia, hyperreflexia, or clonus thus(Bagleyetal2006)

fundamental knowledge of normal anatomy of this region is important to the clinician for diagnosis there are many modality the diagnosis of foramen magnum conventional X-Ray, CT and MRI but the CT is the best demonstrated. Computed tomography (CT) or computed axial tomography (CAT) was commercially introduced into radiology in 1972 and was the first fully digital imaging device it truly revolutionary in diagnostic imaging. In 1979, Godfrey Hounsfield and Allen Cormack were awarded the Nobel Prize in Physiology and Medicine for their contributions in the development of CT . firstly conventional CT, the X-ray tube and detector rotate around the patient with the table stationary The X-ray beam is attenuated by absorption and scatter as it passes through the patient with the detector measuring transmission Multiple measurements are taken from different directions as the tube and detector rotate. A computer reconstructs the image for this single "slice." The patient and table are then moved to the next slice position and the next image is obtained after that to developed the spiral (helical) CT the X-ray tube rotates continuous while the patient and table move through the scanner. Instead of obtaining data as individual slices, a block of data in the form of a helix is obtained Scans can be performed during a single breath hold, which reduces misregistration artifacts, such as occur when a patient has a different depth of CT scanners are now available with multiple rows of detectors (at the time of writing, commonly 64) allowing acquisition of multiple slices in one spiral acquisition and many application in CT (MPR, MIP,3D,…….) In conjunction with fast rotation speeds, the volume coverage and speed performance are improved allowing, for instance. (Lippincott Williams & Wilkins 2011)

1.2 Problem of the study:-

There is no anatomical study about the characterize of foramen magnum for the Sudanese population to the best of our knowledge. Estimation of foramen magnum size to help in predict of any pathological condition according to organ size.

1.3 Objectives of the study

1.3.1General objective

The aim of the study was to find out various measurements of the foramen magnum in Sudanese population.

1.3.2 Specific objective:

-To determine if there is any difference in size due to gender and age.

-Correlate difference measurement between measurement diameter of foramen

Magnum and skull bass diameter.

-Correlate difference measurement between measurement diameter of foramen

Magnum and high of patient..

1.4 The overview of the research

Chapter one deals with introduction, problem, objectives and overview of the research. Chapter two deals with literature review including theoretical background (anatomy, physiology and pathology) and previous studies. Chapter three deals with research Materials and Methods. Chapter four deals with results and finally chapter five deals with discussion, conclusion and recommendations

Chapter TWO

Chapter Two

Literature reviews

2.1Anatomy and Physiology

2.1.1 human skull

In humans the interior of the base of the skull is naturally subdivided into .

The anterior cranial fosse is formed almost entirely by frontal bone but the lesser wings of the sphenoid from the posterior edges of the floor and the cribriform plate of the ethmoid forms a small part of the floor in the midline. The middle cranial fosse is formed by the body and greater wing of the sphenoid bone and temporal bone its posterior border is formed by the upper Border of the petrous.

The posterior cranial fosse is formed mainly by occipital and temporal bones.

Its above the vertebral column and the muscles of the back of the neck consist illustrated to figure (2-1) (Valeria C. Scanlon 2009).

2.1.1.1 Occipital bone:

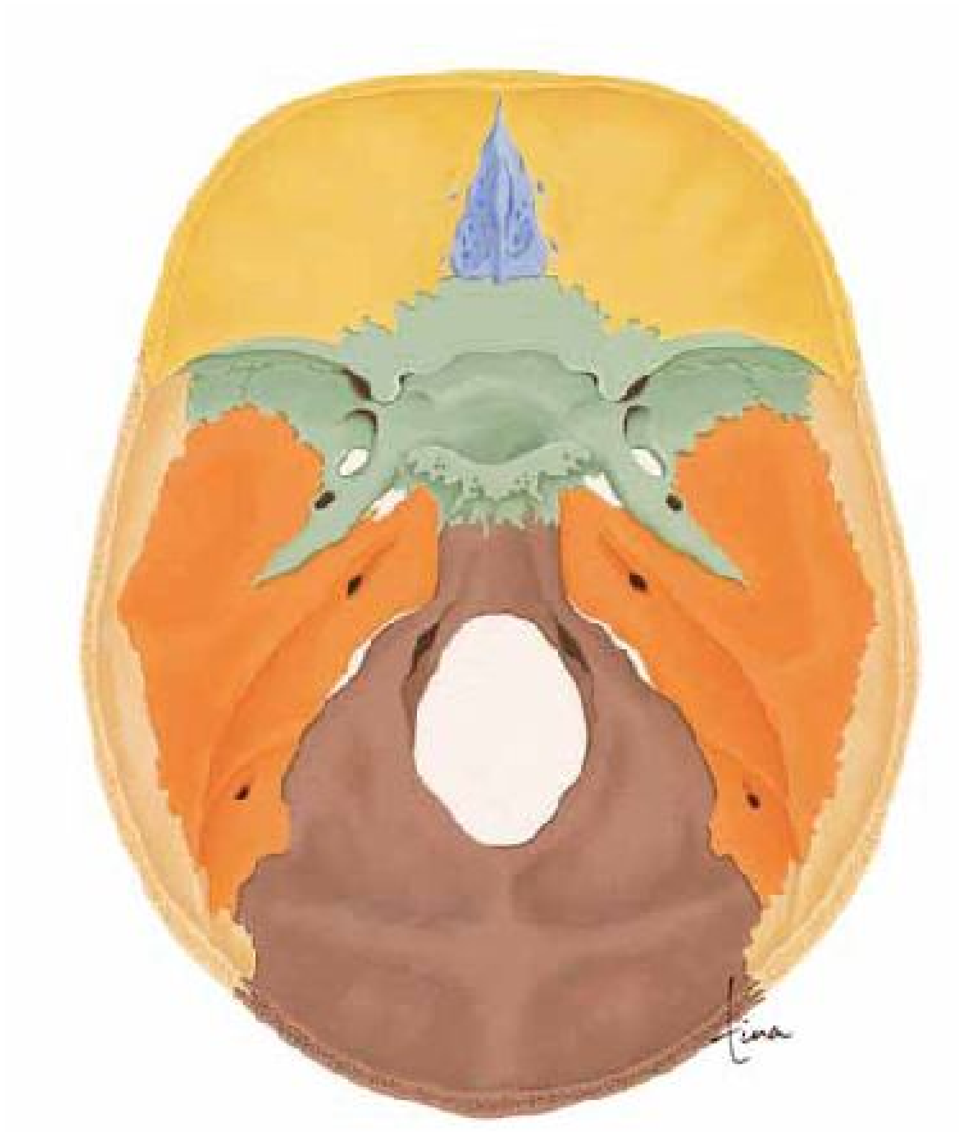
Is one of part of the posterior fossa forms and a large and important part of the base of the skull. It allows for the passage of many structures of the brain. It connects the skull to the upper cervical spine via condyles on its exterior base surface. Moreover, parts of the upper cervical spine develop from the same primitive tissues in the embryo as the base of the skull.

The occipital condyles are knuckle-like projections that drop down on either side of the FM and connect the skull to the upper cervical spine. The condyles are often pierced by tunnels that pass through them called the hypoglossal and condylar canals.

Although, technically speaking, they are anatomically distinct from the foramen magnum, from a functional structural point of view, the inner walls of the condyles form part of the restricted confines of the foramen magnum. In other words, looking down through the foramen magnum from the top side, the condyles increase the depth of the front part of the foramen compared to the rear part. They also intrude slightly into the FM making the tunnel slightly smaller and more restricted for a considerable distance compared to the rear of the foramen. This makes the front of the foramen magnum more like a partial canal. The canals of the skull, like the optic canal and auditory meatus are naturally more restrictive to increases in volume of their contents such as swelling.

Looking at the picture below the thick stem-like projection of the occipital bone that lies anterior to (in front of) the foramen magnum is called the basilar portion. The curved surface of the occipital bone located at the rear of the foramen is called the squama and forms the rear wall of the cranial vault. On the inside of the cranial vault the major drainage routes of the brain called the transverse sinuses are located close to the sides of the occipital bone.

In additon to the link between the condyles of the occipital bone to the articular surfaces of the first cervical vertebra (C1) called atlas.(Wanebo and Chicoine)



Fig(2-1) show posterior cranial fossa

Occiptal bone **Temporal bone** **Parietal bone** **Sphenoid bone**

Frontal bone **foramen magnum**

2.1.1.1.1The foramen magnum:

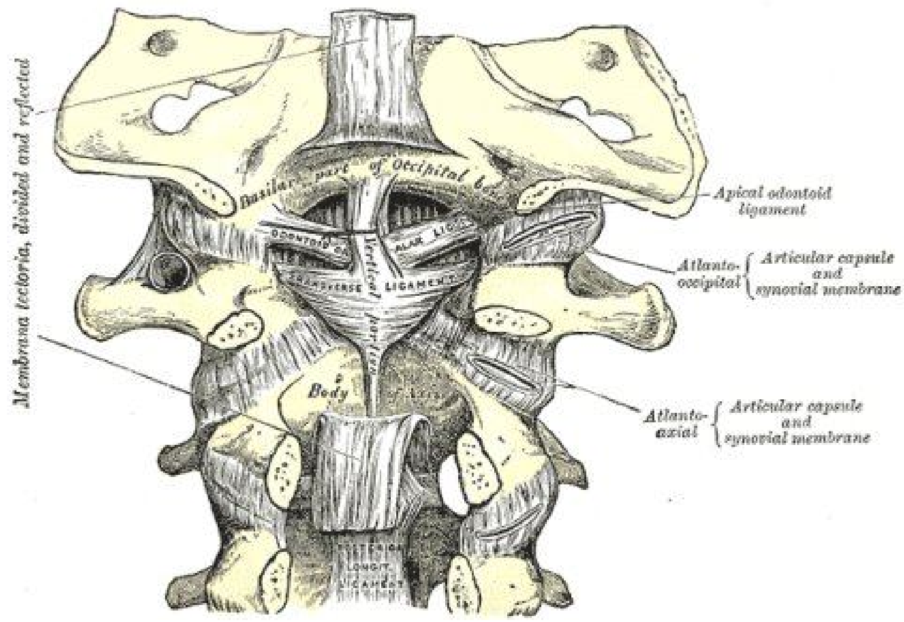
Is connected to the upper cervical spine by connective tissues called the membrana tectoria and the alar ligaments Some of the most important parts that pass through the foramen magnum include the medulla oblongata, cranial nerves and the spinal arteries. The dura mater also passes through this opening. The dura mater is just one of the protective layers that covers the skull and the brain. It is believed that the foramen magnum plays a role in degenerative diseases such as dementia and Alzheimer's disease.(Murshed etal 2003)

Dentate Ligament Connections: the membrana tectoria is also known as the tectorial membrane of the **occipitoaxial ligaments**.

The tectorial membrane of the occipitoaxial ligaments is a strong broad band of connective tissue that covers the odontoid process of the axis vertebra (second cervical vertebra - C2) of the upper cervical spine and its ligaments. The odontoid process is the tall thumb-like projection of the second cervical vertebra that sticks upwards in front of the spinal canal beneath the skull in the picture below. The odontoid process is also sometimes called the dens because it looks like a tooth.

The top picture is a side view of the occiput, FM, upper cervical vertebra, tectorial membrane of the occipitoaxial ligaments in the upper cervical spine, as well as the posterior longitudinal ligaments of the rest of the spine. The second picture is looking at this area from the back side of the head. In this picture the tectorial membrane of the occipitoaxial ligaments has been cut and folded down to show the other upper cervical ligments that lie in front of it.

Some anatomists consider the membrana tectoria to be a continuation of the **posterior longitudinal ligament:** of the vertebral column seen in the picture below. It is fixed below to the posterior surface of the body of the axis (C2) wider as it rises upwards and attaches to the basilar groove of the occipital bone in front of the foramen magnum. At the level of the FM, the anterior (front) surface of the tectorial membrane blends with the transverse ligament of the atlas vertebra (C1).



Fig(2-2**):** tectorial membrane of the **occipitoaxial ligaments**.

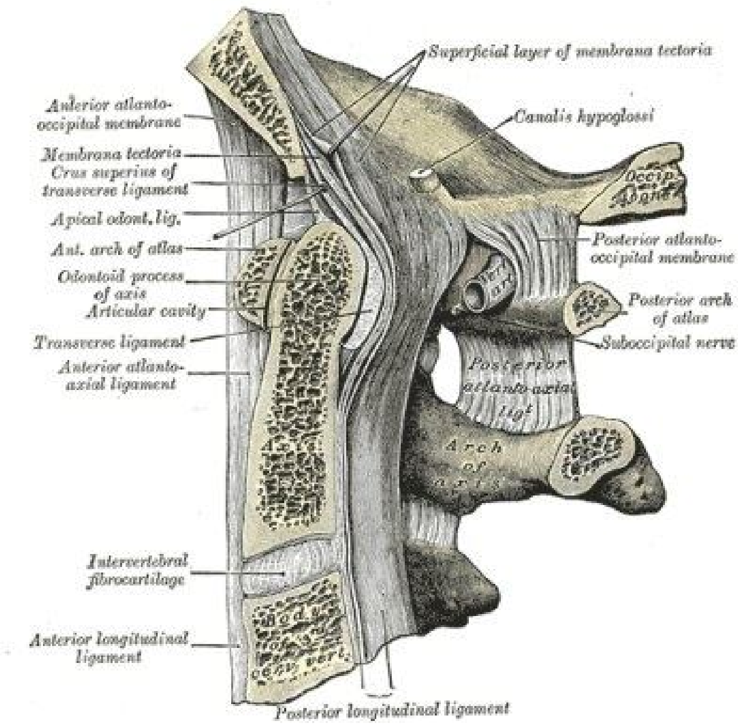


Fig (2-3)**: posterior longitudinal ligament**

The **dura mater**: is the outer of the three protective coats that surround the brain and cord. Craniopathic practioners in chiropractic and osteopathy have long maintained that misalignments of the spine cause dural tension in the brain and cord. The reason for this is the connection of the dura mater of the brain to the foramen magnum, membrane tectoria and the upper cervical ligaments and muscles. At the caudal (bottom) end of the spine, the dura mater attaches to the segments of the spinal canal inside the sacrum of the pelvis.

In addition to the dura mater, the **pia mater** of the cord also appears to attach to the foramen magnum. The pia mater is the inner of the three layers of protective coats that surround the brain and cord. The dentate ligament is part of the pia mater *(Russo, Gabrielle)*.

2.1.2 Pathology

The foramen magnum is a fundamental component in the complex interaction of bony, ligamentous, and muscular structures composing the craniovertebral junction. Shape and size of the foramen is critical parameters for the manifestation of clinical signs and symptoms in craniocervical pathology. The AP and transverse diameters of the foramen magnum have been found to independent risk factors in patients with craniocervical anomalies. (Bagley et al 2006).

2.1.2.1 Meningioma:

A meningioma is a type of tumor that grows from the protective membranes, called meninges, which surround the brain and spinal cord. Most meningiomas are benign (not cancerous) and slow growing; however, some can be malignant. Symptoms typically appear gradually and vary depending on the location and brain area affected. Because these are slow growing tumors, not all meningiomas need to be treated immediately the treatment options focus on removing the tumor and relieving the compression on the brain.

Because meningiomas tend to grow inward, they commonly cause pressure on the brain or spinal cord (Arnautovic and etal) .

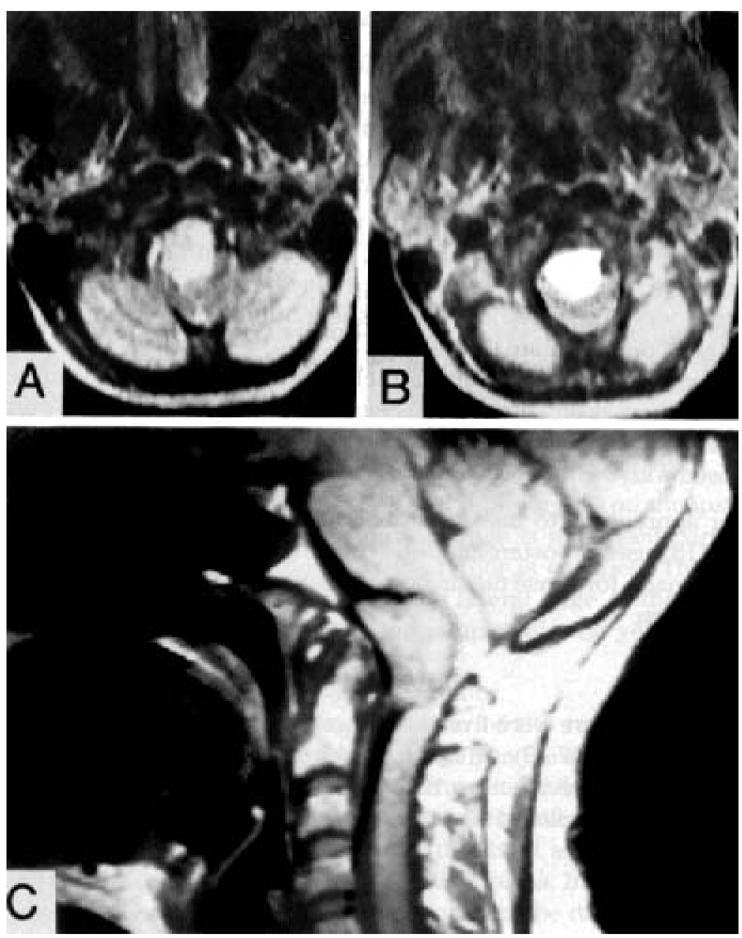
2.1.2.1.1 the symptoms:

Meningiomas grow slowly; it may take years before they cause symptoms. Some people with meningiomas have no symptoms. The tumor may be found incidentally on a diagnostic scan performed for another reason such as a trauma. Symptoms of a meningioma vary by location and size of the tumor. They often first appear as headaches and seizures, primarily due to increased pressure of the growing tumor.

Weakness in the arms or legs, or loss of sensation, may occur with spinal cord meningiomas the meningiomas are often named according to their location and symptoms:

2.1.2.1.2 Posterior fossa meningiomas:

grow along the underside of the brain near the brainstem and cerebellum. These tumors can compress the cranial nerves causing facial symptoms or loss of hearing. Petroclival tumors can compress the trigeminal nerve, resulting in facial pain (trigeminal neuralgia) or spasms of the facial muscles. Foramen magnum meningiomas grow near the area where the spinal cord connects to the brain and can cause headaches, or other signs of brainstem compression such as difficulty walking.



Fig(2-4**):**Foramen magnum meningioma**:** This 49-year-old woman noted increasing difficulty using her right upper extremity and weakness of her right lower extremity. An angiogram showed mild compression of the vertebral artery. Total removal was followed by full recovery. **(A** and **B)** MRI axial images, showing the tumor arising from the right anterior lateral dura with displacement of the brainstem posteriorly and to the left. **(C)** MRI sagittal image, showing the posterior compression of the cervical medullary junction.

2.1.2.1.2.1 The causes:

Scientists are not certain what causes meningioma tumors, although several theories are being investigated. Most agree that a malformed chromosome is the most common abnormality in meningiomas, but the cause of this abnormality is unknown. People with a genetic disorder known as neurofibromatosis type 2 (NF2) are more likely to develop meningiomas. Of people with malignant meningiomas, a higher percent have mutations in NF2. Studies have also found that patients who received radiation treatment to the head for medulloblastomas, ependymomas, or other tumors are at higher risk for developing meningiomas later in life secondary to the radiation.

2.1.2.1.2.2 Who is affected?

Meningiomas represent about 20% of all primary brain tumors and 12% of all spinal cord tumors. They can occur in children, but most often occur in adults between the ages of 40 and 60 years. Most meningiomas are benign (not cancerous), as less than 10% of meningiomas are malignant. While malignant meningiomas occur in both women and men, benign meningiomas occur most often in women.

2.1.2.1.2.3 The diagnosis:

First, the doctor will ask about your personal and family medical history and perform a complete physical examination. In addition to checking your general health, the doctor performs a neurological exam. This includes checks for mental status and memory, cranial nerve function (sight, hearing, smell, tongue and facial movement), muscle strength,

coordination, reflexes, and response to pain. If a problem is found, the doctor may order diagnostic imaging tests such as computerized tomography (CT) or magnetic resonance imaging (MRI) scans to help determine the size, location, and type of tumor, if one exists (Fig. 2). Skull x-rays may be obtained if the tumor is believed to involve the bone. For spinal cord tumors, a myelogram may be done, and in some cases, angiograms, or x-rays of the blood vessels, are necessary. The diagnosis can be confirmed by a biopsy.

Image-guided surgery (IGS) is a technology that helps the surgeon pinpoint the exact location of a tumor - similar to a GPS for the brain. Before surgery, a special MRI scan is performed with fiducial markers placed on the skin around the patient's head. During surgery, the fiducial markers correlate the "real patient" lying on the table to a 3D computer model of the patient created from their MRI or CT scans. Using a hand-held probe, the surgeon can track the probe's position in real time on the computer model of the patient's anatomy. IGS allows very precise planning of the approach by pinpointing the tumor location and guiding the skin and bone openings.

Interventional MRI or CT is a specially designed operating room in which the patient can undergo an MRI or CT scan before, during, and after surgery while still under anesthesia. This enables the surgeon to have real-time images of the patient's brain and to know exactly how much tumor has been removed prior to ending the procedure. This technology improves the ability for total tumor removal and reduces the need for a second operation (Crockard and Sen).

2.1.2.2 Foramen magnum Stenoses

Achondroplasia has a known association with foramen magnum stenosis that can result in cervicomedullary compression, which is most often due to a hypertrophied posterior occipital rim and an undersized transverse diameter. The authors present a unique case of a child with achondroplasia with symptomatic craniocervical compression from marked overgrowth of his opisthion anterior to the posterior arch of the atlas. This 22-month-old child with achondroplasia presented with severe respiratory and motor disabilities, including progressive quadriparesis and apneic episodes requiring continuous positive airway pressure. Magnetic resonance imaging and CT scans revealed marked foramen magnum stenosis from overgrowth of the opisthion, a hypoplastic C1 ring, and spinal cord edema at the cervicomedullary junction. Foramen magnum decompression and a C1 laminectomy were performed. Postoperatively, steady motor improvement has been observed and the patient no longer requires ventilatory support. To the authors' knowledge, this is the first report of this unusual anatomical entity.(Bagley et al 2006)

2.1.2.3 Chiari malformation (Arnold Chiari)

means that the lower parts of your brain have been pushed downwards towards your spinal cord, so they are below the entrance to your skull.

Most people will have a type 1 Chiari malformation, which is the least serious form of the disease. This is where the lowest part of the back of the brain (the cerebellar tonsils) drops down into the top of the spinal canal.

Types 2 and 3 Chiari malformations are less common and more serious. They are associated with spina bifida (a birth defect involving problems with spinal development), and adults will also have hydrocephalus (a build-up of fluid in the brain).(*Rosenbaum, Ciaverella (2004)).*

2.1.2.3.1 **Chiari type 1:-**

Usually, the lower parts of the brain are contained in a space within the skull, above the level of the foramen magnum (opening at the base of the skull). If you have a type 1 Chiari malformation, these brain parts are pushed downwards, because they are too big for the skull.

When parts of the brain are pushed out of the skull towards the spinal cord, this can cause pressure at the base of the brain block the flow of cerebrospinal fluid (CSF) to and from the brain

CSF is a clear fluid that surrounds and protects the brain and spine, and also carries nutrients to the brain and removes waste.

Chiari malformation can sometimes run in families, and it's possible that some children born with this disorder may have inherited a faulty gene that caused problems with their skull development in the womb. Researchers are currently trying to find the gene or genes that are responsible.

However, try not to worry – the risk of passing a Chiari malformation on to your child is very small. Even if children do inherit it, most will not develop symptoms.(*Riveira and Carmiña 2007*)

2.1.2.3.1.1 The symptoms

Many people with a type 1 Chiari malformation will not have any symptoms.

When symptoms do develop, they may include:

headaches, usually at the back of the head – these are brought on, or made worse by, exercise, straining, laughing or bending over

neck pain، dizziness and balance problems، numbness or tingling in the arms or legs، blurred vision and involuntary movement of the eyes (nystagmus) ،swallowing problems (dysphagia)

hearing loss and tinnitus ،feeling sick and vomiting ،depression(*Luokas and etal2011*)

2.1.2.3.2 **Syrinxes and syringomyelia:**

Many people with a type 1 Chiari malformation will develop a condition called syringomyelia, where a tube-shaped cavity forms within their spinal cord and fills with fluid.

This fluid-filled cavity, known as a syrinx, can expand and elongate over time, pressing on, and damaging, the spinal cord. It can cause pain, numbness, weakness, stiffness and problems with bladder or bowel functions, and sometimes leads to paralysis.*(Adnan Burina, Ibrahimagic (2009))*

Surgical treatments involve treating the underlying cause – in other words, operating on the Chairi malformation or treating hydrocephalus – or releasing the fluid using a system of drainage tubes and valves

Reducing the fluid in a syrinx can stop symptoms getting worse and can sometimes improve them.

2.1.2.3.3The diagnoses:

Sometimes, Chiari malformations are discovered by chance after a magnetic resonance imaging brain scan (MRI scan) is done to investigate a different condition.

If you see your with symptoms suggesting you may have a Chiari malformation, they should arrange for you to have an MRI scan to confirm this diagnosis.

brain scan will show up any abnormalities in the structure of your brain and spine.(*Barkovich and et al (1986)*.

2.1.3Computed Tomography

The basic equipment configuration for CT are three major systems imaging system, computer system and image display, record, storage and communication system (Moss, Gamsu, Genant 2015).

The three major system are located separated room:

The image system is located in the Scanner room .

The computer system is located in the computer room.

The display , record, storage system is located in the operators room.

2.1.3.1 Imaging system

2.1.3.1.1 The Gantry:

The gantry is the ring-shaped part of the CT scanner.

It houses many of the components necessary to produce and detect x-rays (Fig. 2-5). Components are mounted on a rotating scan frame. Gantries vary in total size as well as in the diameter of the opening, or aperture the range of aperture size is typically 70 to 90 cm.

The CT gantry can be tilted either forward or backward as needed to accommodate a variety of patients and examination protocols

Fig(2-5) The gantry and patient table are major components of a CT image
system.

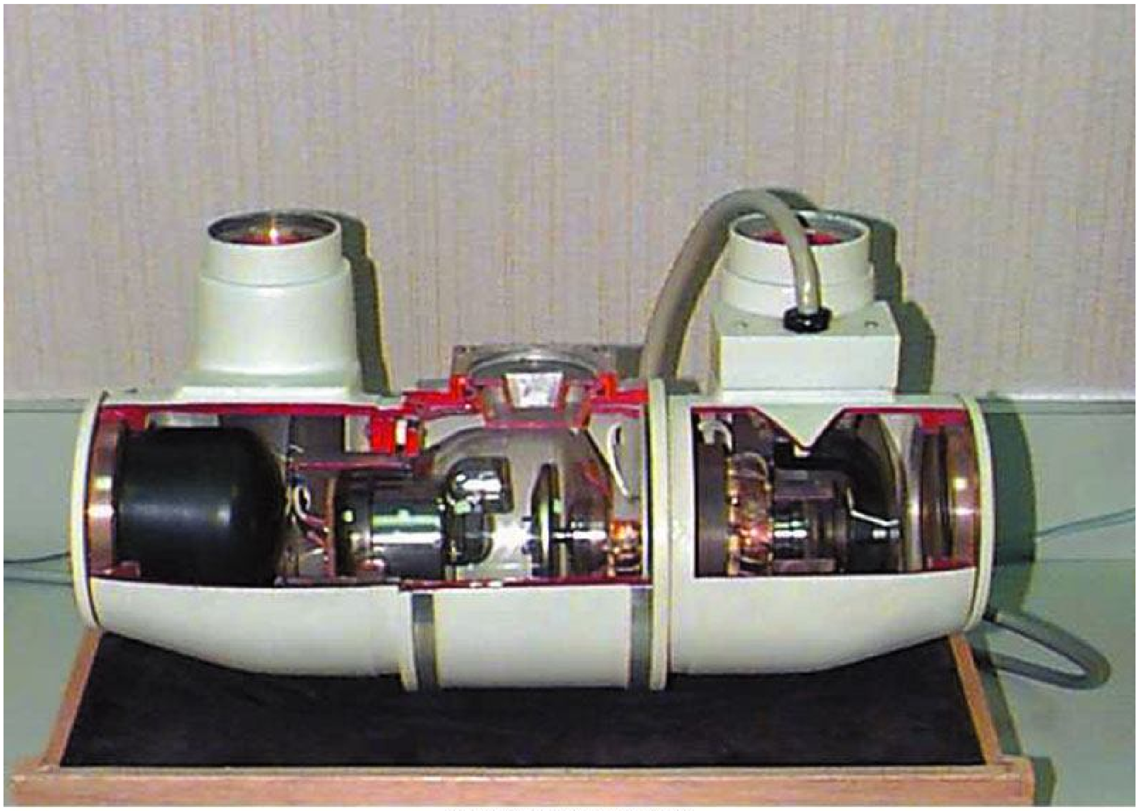
2.1.3.1.2 X-ray tube:

X-ray tube for CT is similar in design to the conventional radiography tube, but is specially designed to handle and dissipate excessive heat units – much higher heat loading

X-ray tubes produce the x-ray photons that create the CT image their design is a modification of a standard rotating anode tube used for the anode target material produces a higher-intensity x-ray beam.

CT tubes often contain more than one size of focal spot; 0.5 and 1.0 mm are common sizes produce sharper images (i.e., better spatial resolution).

All manufacturers list generator and tube cooling capabilities in their product specifications. These specifications usually list the system generator's maximum power



(Courtesy Marconi Medical Systems.)

Fig **(**2-6) Especially tube for spiral computed tomography

2. 1.3.1.3 Filtration:

Filtering the x-ray beam helps to reduce the radiation dose to the patient and improves image quality

the body-scanning filters are used to reduce the beam intensity at the periphery of the beam, corresponding to the thinner areas of a patient's anatomy.

Because of their shape they are often referred to as bow tie filters.

2.1.3.1.4 Detectors:

The term detector refers to a single element or a single type of detector used in a CT system. The term detector array is used to describe the entire collection of detectors included in a CT system. Specifically, the detector array comprises detector elements situated in an arc or a ring, each of which measures the intensity of transmitted x-ray radiation along a beam projected from the x-ray source to that particular detector element.

There are many types of detectors:

1_Solid State(Photodetector) detector material is typically a doped ceramic based material. Detector scintillates and resulting light is collected by silicon based photodetectors to produce voltage.

2_ A xenon detector channel consists of three tungsten
plates when a photon enters the channel, it ionizes the
xenon gas. (Not common in last 15 years) - Non Radioactive Xn gas that is easily ionized in proportion to Incident radiation. Ionizes, produces ion pairs which are collected by electrically charged plates.

Each produces a voltage which is converted to digital value through analog to digital converter (ADC)

2.1.3.1.5 Collimation

Collimators restrict the x-ray beam to a specifi c area, thereby reducing scatter radiation. Scatter radiation reduces image quality and increases the radiation dose to the patient.

Reducing the scatter improves contrast resolution and decreases patient dose. Collimators control the slice thickness by narrowing or widening the x-ray beam.

In CTsystem use tow collimator Prepatient collimation is located near the x-ray source and limits the amount of x-ray the source collimator affects patient dose and determines how the dose is distributed across the slice thickness also use Predetector (Postpatient) collimation is located below the patient and above the detector array the primary functions of predetector collimators are to ensure the beam is the proper width as it enters the detector and to prevent scatter radiation.

2.1.3.1.6 Generator

High-frequency generators are currently used in CT.

They are small enough so that they can be located within the gantry.

Highly stable three-phase generators have also been used, but because these are stand-alone units located near the gantry and require cables, they have become obsolete.

2.1.3.1.7 Patient Couch

Consists of a support referred to as couch top (cradle), made from carbon fiber.

Pedestal houses the mechanical and electronic components that facilitate vertical and longitudinal movement.

CT table height can be adjusted from 40 to 90 cm.

Lowering to 40cm allows seniors and children to sit and lie down comfortably

this feature minimizes any mental or physical discomfort for the patient.

The mechanisms housed within the gantry and the patient table are the components necessary for data acquisition.

2.1.3.2 Computer System

The principal components in a computer are an input device, an output device, a central processing unit (CPU), and memory. Input and output devices are ancillary pieces of computer hardware designed to feed data into the computer or accept processed data from the computer. Examples of input devices are keyboard, mouse, touch-sensitive plasma screen, and CT detector mechanisms. Output devices include monitor, laser camera, printer, and archiving equipment such as optical disks or magnetic tape Soft ware program helping CT user to communicate with the CT system include CPU and mem

2.1.3.2.1 Central Processing Unit(CPU)

The CPU is the component that interprets computer program instructions and sequences tasks. It contains the microprocessor, the control unit, and the primary memory.

In the past the CPU design frequently used for CT image reconstruction was the array processor. Also called a vector processor, this design was able to run mathematical operations on multiple data elements simultaneously.

Array processors were common in the scientifi c computing area throughout the 1980s and into the 1990s, but general increases in performance and processor design resulted in their elimination.

2.1.3.3 Image display, record and storage System

Image record by solid state laser printersand gas laser printer and the Image storge by magnetic tapes , Magnetic Optical Disk (MOD) and CD.

2.2 Previous Studies:-

Lang and Hornung (1993), in a study in Germany on comparison of the difference between the transverse diameter and anteroposterior diameter values of foramen magnum in male and female subjects showed statistical significance in terms of size.

The study showed that in male subjects, the anteroposterior diameter and transverse diameter values were larger than those found in females, the anteroposterior diameter of foramen magnum was found to be 35.33mm, and the transverse diameter 29.67mm.

The anteroposterior diameters of the foramen magnum were on average

significantly greater than transverse diameters, this is consistent with the normal
oval shape of the foramen magnum. Furthermore, both diameters show an inter-
individual variability and both are normally distributed.

Philipp and et al 2009 the study on central europian male and female dry skulls, the anteroposterior diameter ranges from the minimum value of 30mm to maximum value of 43mm.

The transverse diameter ranges from the minimum value of 25 mm to the maximum of 39 mm .

The diameters of the female foramen magnum are on average slightly smaller than those of the males .

It was found that a weak positive correlation with individual age exists for both diameters (anteroposterior diameter: $r = 0.22$, transverse diameter: $r = 0.10$), yet none is significant.

Fatma, Vedat, Mehmet and Oktay, 2010, to evaluate the foramen magnum in sex determination using computerize tomography scan in the study that was carried out on 95 adult dry skulls in Sivas Turkey, the mean anteroposterior diameter of the foramen magnum was found to be 3.63cm ± 0.27cm, and the
transverse diameter 3.04cm ± 0.27cm.

Chapter Three

Chapter Three

Materials And Methods

3.1 Materials:-

3.1.1 Population:-

This study included 50 subjects (30 males and 20 females), normal adult Patients cranial CTs and good position were included. abnormal cranial CTs, poor quality of the scan images were excluded.

3.1.2 Study Variables:-

The variables that were collected from each subject included gender, patient age and hiegh, foramen magnum and skull bass diameter.

3.1.3 Equipment:-

used in taking the Cranial CT Scans used in the study include Toshiba Spiral CT machine multislice Helical CT (2009) model.

Cranial computerized tomographic Scans were obtained from the local data

base of the computerized tomographic machine and back up compact disc from

the computerized tomographic library.

Measurement was made with Toshiba 16slice and 4slice Medical System Company Limited software, the software provides a meter rule.

3.2 Method:-

3.2.1 Technique:-

Patient supine and the head first and good position of the other part the FM measurements (sagittal, transverse) were obtained from reformatted axial sections using helical CT scan with 5 mm thickness, 150 kVp, 200–230 mAs, 1800 AU window levels and 35–45 s scan time. All sections selected were parallel to the plane of the FM in order to select the best image of the foramen The FM length diameter was recorded as the greatest anteroposterior dimension of the FM and the FM transverse diameter (FMTD) was recorded as the greatest width of the FM. the area of FM were automatically given after tracing the bony margin of the FM on the CT image using a 3D program on the CT workstation with a resolution of 1280×1042 full screen format.

3.2.2 Method of measuring Foramen magnum and Skull bass:-

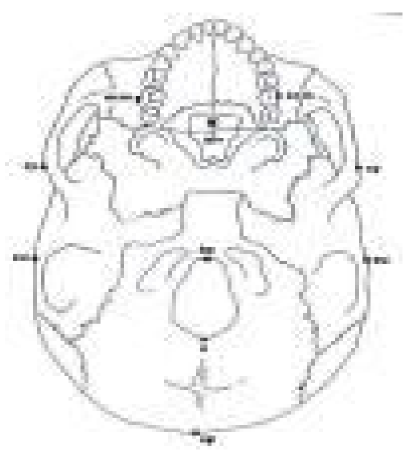
Foramen Magnum Length (APD): direct distance from basion to opisthion Instrument: sliding caliper. tips of caliper should rest precisely on opposing edges of the border of foramen magnum.

Foramen Magnum Width (TD): distance between the lateral margins of foramen magnum at the points of greatest lateral curvature

Fig(3-1) measurement of FM

Bass of the Skull Width (TD) , measure to the outside of the roots of the zygomatic processes at their deepest in curvature and slightly anterior to the external auditory meatus, with the sharp points of the caliper.

Length(APD) measure to distand between anterior border and posterior border.



Fig(3-2) measurement of bass of skull

3.2.3 Data collection:-

Data collection sheet used and other information were collected directly from patients in addition to references, websites and previous studies

3-2-4 Data analysis:-

The results were scheduled for analysis by using statistical package for social studies (SPSS) and Excel to obtain the results related to correlation between variables.

Chapter Four

Chapter Four

Results

The following tables and figures present the data obtained from 50 patients who were examined for cranial CT scan , at Radiology Departments of Abdoon Side Ahmed Diagnostic Center and Alfaisal Specialized Hospital.

Table (4.1) show statistical parameters for all patients

	Mean	**STD**	**Min**	**Max**
Age	49.24	19.69	20	85
High	165.66	7.9	145	180
FM Length	36.76	3.37	30	45
FM Width	30.06	2.77	26	35
BS length	178.98	7.92	160	195
BS Width	125.6	6.60	112	142

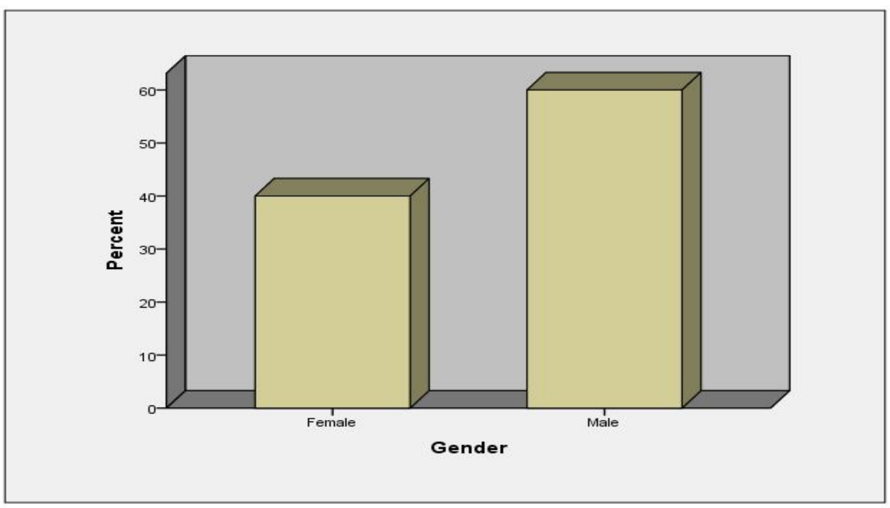


Figure (4.1) show the Ratio male to female for all patients

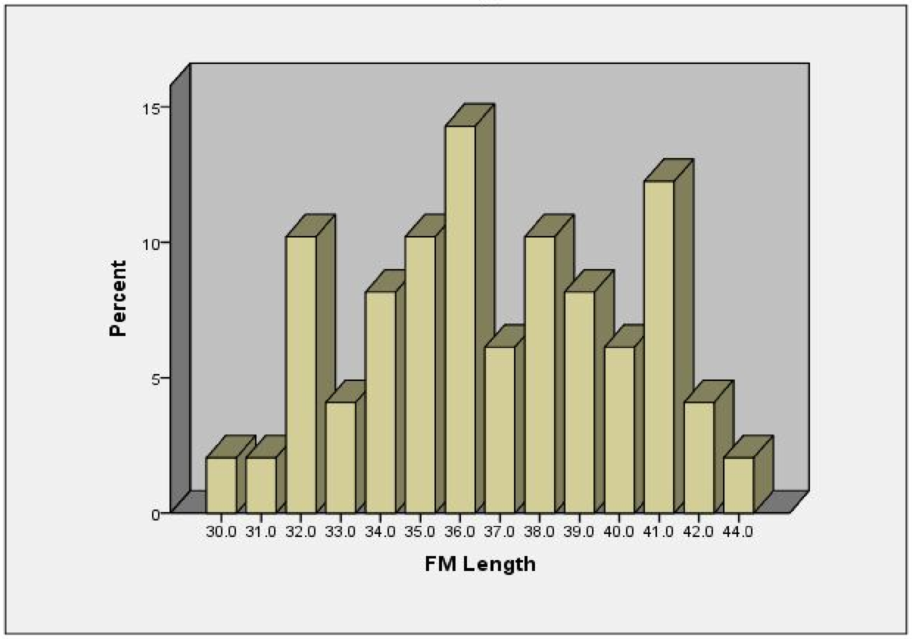


Figure (4.2) show distribution of FM Length for all patients

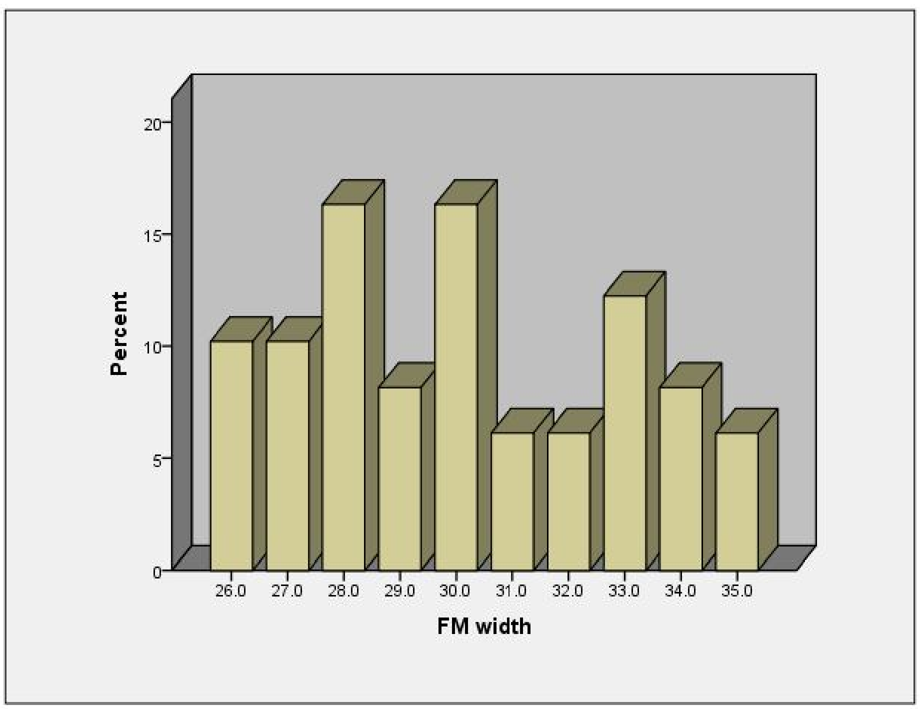


Figure (4.3) show distribution of FM width for all patients

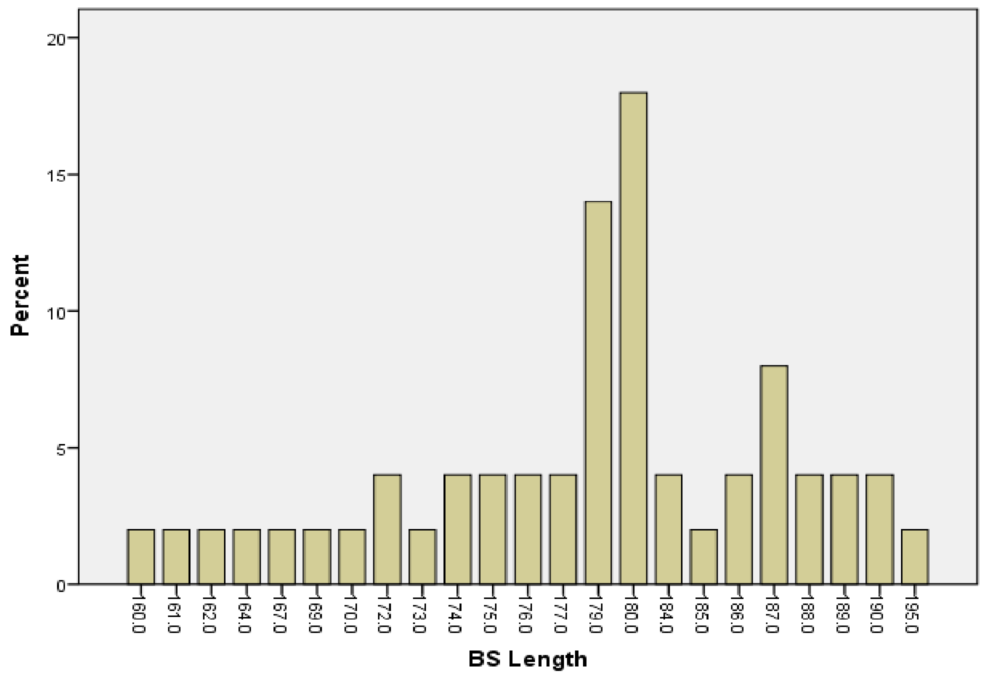


Figure (4.4) show distribution of BS Length for all patients

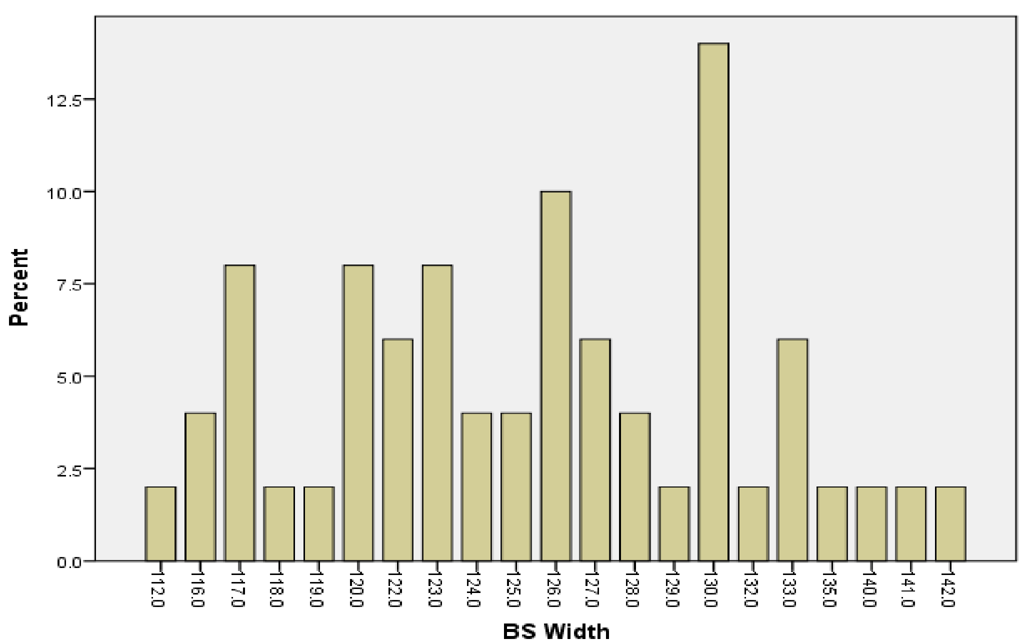


Figure (4.5) show distribution of BS width for all patients

Table (4.2) show statistical parameters for Female

	Mean	STD	Min	Max
Age	48.55	19.57	20	84
High	161.7	7.59	145	175
FM Length	35.8	2.88	31	41
FM Width	28.8	1.96	26	33
BS length	174.15	7.58	160	187
BS Width	120.85	5.02	112	133

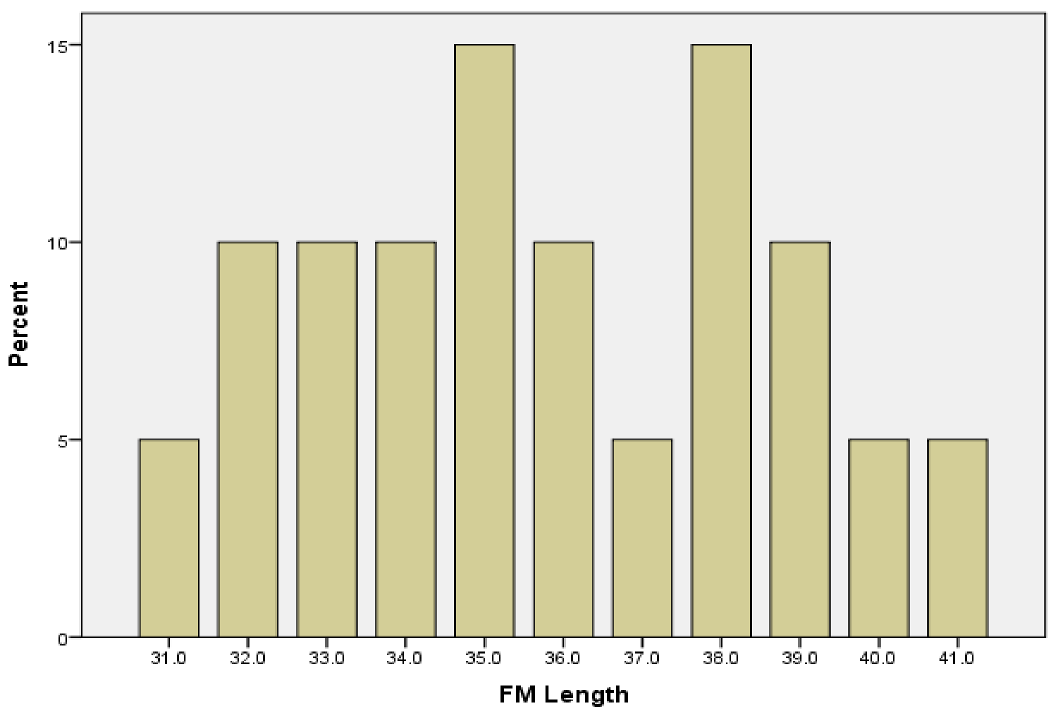


Figure (4.6) show distribution of FM Length for Female

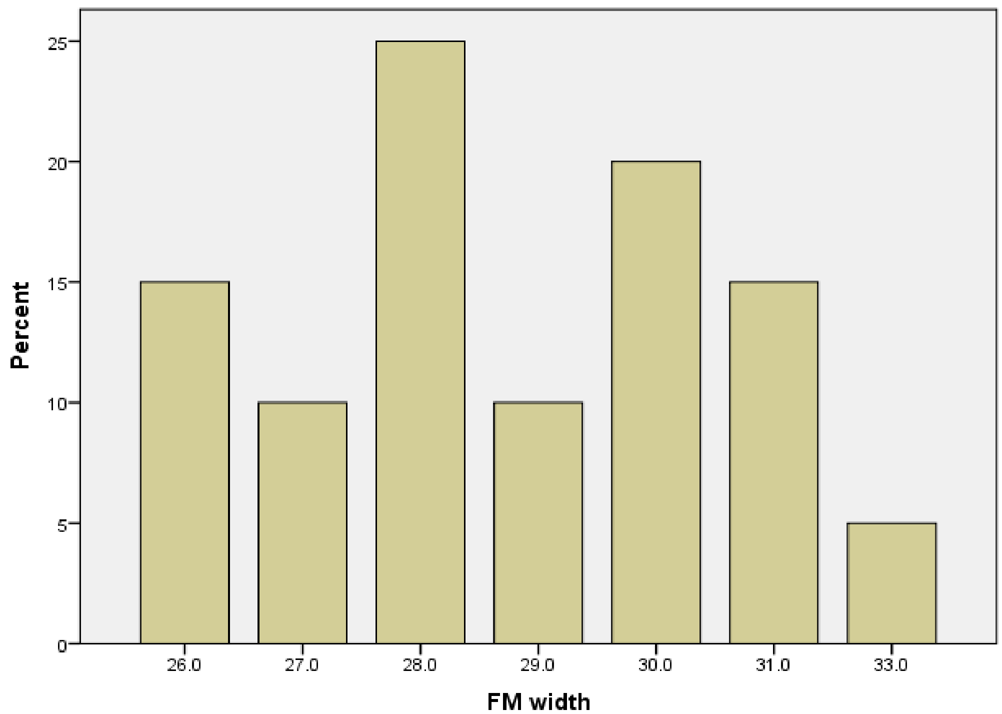


Figure (4.7) show distribution of FM Width for Female

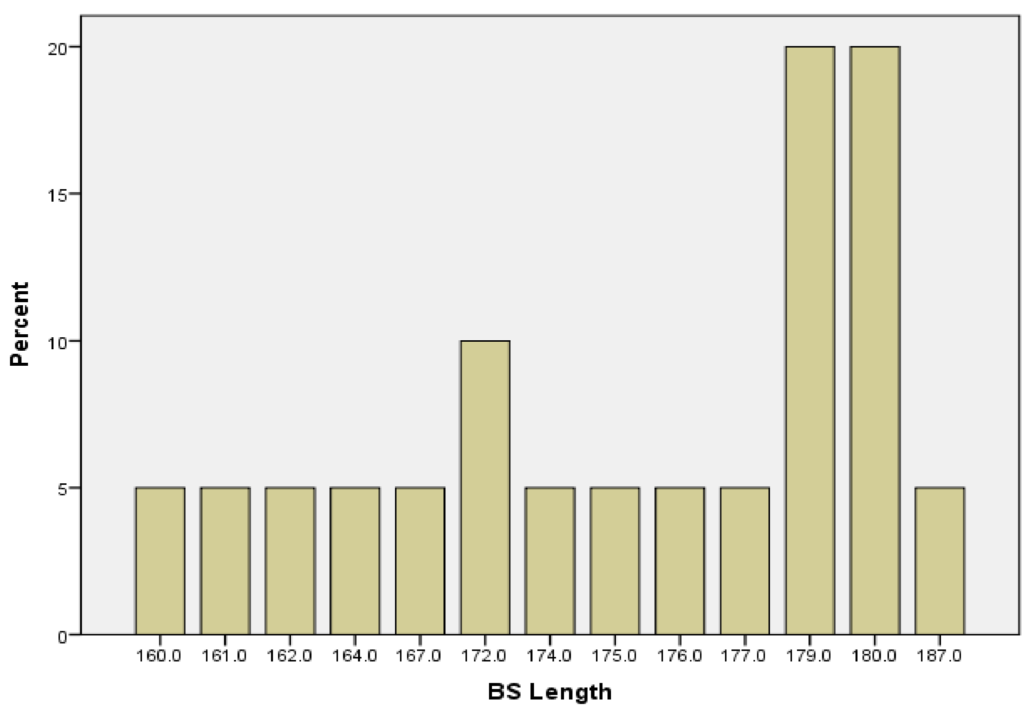


Figure (4.8) show distribution of BS Length   for Female

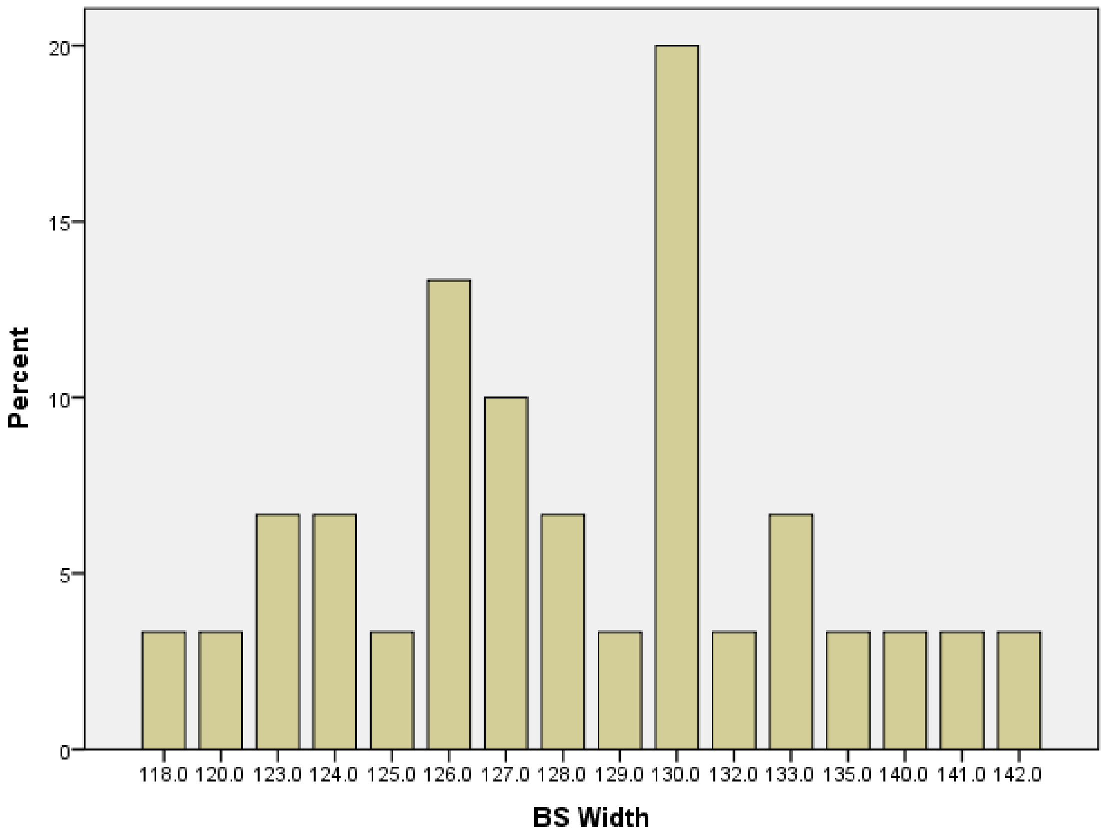


Figure (4.9) show distribution of BS width for female

Table (4.3) show statistical parameters for Male

	Mean	STD	Min	Max
Age	49.7	20.3	22	85
High	168.3	7.06	155	180
FM Length	37.41	3.57	30	44
FM Width	30.93	2.95	26	35
BS length	182.2	6.45	169	195
BS Width	128.77	5.59	118	142

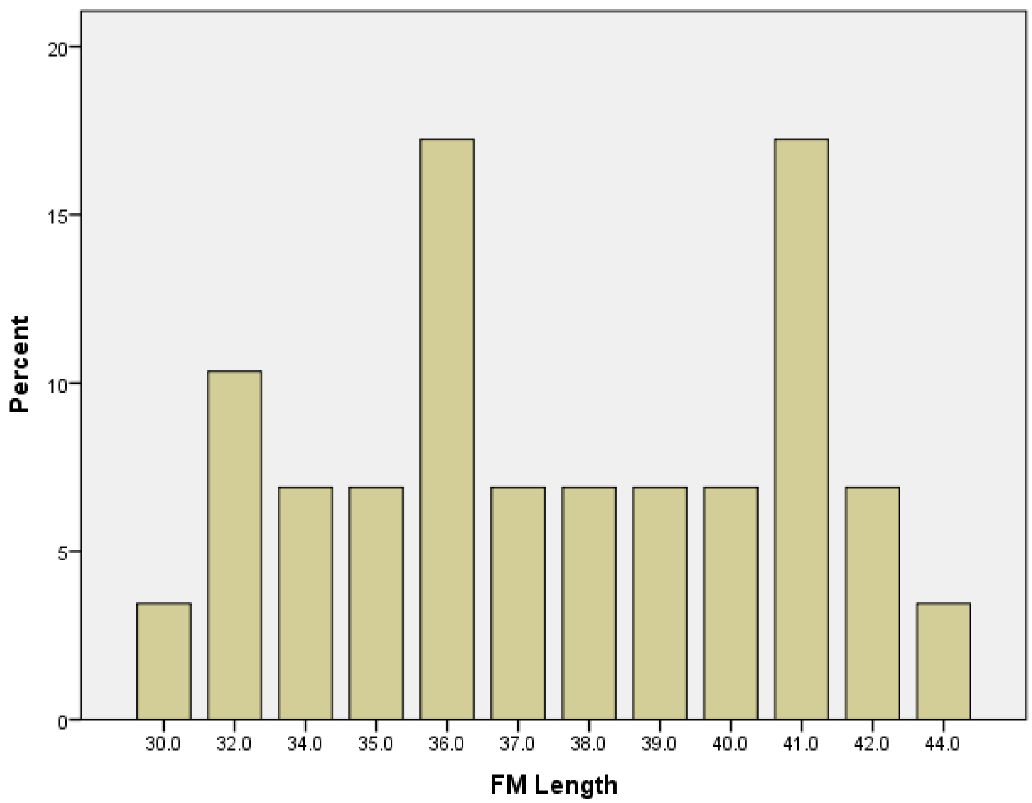


Figure (4.10) show distribution of FM Length for Male

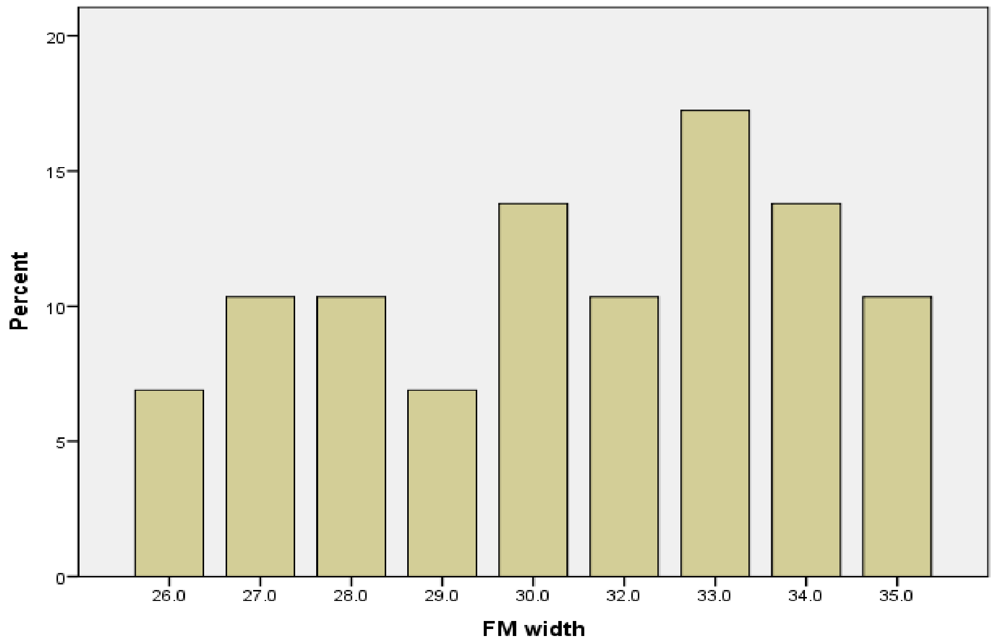


Figure (4.11) show distribution of FM Width for Male

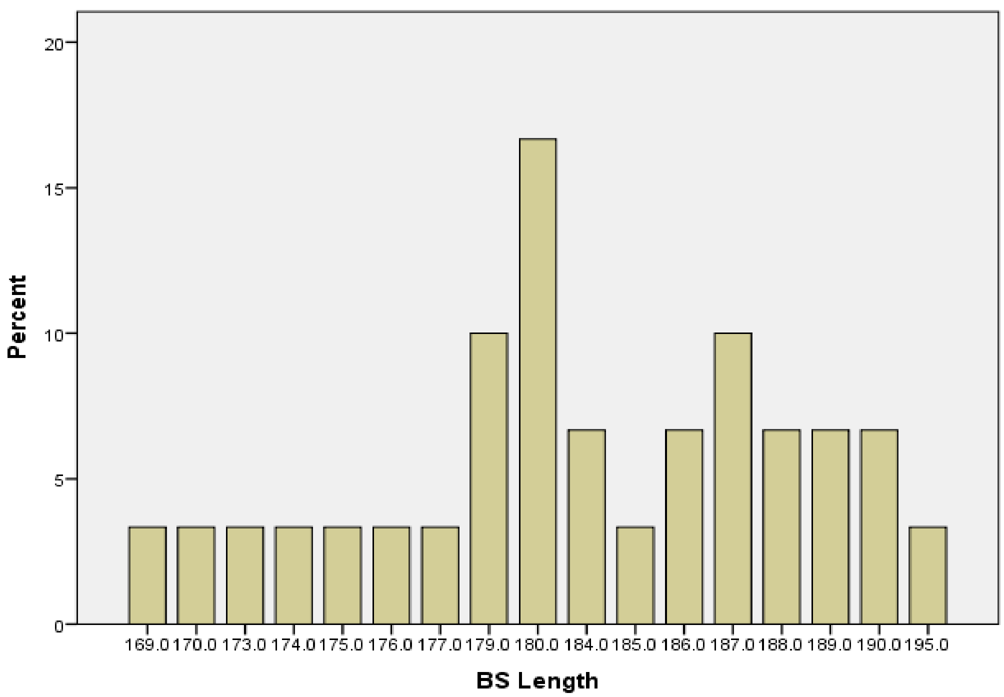


Figure (4.12) show distribution of BS Length for Male

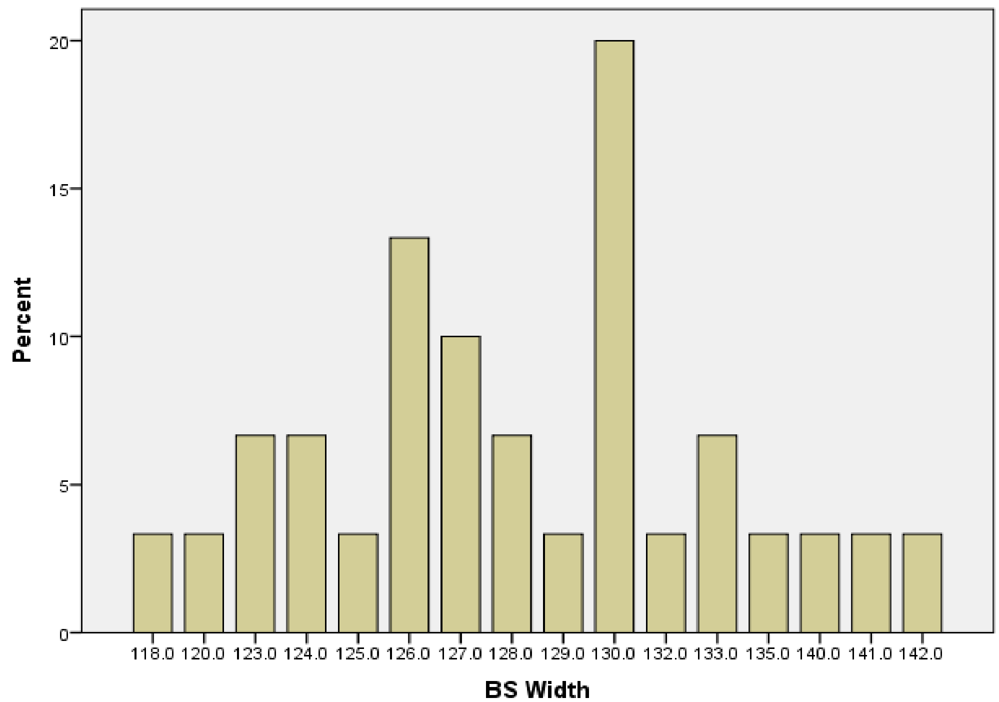


Figure (4.13) show distribution of BS Width for Male

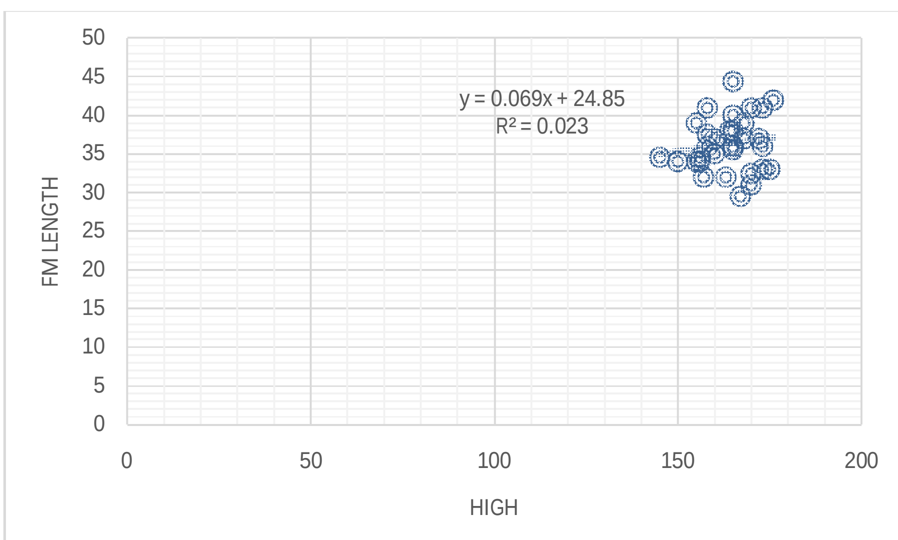


Figure (4.14) show correlation between FM length and High for all patients

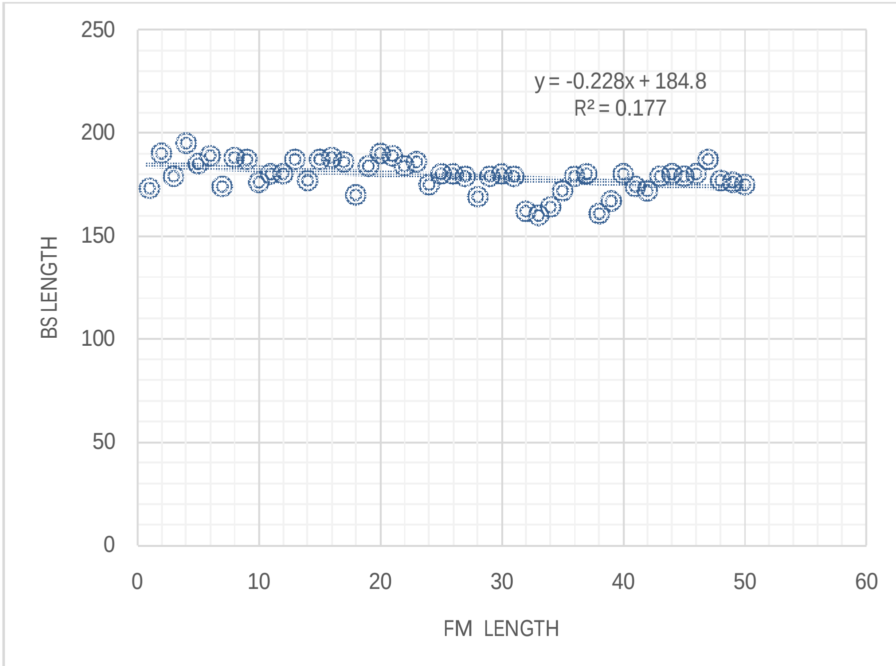


Figure (4.15) show correlation between FM length and BS length

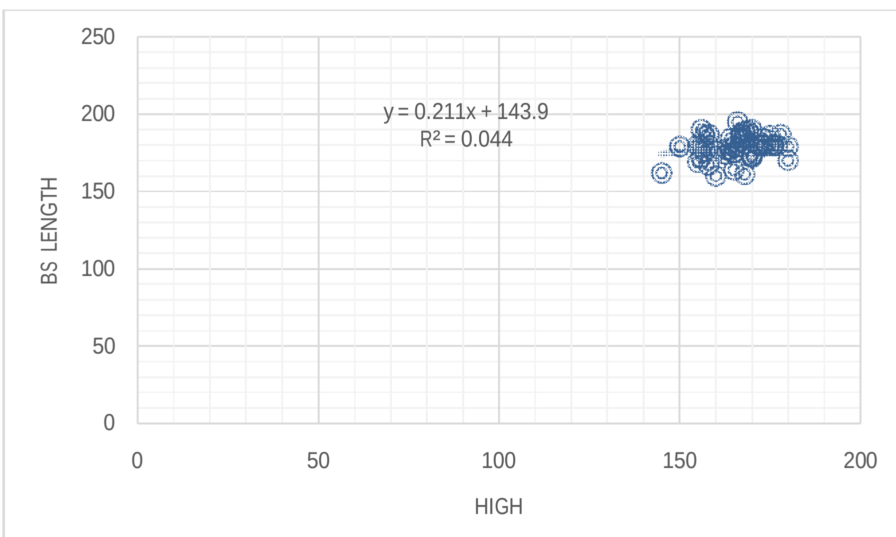


Figure (4.16) show correlation between BS length and height

Chapter Five

Chapter Five

Discussion, Conclusion and Recommendation

5.1 Discussion

This study aimed to characterization of foramen magnum dimension for Sudanese population used to computed tomography. A total of 50 subjects were involved in the study. Out of this number, 40% were females and 60% were males. The ratio of male to female was 1.5:1. The age range of the subjects was 20 to 85 years, and the mean of age was 49.24 years (±19.69).

The average of the foramen magnum diameters were 30.0mm to 45.mm for anterior posterior diameter and 26mm to 35.4mm for the width of the foramen magnum.The mean anterior posterior diameter and width of the foramen magnum were 36.8mm (±3.37) and 30.06mm (±2.77) respectively.

Compares the mean and standard deviation of the foramen magnum diameters, for males and females used in the study.

The mean for the anteroposterior diameter in male subjects was 37.41mm (±3.27), and that of the female subject 35.8mm (±2.88). This indicates that there is no statistically significant difference among the sexes.

The mean measurement for the foramen magnum width in male subjects was

30.93mm (±2.95) and that of the female subjects was 28.8mm (±1.96). This indicates that there was statistically significant difference between the sexes.

the mean anterior posterior diameter and the width of the foramen magnum in all subjects were found to be 36.376mm (±3.37) and 30.06mm (±2.77) respectively. This is same to found by Osunwoke, Oladipo, Gwunireama and Ngaokere (2012) in Anambra State, Nigeria, which were found to be 36.11mm and 29.56mm for the mean length and width of the foramen magnum respectively.

This study finds the mean anterior posterior diameter in male subjects as 37.41mm (±3.27) and that of the female subjects 35.8mm (±2.88) with no significance statistically, the mean width of the foramen magnum in male subjects was 30.93mm (±2.95) and that of the female subjects was 28.8mm (±1.96) which is statistically significant. This shows a larger value in males than females, which is the same as reported by Catalina-Herrera (1987) from Spain and Selma-Uysal et al (2005).

from Turkish population. The mean anteroposterior diameter and width of the foramen magnum in relation to the age groups of subjects studied shows no difference across the age groups from 20 to 79 years of age.there is same reported in this study.

A correlation was made between FM length and BS length the effect of bass of skull diameter on the measurement of foramen magnum, and it was found that there was the direct relation the R^2=0.177 which means that this correlation was weak.

A correlation was made between FM Length and high of patient it was found that there was a direct relation the R^2=0.023 which means a weak correlation between FM Length and high of patient.

A correlation was made between BS length and high of patient it was found that there was a direct relation the R^2=0.044 which means a weak correlation between BS Length and high of patient.

5.2 Conclusion

The foramen magnum is a three dimensional aperture within the basal central region of the occipital bone. It is an oval or circular aperture in the base of the skull. It transmits the medulla oblongata and its membranes, the spinal accessory nerve, vertebral arteries, the anterior and posterior spinal arteries, the membrane tectoria and alar ligaments. Studies related to International Journal of Health and Medical Information Volume 2, Number 2, August 2013
morphometric analysis of antero-posterior diameter (APD) and transverse diameter (TD) of the foramen magnum showed differences and has an extreme importance in sex determination. The age range of subject used in this study was 20 to 85 years this is fairly comparable with the age range of individuals used by Giles and Eliot (1963) which is between 21 to 75 years. This study concludes that the dimensions of the foramen magnum are greater in Sudanese males than in their female

From the study it could be concluded that there was a direct relation between FM and BS but there was a weak correlation between this variables the R^2=0.177. In other words, the effect of bass of skull diameter to the foramen magnum diameter was very weak.

Also the result showed there was a relation between foramen magnum diameter and high of patients, although the correlation was weak. That means the effect of high of patients to the measurement of FM was weak the R^2=0.023.

5.3 Recommendations

- We recommend professors of high education to present and discuss all the previous studies, which related to the themes of the course in order to avoid repetition when students choose their research topics.
- Future study should be done to study the effect of the shape of the skull to the foramen magnum.

References and Appendix

Reference

Adnan Burina, Dževdet Smajlovic, Osman Sinanovic, Mirjana Vidovic, Omer Ć. Ibrahimagic (2009). "Arnold chiari malformation and syringomyella". *Acta Med Sal 38: 44–46* .

Arnautovic KI, Al-Mefty O, Husain M.Ventral foramen magnum meningiomas. J Neurosurg 2000;92(Suppl 1):S71-S80.

Bagley CA, Pindrik JA, Bookland MJ, Camara-Quintana JQ, Carson BS. Cervicomedullary decompression for foramen magnum stenosis in achondroplasia. J Neurosurg. 2006;104(3 Suppl):166–72

Crockard HA,Sen CN.The transoral approach for the management of intradural lesions at the craniovertebral junction: review of Neurosurgery 1991;28:88-98.

Dysautonomia News – Winter/Spring 2006". *Dinet.org. Archived from* the original *on November 29, 2011*. Retrieved 2011-11-04.

Günay Y, Altinkök M, Çagdir S, Sari H. Is foremen magnum size useful for gender determination (in Turkish). Bull Legal Med 1998;3:41–45

Hecht JT, Nelson FW, Butler IJ, Horton WA, Scott CI, Jr, Wassman ER, et al. Computerized tomography of the foramen magnum: Achondroplastic values compared to normal standards. Am J Med Genet. 1985;20:355–60

Lippincott Williams & Wilkins 2011. Computed tomography for technologists : a comprehensive text /Lois E. Romans Printer*:* C&C Offset - China

*Loukas M, Shayota BJ, Oelhafen K, Miller JH, Chern JJ, Tubbs RS, Oakes WJ (2011). "Associated disorders of Chiari Type I malformations: a review". Neurosurg Focus **31** (3): E3.* doi*:* PMID 21882908*.*

Murshed KA, Çıçekcıibaşi AE, Tuncer I. Morphometric evaluation of the foramen magnum and variations in its shape: a study on computerized tomographic images of normal adults. Turk J Med Sci 2003;33:301–306

Osunwoke, Oladipo, Gwunireama and Ngaokere (2012) measurement of foramen magnum by Computerized tomography in Anambra State, Nigeria

*Riveira, Carmiña; Pascual, Julio (2007). "Is Chiari type I malformation a reason for chronic daily headache?". Current Pain and Headache Reports **11** (1): 53–5.* doi*:*10.1007/s11916-007-0022-x. PMID 17214922.

Russo, Gabrielle A.; Kirk, Christopher E. (November 2013). "Foramen magnum position in bipedal mammals"*. Journal of Human Evolution 65 (5): 656–670.* doi*:*10.1016/j.jhevol.2013.07.007. Retrieved 12 March 2015

Selma-Uysal, R. M., Dilek Gokharman, M. D., Mahmut Kacar, M. D., Is?l Tuncbilek, M. D. and Ugur Kosar, M. D. (2005). Estimation of Sex by 3D CT Measurementsof the Foramen Magnum. Journal of Forensic Science, 50 (6), 1-5

Valeria C. Scanlon 2009.Essential of Anatomy and physiology 5th edition . New York.

Wanebo JE, Chicoine MR. Quantitative analysis of the transcondylar approach to the foramen magnum. Neurosurgery 2001;49:934–941

Wang H, Rosenbaum AE, Reid CS, Zinreich SJ, Pyeritz RE. Pediatric patients with achondroplasia: CT evaluation of the craniocervical junction. Radiology. 1987;164:515–9

Appendix (A)

Data collection sheets

No	Age	Gender	height	Fm width	Fm length	BS width	BS length	Sha

Appendix (B)

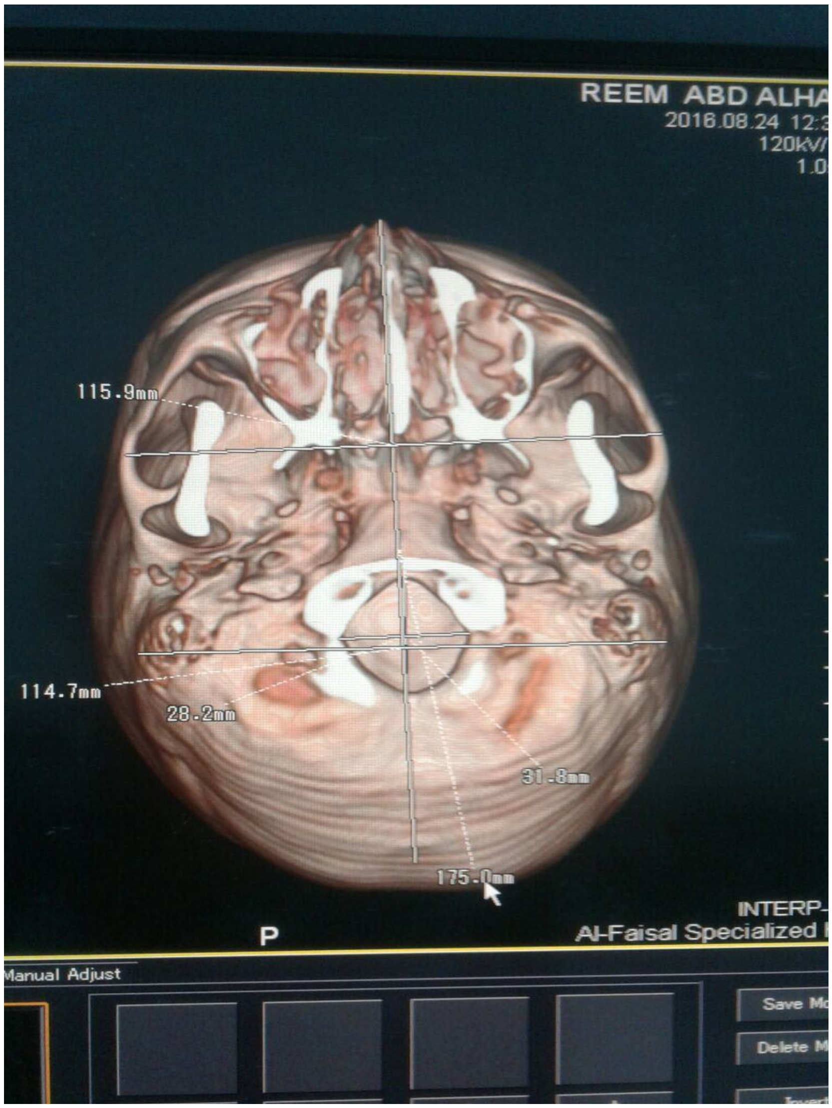


Figure (1), show 3D skull, female, 47years demonstrates width and length measures of base of skull and foramen magnum

Figure (2), show 3D skull, male, 25 years demonstrates width and length measures of base of skull and foramen magnum

Figure (3), show 3D skull, female, 27 years demonstrates width and length measures of base of skull and foramen magnum