

Sudan University of Science and Technology

College of Graduate Studies

**Measurement of Spinal Canal Diameter for Sudanese Using Magnetic
Resonance Imaging**

قياس قطر القناة الشوكية للسودانيين باستخدام التصوير بالرنين المغناطيسي

**A thesis submitted for partial fulfillment of the requirement of M.Sc degree in
Diagnostic Radiologic Technology**

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الآية

بسم الله الرحمن الرحيم

قال تعالى:

((خَلَقَ السَّمَاوَاتِ وَالْأَرْضَ بِالْحَقِّ تَعَالَى عَمَّا يُشْرِكُونَ (3) خَلَقَ الْإِنْسَانَ مِنْ نُطْفَةٍ فَإِذَا هُوَ خَصِيمٌ مُبِينٌ (4)).

صدق الله العظيم

سورة النحل

Dedication

To everyone who lightened a dark spot in my minds... To myparents, to my family and my friends.

Acknowledgment

Firstly I thanks Allah for his help to finish this work successfully.

I would like to express my deepest gratitude thanks to my supervisor Duha Abdu (Ass.Dr) for her guidance.

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List of Abbreviation:

MRI Magnetic Resonance Imaging

CT Computed Tomography

T1 Longitudinal relaxation time

T2 Transvers relaxation time

TR Time of Repeat

TE Time to Echo

L1 First lumbar vertebra

L2 Second lumbar vertebra

L3 Third lumbar vertebra

L4 Forth lumbar vertebra

L5 Fifth lumbar vertebra

S1 First sacrum vertebra

AP AntoroPosterior

ALL Anterior Longitudinal Ligament

PLL Posterior Longitudinal Ligament

RF Radio Frequency

SE Spin Echo

GRE Gradient Echo

FSE Fast Spin Echo

FOV Field Of View

LCS Lumbar Canal Stenosis

CSF	Cerebro Spinal Fluid
Fig	Figure
SPSS	Statistical Package for Social Sciences
Sig	Significance
mm	Millimetres
CTL	Cervical-Thorothic-Lumbar

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Abstract

This study was done to determine the normal Antero-posterior diameter of the spinal canal in lumbosacral region (all lumbar and first sacral level) among the adult Sudanese population using the MRI and to determine whether there are any differences related to age, weight and gender regarding this diameter. The study was retrospective descriptive cross-sectional analytical study. MRI examinations were performed in Modern Medical Center for 200 normal Sudanese subjects to study the lumbosacral region. The data was collected through check list, analyzed by SPSS. The majority of the participants were male (49.50%), young between 29 and 37 years of age and mean weight 65 kilogram. The results showed that the longest mean AP diameter was at L1 (17.4 ± 2.0 mm) in male while (17.9 ± 2.7) in female. The shortest mean AP diameter was at S1 (15.9 ± 3.3 mm) in male and (15.5 ± 3.1) in female. The AP diameter gradually decreased from L1 to S1. The equation of AP diameter with age is described in ($y = 0.02106x + 18.155$) for ages 20-28, ($y = 0.4391x + 18.155$) for ages 29-37 and ($y = 0.3686x + 16.977$) for ages 38-45. There is no significant difference between both gender. There is association between age and weight and the AP canal diameter.

ملخص الدراسة :

أجريت هذه الدراسة لتحديد القطر الأمامي الخلفي العادي من القناة الشوكية في المنطقة القطنية العجزية (جميع الفقرات القطنية والفقرة العجزية الأولى) بين السودانيين البالغين باستخدام التصوير بالرنين المغناطيسي، وتحديد ما إذا كان هنالك أي اختلافات تتعلق بالعمر والوزن والجنس بخصوص هذا القطر وكانت دراسة مرجعية وصفية تحليلية دراسة مستعرضة. أجريت فحوصات التصوير بالرنين المغناطيسي في المركز الطبي الحديث لـ 200 شخص سوداني سليم لدراسة المنطقة القطنية العجزية. تم جمع البيانات من خلال قائمة الاختيار، وتحليلها من قبل SPSS. وكانت غالبية المشاركين من الذكور (49.50%) والذين تتراوح أعمارهم 29-37 سنة من العمر مع متوسط وزن 65 كيلوغرام. وأظهرت النتائج أن أطول قطر كان في الفقرة القطنية الأولى (2.0 ± 17 ملم) في الذكور (2.7 ± 17.9 ملم) في الإناث. كان أقصر متوسط قطر في الفقرة العجزية الأولى (3.3 ± 15.9 ملم) في الذكور (3.1 ± 15.5 ملم) في الإناث. القطر الأمامي الخلفي للقناة الشوكية ينخفض تدريجياً من الفقرة القطنية الأولى إلى الفقرة العجزية الأولى. معادلة قياس القطر الأمامي الخلفي من العمر كالاتي $y=0.02106x+18.155$ للاعمار ما بين 20-28 و $y=0.4391x+18.155$ للاعمار ما بين 29-37 و $y=0.3686x+16.977$ للاعمار ما بين 38-45. لا يوجد فرق كبير بين كلا الجنسين. هنالك علاقة بين العمر والوزن والقطر الأمامي الخلفي للقناة الشوكية.

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Chapter One

Introduction

Chapter One

Introduction

1.1 Introduction:

Magnetic resonance imaging of the lumbar spine is a safe and painless test that uses a magnetic field and radio waves to produce detailed pictures of the lumbar spine bones, disks, and other structures in the lower back . An MRI differs from a CT scan because it does not use radiation. MRI image helps to pinpoint problems in the lumbar spine when the scan focuses on that area.MRI can detect a variety of conditions of the lumbar spine, including problems with the bones, vertebrae, soft tissues.(Amante,2015).

MRI sometimes is performed to assess the anatomy of the lumbar spine, to help plan surgery on the spine, or to monitor changes in the spine after an operation. It can find areas of the spine where the spinal canal is abnormally narrowed and might require treatment. It can assess the disks to see whether they are bulging, ruptured, or pressing on the spinal cord or nerves.MRI of the lumbar spine can be useful in evaluating symptoms such as lower back pain, leg pain, numbness, tingling or weakness, or problems with bladder and bowel control. It can also help to diagnose tumors, bleeding, swelling, developmental or structural abnormalities, and infections or inflammatory conditions in the vertebrae or surrounding tissues. (Amante,2015).

1.2 Problem of study:

Although spinal stenosis has been recognized for many years as a clinical Problem, it has yet to be exactly defined and agreed uponstenotic diameter. And that there was no reference measurements of spinal canal diameter for Sudanese it had to be the work of this study .

1.3 Objectives:

1.3.1 General objective:

To measure spinal canal diameter for Sudanese using magnetic resonance imaging.

1.3.2 Specific objectives:

- To determine the normal anteroposterior diameter of the spinal canal in the lumbosacral region using the magnetic resonant image .
- To determine whether there are any differences related to age, weight, and gender regarding the normal AP diameter of lumbosacral spinal canal.

1.4 Over view of the Study:

The study will fall into five chapters, Chapter one consists of introduction, problem of the study, objectives, and the overview of the study. Chapter two includes the literature review, Chapter three detailed the material and methods, Chapter four includes the presentation of the results, chapter five include the discussions, conclusion, recommendation and finally References and Appendices .

Chapter Two

Theoretical background and literature Review

Chapter Two

Theoretical background and previous studies

2.1.1 Anatomy of spine

The vertebral column is composed of a series of 31 separate bones known as vertebrae. There are seven cervical or neck vertebrae, 12 thoracic vertebrae, and five lumbar vertebrae. The sacrum is composed of five fused vertebrae, and there are two coccygeal vertebrae which are sometimes fused. In the normal adult there are four curvatures in the vertebral column in an anteroposterior plane. These serve to align the head with a vertical line through the pelvis. In the thoracic and sacral regions, these curves are oriented concave anterior and each is known as a kyphosis. In the lumbar and cervical regions the curves are convex anterior and each is known as a lordosis. These latter normal curvatures develop during childhood in association with lifting the head and assuming upright sitting and they are thus known as secondary curvatures. The thoracic and sacral curvatures are the same in adult as they are in fetal life and they are known as primary curvatures (Stephanie, et al ,2004).

Each vertebra is composed of a body anteriorly and a neural arch posteriorly. The arch encloses an opening, the vertebral foramen, which helps to form a canal in which the spinal cord is housed. Protruding from the posterior extreme of each neural arch is a spinous process and extending from the lateral edges of each arch are transverse processes. These bony elements serve as important sites of attachment of deep back muscles. The neural arch of each vertebrae is divided into component parts by these processes. The parts of the neural arch between the spinous and transverse processes are known as the laminae and the parts of the arch between the transverse processes and the body are the pedicles. At the point

where the laminae and pedicles meet, each vertebra contains two superior articular facets and two inferior articular facets. The former pair of facets form articulations, which are synovial joints, with the two inferior articular facets of the vertebra immediately above (or the skull, in the case of the first cervical vertebra). The pedicle of each vertebra is notched at its superior and inferior edges. Together the notches from two contiguous vertebra form an opening, the intervertebral foramen, through which spinal nerves pass .(Keith ,2015)

Lumbar vertebrae are characterized by massive bodies and robust spinous and transverse processes. Their articular facets are oriented somewhat parasagittally, which is thought to contribute the large range of anteroposterior bending possible between lumbar vertebrae. Lumbar vertebrae also contain small mammillary and accessory processes on their bodies. These bony protuberances are sites of attachment of deep back muscles.(Keith,2015).

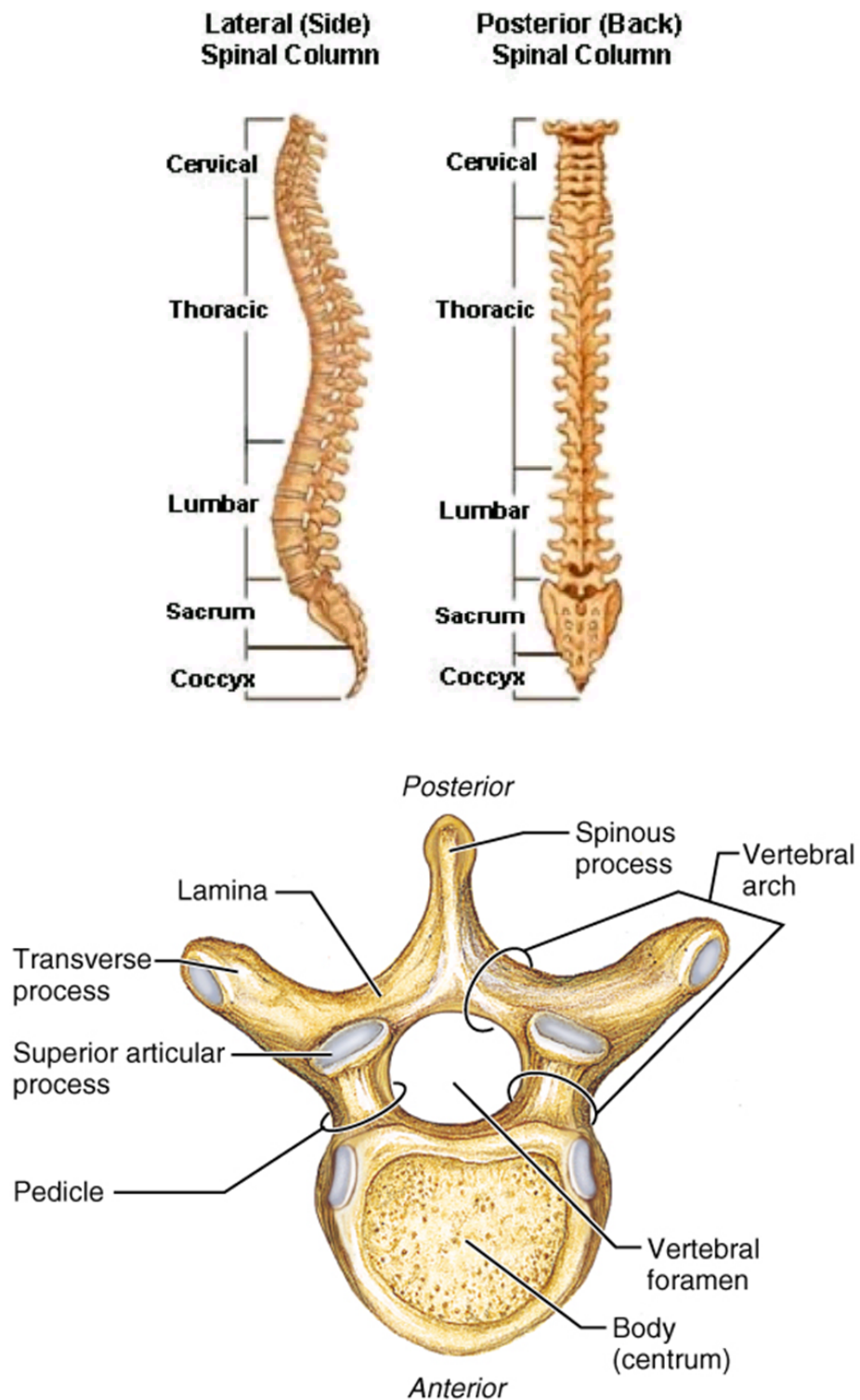


Figure 2.1 shows normal spinal curvatures with Atypical lumbar vertebra (Stephen,etal,2015)

Adjacent vertebrae are connected by three types of intervertebral articulations. Synovial joints are formed between the inferior articular facets of one vertebrae and the superior articular facets of the vertebrae below. These joints are extensively reinforced by different ligaments. These ligaments connect the tips of the spinous processes (supraspinous ligaments), the base of the spinous processes (interspinous ligaments), and the transverse processes (intertransverse ligaments). In addition the laminae of adjacent vertebrae are bound together by a ligamentum flavum. The bodies of adjacent vertebrae are connected by specialized cartilaginous joints known as intervertebral discs. Each disc is composed of a central core of gelatinous material, known as the nucleus pulposus, and a surrounding series of fibrous rings known as the annulus fibrosus. Normally body weight is transmitted through the disc by loading the nucleus pulposus, which is then compressed and transfers its loading to the annulus fibrosus. In most individuals, the fibers of the annulus fibrosus effectively resist this load, but in some people they do not and the nucleus pulposus is forced out of the disc, or is herniated. A herniated nucleus pulposus can have a profound effect on the adjacent spinal nerves. Two ligaments connect the vertebral bodies anteriorly and posteriorly and thereby reinforce the intervertebral disc. The anterior longitudinal ligament is strong and robust throughout but the posterior longitudinal ligament becomes thin and narrow in the lumbar region. This change in structure of the posterior longitudinal ligament is part of the reason that the overwhelming majority of disc herniations occur posteriorly in the lumbar region.(Keith,2015).

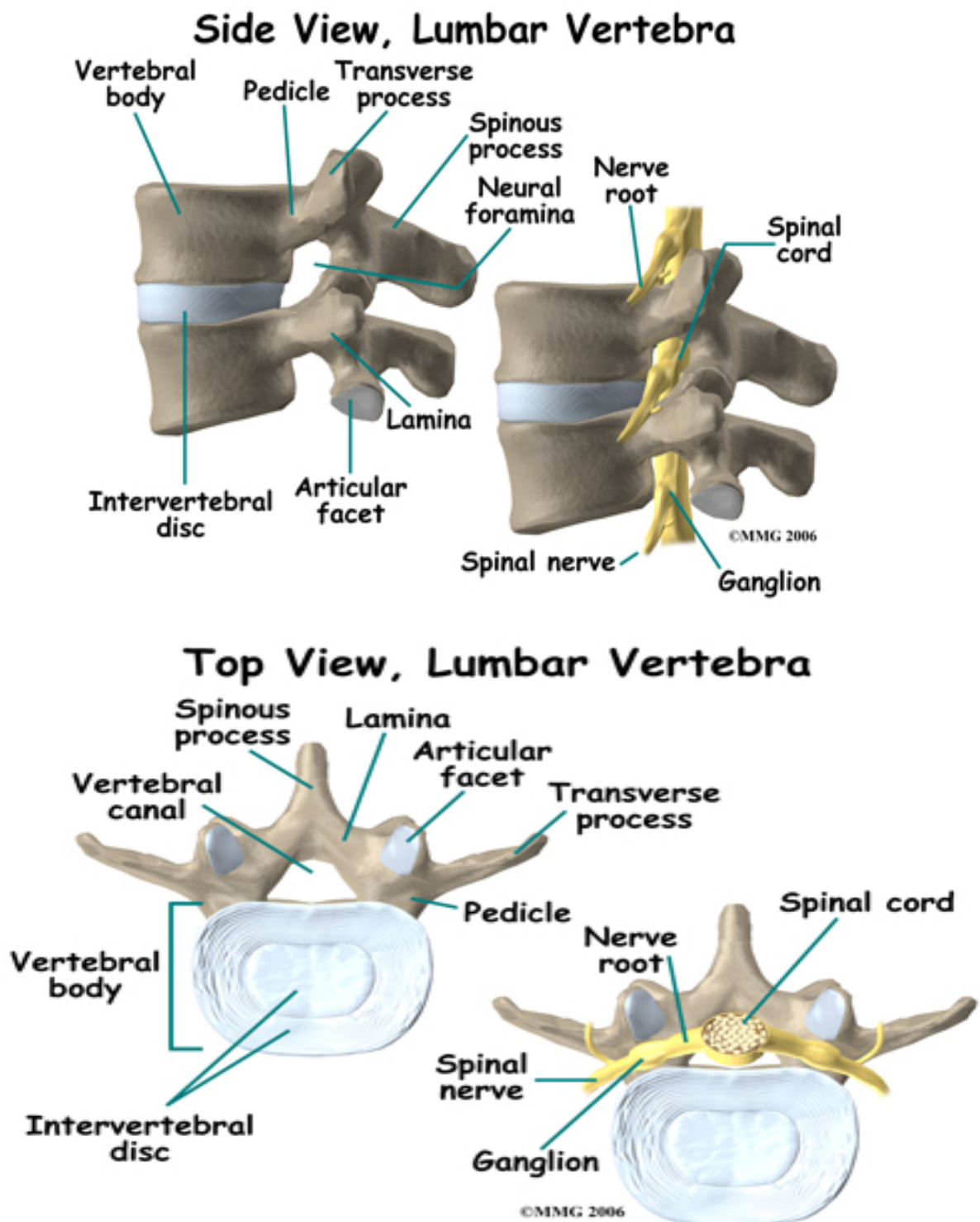


Figure 2.2 shows lumbar vertebra from top and side (Eva et al,2012)

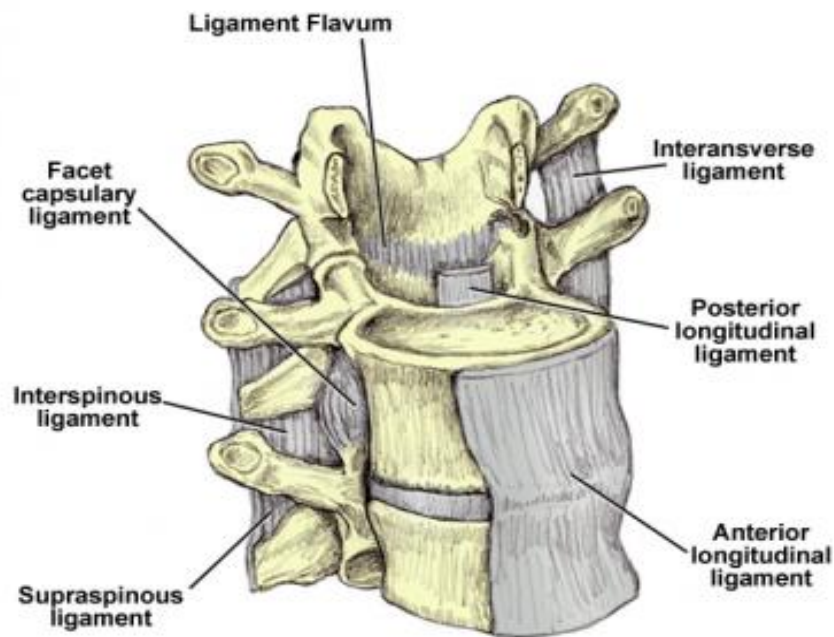


Figure 2.3 shows vertebral column ligaments(Stephen et al,2015)

The two main muscle groups that affect the spine are extensors and flexors. The extensor muscles enable to stand up and lift objects. The extensors are attached to the back of the spine. The flexor muscles are in the front and include the abdominal muscles. These muscles enable to flex, or bend forward, and are important in lifting and controlling the arch in the lower back. The back muscles stabilize spine. Something as common as poor muscle tone or a large belly can pull entire body out of alignment. Misalignment puts incredible strain on the spine,(Tonya,2013).

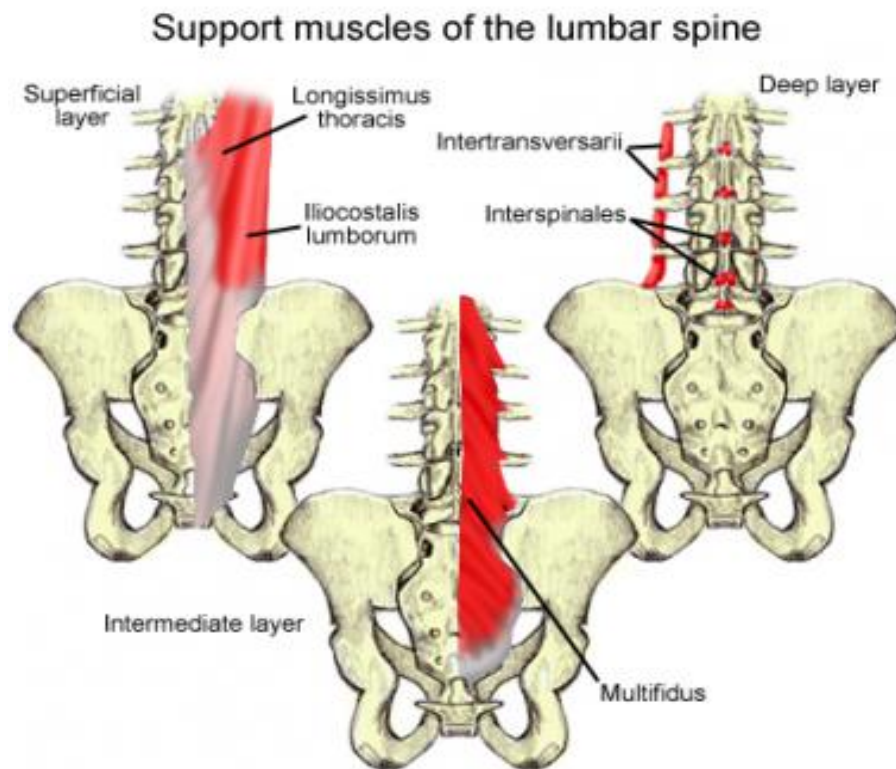


Figure 2.4 shows support muscles of the lumbar spine (Stephen et al, 2015)

The spinal cord lies within the vertebral canal and is covered by three membranes, known as meninges. The outermost layer is the dura mater, a tough fibrous sheath closely applied to the inner layer of bone surrounding the spinal canal. Between the dura and the bone is a potential space, the epidural space, which normally contains a small amount of fat and vertebral veins. The spinal dura mater is continuous with the dura mater lining the skull and continues to the level of the second sacral vertebra. It covers each of the spinal nerves as they leave the spinal canal and forms a tough sheath about the dorsal root ganglion. Beneath the dura mater is a thin and delicate membrane called the arachnoid mater, because of its resemblance to a spider's web. Normally the arachnoid mater is closely applied to the underside of the dura mater, but a potential space exists, the subdural space, which can fill

with blood or pus under pathologic conditions. Beneath the arachnoid mater and intimately applied to the spinal cord is the pia mater. Both the arachnoid and pia mater are continuous with the arachnoid and pia surrounding the brain, but unlike the arachnoid, which follows the dura mater, the pia essentially ends, with the caudal end of the spinal cord, at the level of the second lumbar vertebra. A rope like extension of the pia mater, the filum terminale attaches the end of the spinal cord to the caudal end of the dura mater. In addition, the pia mater contains lateral projections called denticulate ligaments, which connect the spinal cord to the dura mater by projecting between the dorsal and ventral roots. The space between the arachnoid mater and pia mater is the subarachnoid space. It is normally filled with cerebrospinal fluid, which surrounds the entire brain and spinal cord. (Tonya ,2013).

The spinal cord proper begins at the level of the foramen magnum of the skull and ends at the level of the L1,L2 intervertebral joint . There it tapers to a cone shaped ending known as the conus medullaris. A stalk of pia mater, the filum terminale attaches it to the end of the dura mater at S2. All of the roots of the spinal nerves from L2 to the lowest coccygeal nerve pass caudal to the conus medullaris to exit at their respective intervertebral foramina. This mass of spinal roots within the spinal canal in the subarachnoid space is known as the cauda equina. The area of the subarachnoid space below the L2 vertebra typically L4 is considered a safe place to insert a needle to sample cerebrospinal fluid, since only nerve roots and not spinal cord are found there. The posterior protrusion of a herniated lower lumbar intervertebral disc, while not pressing on the spinal cord, can compress a lumbar nerve root, causing severe pain or physical dysfunction in distinct areas of the lower limb. (Tonya ,2013).

Lumbar vertebrae are contacted anterolaterally by paired lumbar arteries that arise from the aorta, opposite the bodies of L1-L4. Each pair passes

anterolaterally around the side of the vertebral body to a position immediately lateral to the intervertebral canal and leads to various branches. The periosteal and equatorial branches supply the vertebral bodies. Spinal branches of the lumbar arteries enter the intervertebral foramen at each level. They divide into smaller anterior and posterior branches, which pass to the vertebral body and the combination of vertebral arch, meninges, and spinal cord, respectively. (Stephen et al, 2015) These arteries give rise to ascending and descending branches that anastomose with the spinal branches of adjacent levels. Nutrient arteries from the anterior vertebral canal travel anteriorly and supply most of the red marrow of the central vertebral body. The larger branches of the spinal branches continue as radicular or segmental medullary arteries, distributed to the nerve roots and to the spinal cord, respectively. Up to age 8 years, intervertebral discs have a good blood supply. Thereafter, their nutrition is dependent on diffusion of tissue fluids through 2 routes: (1) the bidirectional flow from the vertebral body to the disc and vice versa and (2) the diffusion through the annulus from blood vessels on its surface. As adults, the discs are generally avascular structures, except at their periphery. The venous drainage parallels the arterial supply. Venous plexuses are formed by veins along the vertebral column both inside and outside the vertebral canal (internal/epidural and external vertebral venous plexuses). Both plexuses are sparse laterally but dense anteriorly and posteriorly. The large basivertebral veins form within the vertebral bodies, emerge from the foramen on the posterior surfaces of the vertebral bodies, and drain into the internal vertebral venous plexuses, which may form large longitudinal sinuses. The intervertebral veins anastomose with veins from the cord and venous plexuses as they accompany the spinal nerves through the foramen to drain into the lumbar segmental veins. (Stephen et al, 2015)

2.1.2 physiology of the spine:

2.1.2.1 vertebral column:

The major functions of the vertebral column are protection of the spinal cord ,providing stiffening for the body and attachment for the pectoral and pelvic girdle and many other muscles ,providing motion for the human skeleton ,transmitting body weight in walking and standing , produce red blood cells by bones, and mineral storage.(G farr,2007)

2.1.2.2 spinal cord:

The spinal cord has two principal functions in maintaining homeostasis: nerve impulse propagation and integration of information. The white matter tracts in the spinal cord are highways for nerve impulse propagation. Sensory input travels along these tracts toward the brain, and motor output travels from the brain along these tracts toward skeletal muscles and other effector tissues. The gray matter of the spinal cord receives and integrates incoming and outgoing information. Spinal nerves connect the brain and spinal cord to the limbs and organs of the body.(G farr,2007)

2.1.3 The Pathology:

The major pathological conditions that affected the spine are:

2.1.3.1Herniated disc: A herniated disc occurs when one of the small, spongy discs that cushion the vertebrae bulges or breaks open. This condition, also known as a slipped or ruptured disc, can affect any part of the spine, but is most common in the lower back(Resnick,2001).

2.1.3.2Degenerative disc disease:Degenerative disc disease refers to the normal breakdown of spinal discs as we age. A sudden injury leading to a herniated disc may also begin the degeneration process. The condition causes back or neck pain, and can lead to osteoarthritis or spinal stenosis(Resnick,2001)..

2.1.3.3Myelopathy:Myelopathy is the gradual loss of nerve function caused by disorders of the spine. The condition commonly results from spinal injury or spinal stenosis, a progressive narrowing of the spinal canal.(Resnick,2001).

2.1.3.4Kyphosis:Kyphosis is a progressive disorder that causes curvature of the thoracic spine in children and adults. It is most often the result of developmental problems, trauma, degenerative diseases or osteoporosis with compression fractures(Resnick,2001).

2.1.3.5Scoliosis:Scoliosis is a lateral curvature of the spine. Instead of the gentle inward and outward curves of a normal spine, scoliosis produces an “S” or “C” shape. The condition is primarily congenital, but also results from traumatic injury or osteoporosis. (Neurosci ,2005)

2.1.3.6Spinal stenosis:Spinal stenosis is a narrowing of the spinal canal, which places pressure on the spinal cord. While the condition can affect any part of the spine, it is most common in the lumbar and cervical regions. Some people are born with stenosis; others develop it as they age. (Neurosci ,2005)

2.1.3.7 Spondylolisthesis: Spondylolisthesis is a forward slip of one vertebra in the spinal column and usually occurs in the lumbar region. Some people are born with a defective vertebra; in others, trauma, a stress fracture, infection or disease may cause the problem. The condition is on the rise among children and adolescents who are active in athletics.(Resnick,2001).

2.1.3.8 Radiculopathy: Radiculopathy is a disease of the spinal nerve roots and spinal nerves. Cervical radiculopathy affects the nerve roots near the neck and radiates through the arms and hands. Lumbar radiculopathy causes nerve irritation in the lower back that radiates through the legs and feet. Wear and tear, degeneration, herniated discs and traumatic injury are the primary causes.(Resnick,2001).

2.1.3.9 Compression fracture: A compression fracture is a broken vertebra in the spine. It usually occurs due to severe trauma, but is also the result of cancer or osteoporosis. Compression fractures are most common in the vertebrae of the lower back.. (Neurosci ,2005)

2.1.4 Magnetic Resonance Imaging :

2.1.4.1 MRI physics:

Magnetic resonance imaging (MRI) is a medical imaging procedure that uses strong magnetic fields and radio waves to produce cross-sectional images of organs and internal structures in the body. Because the signal detected by an MRI machine varies depending on the water content and local magnetic properties of a particular area of the body, different tissues or substances can be distinguished from one another in the study image. MRI can give different information about structures in the body than can be obtained using a standard x-ray, ultrasound, or computed tomography (CT) exam. an MRI exam of a joint can provide detailed images of ligaments and cartilage, which are not visible using other study types. In some cases, a magnetically active material (called a contrast agent) is used to show internal structures or abnormalities more clearly.(Pooely,2005).

Many MR systems are commercially available, each possessing different features and capabilities that are often difficult to evaluate and compare objectively. Many of these features are based on the operating software provided by the manufacturer, but certain hardware components are common to all systems. The major components are the computer and image processing systems, a magnet system, a gradient system, a radiofrequency system, and a data acquisition systems(Pooely,2005).

In most MRI devices, an electric current is passed through coiled wires to create a temporary magnetic field around a patient's body. (In open-MRI devices, permanent magnets are used.) Radio waves are sent from and received by a transmitter/receiver in the machine, and these signals are used to produce digital images of the area of interest. Using MRI scans, physicians can diagnose or monitor treatments for a variety of medical conditions, including: Abnormalities of

the brain and spinal cord, Tumors, cysts, and other abnormalities in various parts of the body, Injuries or abnormalities of the joints ,Certain types of heart problems, Diseases of the liver and other abdominal organs, Causes of pelvic pain in women, Suspected uterine abnormalities in women undergoing evaluation for infertility . MRI does not use ionizing radiation. There are no known harmful side-effects associated with temporary exposure to the strong magnetic field used by MRI scanners. There are important safety concerns to consider before performing or undergoing an MRI scan: The magnet may cause pacemakers, artificial limbs, and other implanted medical devices that contain metal to malfunction or heat up during the exam, Any loose metal object may cause damage or injury if it gets pulled toward the magnet, If a contrast agent is used, there is a slight risk of an allergic reaction. MRI contrast agents can cause problems in patients with significant kidney disease, Dyes from tattoos or tattooed eyeliner can cause skin or eye irritation, Medication patches can cause a skin burn, The wire leads used to monitor an electrocardiogram (ECG) trace or respiration during a scan must be placed carefully to avoid causing a skin burn and Prolonged exposure to radio waves during the scan could lead to slight warming of the body. (Pooely,2005)

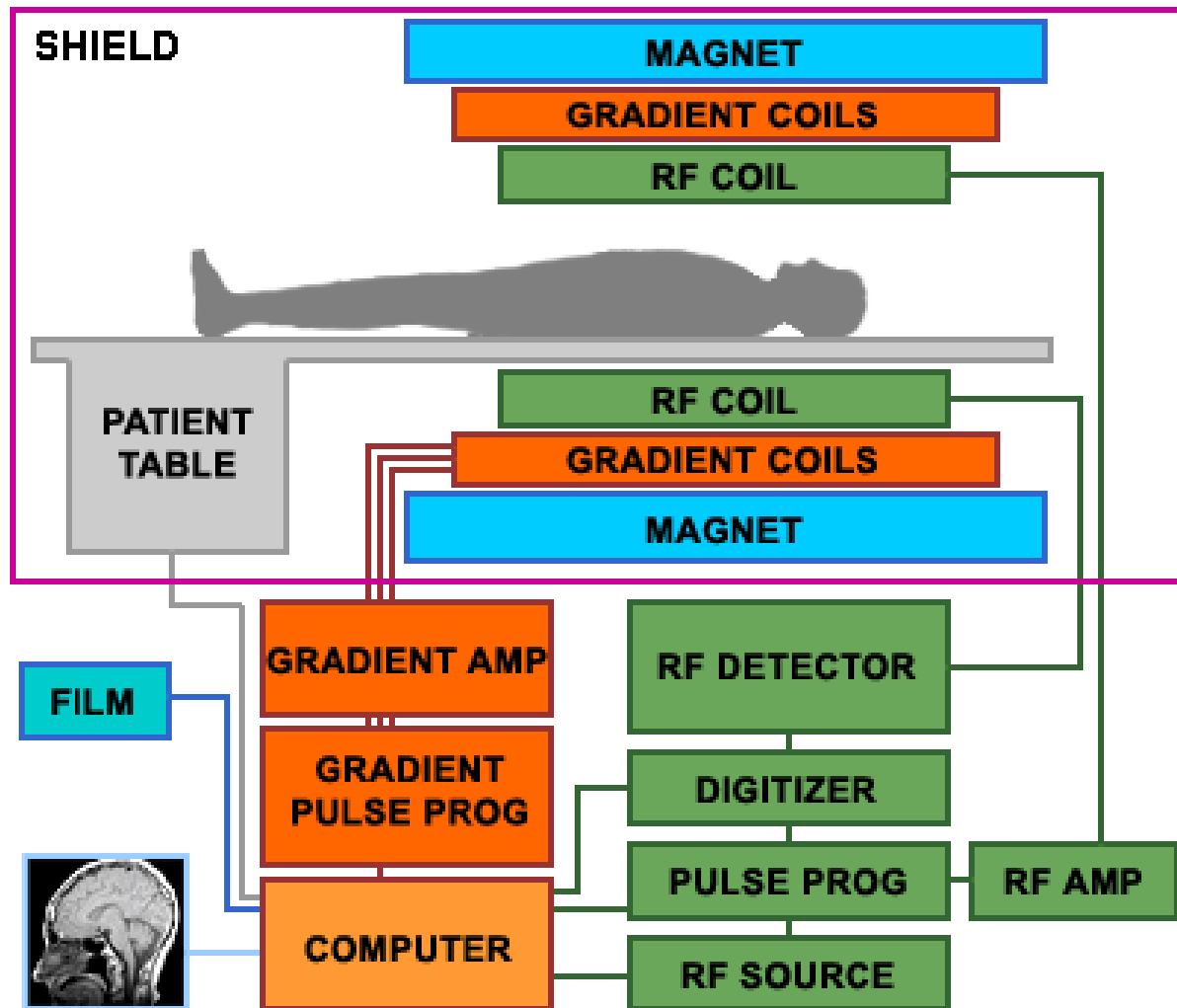


FIGURE 2.5 MRI schematic diagram

MRI is widely used now to visualize the spinal column and its contents. T1- and T2-weighted images give information about morphology and integrity of discs and vertebrae, the intervertebral foramina and facet joints, and an outline of the spinal cord. The vertebrae have a low-signal outer rim surrounding the high-signal cancellous bone. The basivertebral veins are seen in the posterior midline of the vertebral body. (Malcolm, 2002)

A very simplified pulse sequence is a combination of RF pulses, signals and intervening periods of recovery. TR and TE. A pulse sequence consists of several time periods: The repetition time (TR) is the time from the application of one RF pulse to the application of the next RF pulse for each slice and is measured in milliseconds (ms). The TR determines the amount of longitudinal relaxation that is allowed to occur between the end of one RF pulse and the application of the next. TR thus determines the amount of T1 relaxation that has occurred when the signal is read. The echo time (TE) is the time from the application of the RF pulse to the peak of the signal induced in the coil and is also measured in (ms). The TE determines how much decay of transverse magnetization is allowed to occur. TE thus controls the amount of T2 relaxation that has occurred when the signal is read. (Catherine Westbrook, et al –2011)

To demonstrate either T1, proton density or T2 contrast, specific values of TR and TE are selected for a given pulse sequence. The selection of appropriate TR and TE weights an image so that one contrast mechanism predominates over the other two. A T1 weighted image is one where the contrast depends predominantly on the differences in the T1 times between fat and water (and all the tissues with intermediate signal). Because the TR controls how far each vector recovers before the slice is excited by the next RF pulse, to achieve T1 weighting the TR must be short enough so that neither fat nor water has sufficient time to fully return to B0. If the TR is too long, both fat and water return to B0 and recover their longitudinal Magnetization fully. When this occurs, T1 relaxation is complete in both tissues and the differences in their T1 times are not demonstrated. TR controls the amount of T1 weighting. For T1 weighting the TR must be short. (Catherine Westbrook, et al –2011)

A T2 weighted image is one where the contrast predominantly depends on the differences in the T2 times between fat and water (and all the tissues with

intermediate signal). The TE controls the amount of T2 decay that is allowed to occur before the signal is received. To achieve T2 weighting, the TE must be long enough to give both fat and water time to decay. If the TE is too short, neither fat nor water has had time to decay, and therefore the differences in their T2 times are not demonstrated. TE controls the amount of T2 weighting. For T2 weighting the TE must be long. (Catherine Westbrook, et al –2011)

A proton density image is one where the difference in the numbers of mobile hydrogen protons per unit volume in the patient is the main determining factor in forming image contrast. Proton density weighting is always present to some extent. To achieve proton density weighting, the effects of T1 and T2 contrast must be diminished so that proton density weighting can dominate. A long TR allows both fat and water to fully recover their longitudinal magnetization and so diminishes T1 weighting. A short TE does not give fat or water time to decay and so diminishes T2 weighting. In any image, the contrast due to the inherent proton density together with T1 and T2 mechanisms occur simultaneously and contribute to image contrast. To weight an image so that one process is dominant, the other processes must be diminished. (Catherine Westbrook, et al –2011)

2.1.4.2MRI Technique:

2.1.4.2.1Patient Positioning:

The patient lies supine on the examination couch with their knees elevated over a foam pad, for comfort and to flatten the lumbar curve so that the spine lies nearer to the coil. The coil should extend from the xiphister- num to the bottom of the sacrum for adequate coverage of the lumbar region. The patient is positioned so that the longitudinal alignment light lies in the midline, and the horizontal alignment light passes just below the lower costal margin, which corresponds to the third lumbar vertebra.(Catherine Westbrook. – 2008)

2.1.4.2.2 Suggested Protocol:

- Sagittal/coronal SE/FSE T1 or coherent GRE T2*

Acts as a localizer if three-plane localization is unavailable.

- Sagittal SE/FSE T1

- Sagittal SE/FSE T2 or coherent GRE T2*

- Axial/oblique SE/FSE T1/T2 or coherent GRE T2*

(Catherine Westbrook. – 2008)

2.1.4.2.3 Additional Sequences:

- Axial/oblique or Sagittal SE/FSE T1

With contrast for determining disc prolapse versus scar tissue in failed back syndrome, and for some tumours.

- Coronal SE/FSE T1

For cord tethering or alternative view of conus when sagittals are inconclusive.

- Axial/oblique FSE T2

For arachnoiditis.

(Catherine Westbrook. –2008)

2.1.4.2.4 Patient Considerations:

Many patients are in severe pain especially if they are suffering from a prolapsed lumbar disc. Make the patient as comfortable as possible with pads supporting their knees in a slightly flexed position. Small pads placed in the lumbar curve often help to alleviate sciatica and other types of back pain. Due to excessively loud gradient noise associated with some sequences, ear plugs must always be provided to prevent hearing impairment. (Catherine Westbrook. – 2008)

2.1.4.2.5 Contrast Usage:

Contrast is used to distinguish disc prolapse from scar tissue post- operatively in failed back syndrome. Contrast is also invaluable to visualize suspicious lesions in the conus. (Catherine Westbrook. – 2008).



Figure 2.6 shows sagittal T1normal lumbar spine



Figure 2.7 shows sagittal T2 normal lumbar spine

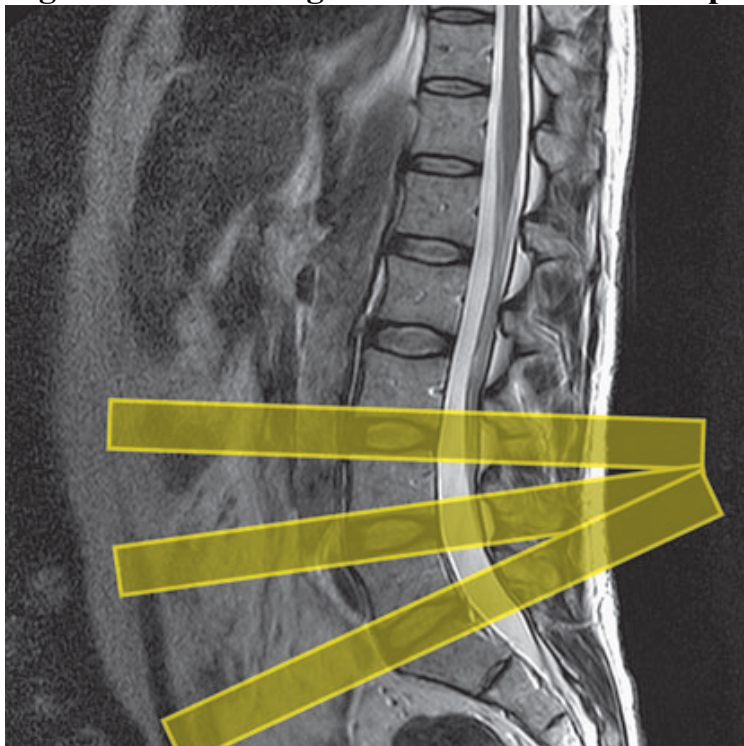


Figure 2.8 showing slice prescription boundaries and orientation for axial/oblique imaging of lumbar discs in sagittal T2.

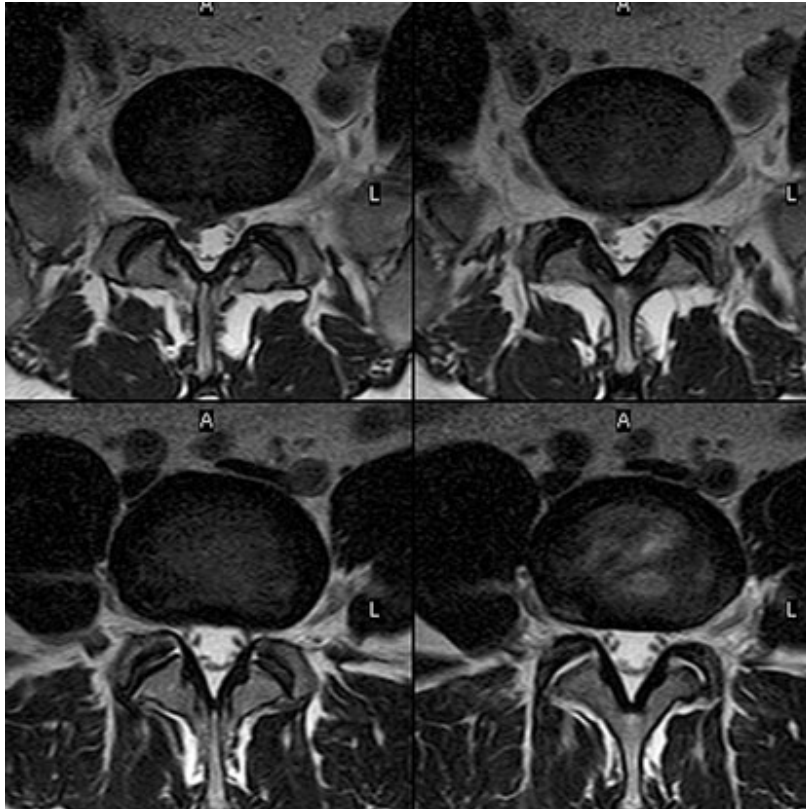


Figure 2.9 shows axial/oblique T2 of lumbar spine.

2.1.5 Normal measurement for AP diameter of lumbar canal:

The lumbar vertebral canal is roughly triangular in shape and is narrowest in its anteroposterior diameter in the axial plane. The average anteroposterior diameter of the lumbar canal in adults , as determined by anatomic and radiographic studies , ranges from 15 to 23 mm. the canal is bounded anteriorly by the posterior edge of the vertebral body including the posterior longitudinal ligament, which is closely apposed to the posterior vertebral body surface, laterally by the pedicles, posterolaterally by the facet joints and articular capsules, and posteriorly by the lamina and ligmenta flava .there are four diameters of vertebra .transvers diameter of canal represented as A , anteroposterior diameter of canal represented as B, transvers diameter of vertebral body represented by C, and anteroposterior diameter of vertebral body represented as D.

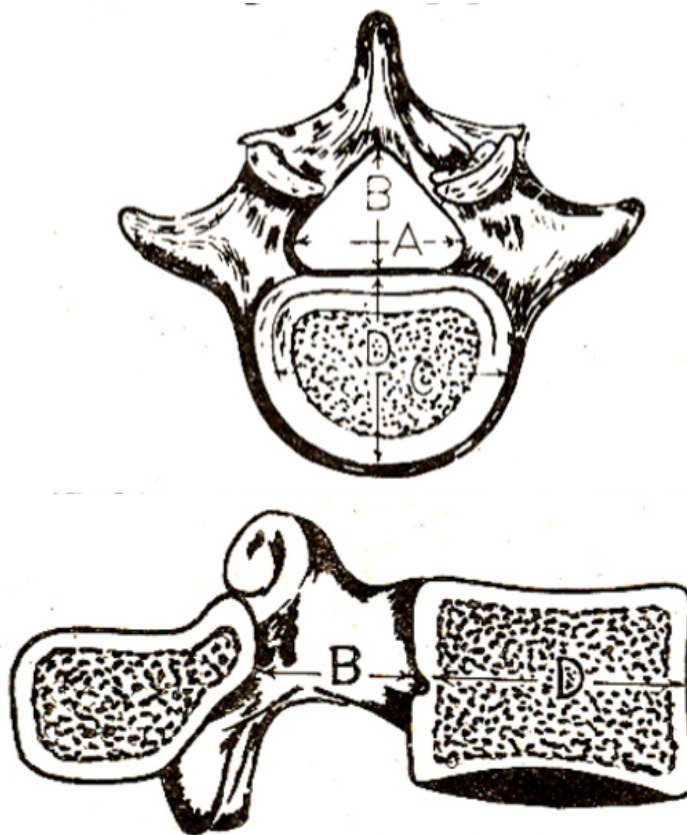


FIGURE 2.10 shows the vertebral diameters

2.2 Previous Studies:

Yasir A Elhassan,etal (2014) were studied Sagittal diameter of the lumbosacral spinal canal in normal (asymptomatic) adult Sudanese population . This study aims to determine the normal Anteroposterior diameter of the spinal canal in lumbosacral region among the adult Sudanese population using the MRI and to determine whether there are any differences related to age, sex and race regarding this diameter. MRI measurements were performed for 142 normal Sudanese subjects to study the lumbosacral region. The data was collected through check list, analyzed by SPSS.The majority of the participants were male (57%), young between 20and 28 years of age with mean height 168cm and mean weight 66 kilogram. The results showed that the longest mean AP diameter was at L1 ($17.5\pm2.0\text{mm}$) in male while (18.1 ± 2.7) in female. The shortest mean AP diameter was at S1 ($15.9\pm3.2\text{mm}$) in male and (15.4 ± 3.2) in female. The AP diameter gradually decreased from L1 to S1.there is no significant difference between both sexes. There is significant difference between people live in different zones. There is association between age, height and weight and the AP canal diameter.

Inderpawar,etal (2013) were studied Magnetic resonance imaging in the diagnosis of lumbar canal stenosis in Indian patientsThe radiological criteria for diagnosis of LCS are still ambiguous. Aim of this study is to find out the radiological dimensions on MRI of lumbar spinal canal in Indian patients and the critical dimensions at which the symptoms occur. A cross-sectional study was conducted in ESI Hospital, New Delhi from July 2011 to 2013. Two study groups were studied, the symptomatic LCS group, consisted of 30 individuals of either sex in age group of 45-65 years. Dimensions of lumbar canal at all the levels (L1-L5) of lumbar vertebra of 60 patients were measured. In symptomatic group, narrowest mid-sagittal diameter antero-posterior (mean 10.61) was at L5-S1 level. The interligamentous diameter (ILD) showed no significant difference between the two

groups. Lateral recess depths showed a significant difference between the two groups at all levels except L1 on right side and L1 and L2 on left side. Critical canal dimension was found to be 11.13 mm.

MehmazMashoufi et al (2010) were studied The Evaluation of Lumbar Spinal Canal Diameters by MRI. The aim of this study is to evaluate lumbar spinal canal diameters and relationship with gender, age, stature, weight and job. The 100 men and 100 women in the age range of 25 to 40 years from East Azarbayjan who were referred to Sheikholrais MRI Center were selected. The diameters of the spinal canal were measured on the midsagittal and axial section on T2 weighted images by 0.3 T MRI Unite. The results of measurements were analyzed by SPSS software. The results showed that the least anteroposterior diameter was at the third lumbar vertebra but the narrowest transverse diameter was at the first lumbar vertebra. The mean anteroposterior diameter of the lumbar spinal canal decreased from the first to the third lumbar vertebra, followed by an increase from the third to the fifth. From the first to the fifth lumbar vertebra, there was an increase in the mean transverse diameters. The mean transverse diameter in the middle part of the vertebra is longer than the lower part. A frank relation was seen between the gender of physical workers with lumbar spinal canal stenosis, although there was no relation between age, stature, and weight with lumbar spinal canal stenosis.

Valentinosadchiy, et al (2007) were studied measuring spinal canal size in lumbar spinal stenosis. The authors seek to create method of assessment of the spinal canal narrowing degree, based on anatomical aspects of lumbar spinal stenosis. Development of diagnostic criteria based on analysis of a consecutive patients group and a control group. Thirty seven patients (73 stenotic segments) with mean age 62,4 years old were involved in the study. Mean number of the stenotic segments was 1.97. For all patients 8 radiological criteria have been measured. In the control group have been included 37 randomly selected patients

(volunteers) in mean age of 53,4 years old without stenosis signs and narrowing of the spinal canal on the MRI imaging (73 segments total). Measurements were performed at the middle of intervertebral disc and facet joints level. For description of the state of spinal canal we offer the coefficient: ratio of the lateral canals total area to the cross-sectional area of the dural sac ("coefficient of stenosis"). Comparison of mean values of "coefficient of stenosis" for main and control groups showed statistically significant differences ($t = -12,5$; $p < 0.0001$). In this study new method of assessment of the spinal canal narrowing degree has been applied.

Dae Moo Shim, et al (2008) were studied Analysis and Measurement of the Lumbar Spinal Canal Dimension using Magnetic Resonance Imaging. The purpose of this study is to determine reference values of the spinal canal dimension in a population of normal Korea subjects and to evaluate other measurement methods of the spinal canal dimension that correlate to normal spinal canal dimensions determined using Magnetic Resonance Imaging (MRI). 100 patients who had mild symptoms and had normal MRI findings from 2475 outpatients that had undergone lumbar MRI from November 2002 to May 2004. The dimension of the spinal canal and dural sac was measured at the center of intervertebral discs L3/4, L4/5 and L5/S1. The dimension of the spinal canal and vertebral body was measured and was compared at the transverse plane perpendicular to the spinal canal that transected L4, L5 and the S1 pedicle. The results for the sequence of L3/4, L4/5 and L5/S1, the mean spinal canal dimensions were $249.38 \pm 38.30 \text{ mm}^2$, $253.04 \pm 48.62 \text{ mm}^2$ and $288.46 \pm 57.62 \text{ mm}^2$, respectively. For the sequence of L4, L5 and S1, the mean spinal canal dimensions were $279.78 \pm 42.36 \text{ mm}^2$, $301.50 \pm 54.26 \text{ mm}^2$ and $355.10 \pm 60.65 \text{ mm}^2$, respectively. The correlation coefficient was high at 0.913 for the L3/4 and L4 interpedicular transverse plane. The correlation coefficient for

L4/5 and L5 was 0.905, and the correlation coefficient for L5/S1 and S1 was 0.845.

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Materials:

This study was retrospective descriptive cross-sectional analytical study. All measurements were done in Modern Medical Center during 2015.

3.1.1 Samples:

200 patients in both gender undergo MRI test for spine and diagnosed as normal. The age ranged (20-45) years. Any subject with a history of trauma to the low back was excluded from the study also those who developed low back pain and/or lower-extremity pain, vertebral abnormalities, gross spinal pathology (e.g. spondylo-listhesis), previous spinal surgery, females who were pregnant or suspected to be pregnant all were excluded from the study. And those who refused to participate after the researcher explanation.

3.1.2 Machine:

(GE Healthcare) close MRI machine with 1.5 tesla and CTL coil.

3.2 Methods:

3.2.1 Spine MRI Protocol:

The patient lies on the examination couch with their knees elevated over foam pad, for comfort and to flatten the lumbar curve so that the spine lies nearer to the coil. The coil should extend from the xiphisternum to the bottom of the scrum for adequate coverage of the lumbar region. The patient is positioned so that the longitudinal alignment light lies in the midline, and the horizontal alignment light passes just below the lower costal margin, which corresponds to the third lumbar vertebra.

MRI of the lumbosacral spine was performed with multiplane imaging and multiweighted sequences. The following sequences were obtained:

*AxialT1(TR)/(TE)500/1ms, the matrix size 446x512,FOW300X300, slice thickness 5mm, and (FSE)sequence.

*Sagittal T1(TR)/ (TE) 500/10 msec. the matrix size was 334x512, FOW300x300, slice thickness 5 mm , and (SE)sequence.

*Axial T2(TR)/ (TE) 3500/120 msec. the matrix size was 390x512, FOW 250x250, slice thickness 5 mm.

3.2.2 Spinal Canal Measurement:

The antero-posterior diameter was measured posterior from the junction of lamina and anterior from border of body of vertebra in axial/oblique T2 image. The antero-posterior diameter of osseous measured from the posterior border of vertebra to the pedicles in the mid sagittal image. Using the cursor of the mouse over an initial reference point these measurement of vertebral canal made (Appendix c1,c2) .

3.2.3 Data Collection and Analysis:

The data were collected by data collection sheets include the gender, age ,weight ,canal diameter in level L1,L2,L3,L4,L5 and S1 after saved it on CDes from MEDICAL MODREN CENTER computer.All calculations made by using SPSS windows softwere.

Chapter Four

Results

Chapter Four

Results

4.1 Results:

Table 4.1 shows gender distribution among study sample

Gender	Male	Female
Frequency	109	91

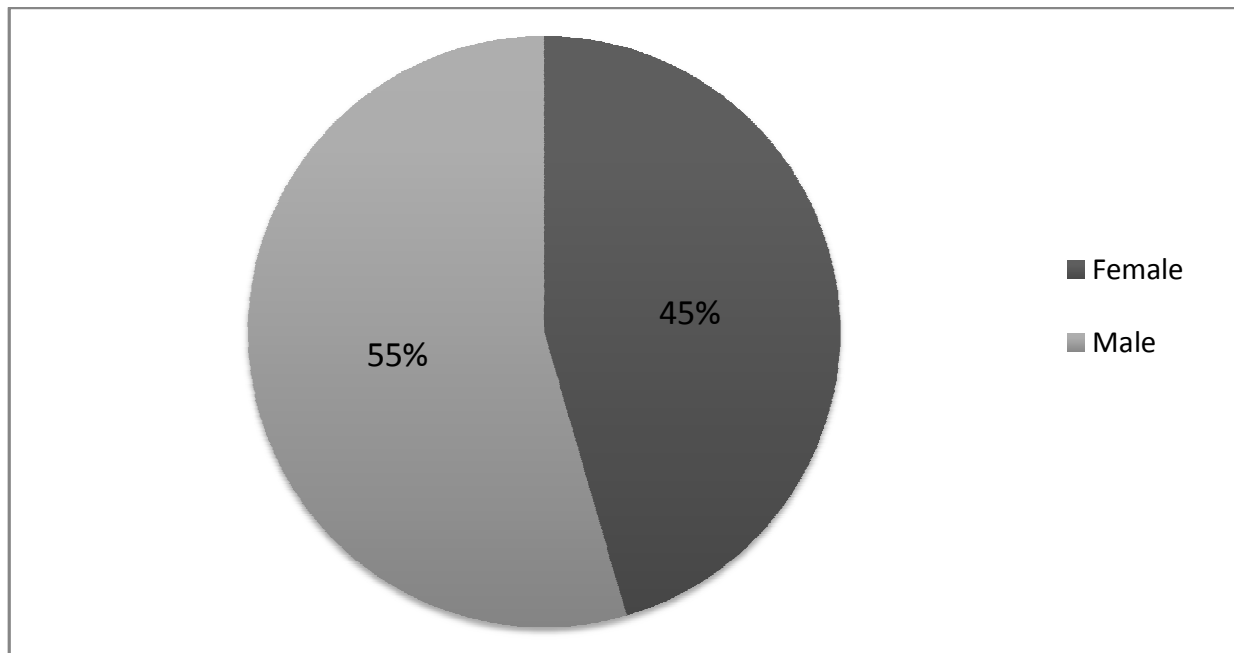


Figure 4.1 shows gender distribution in study sample

Table 4.2 shows age group and gender distribution

Age group	No of patients	Percentage
20-28	68	33.90%
29-37	99	49.50%
38-45	33	16.50%

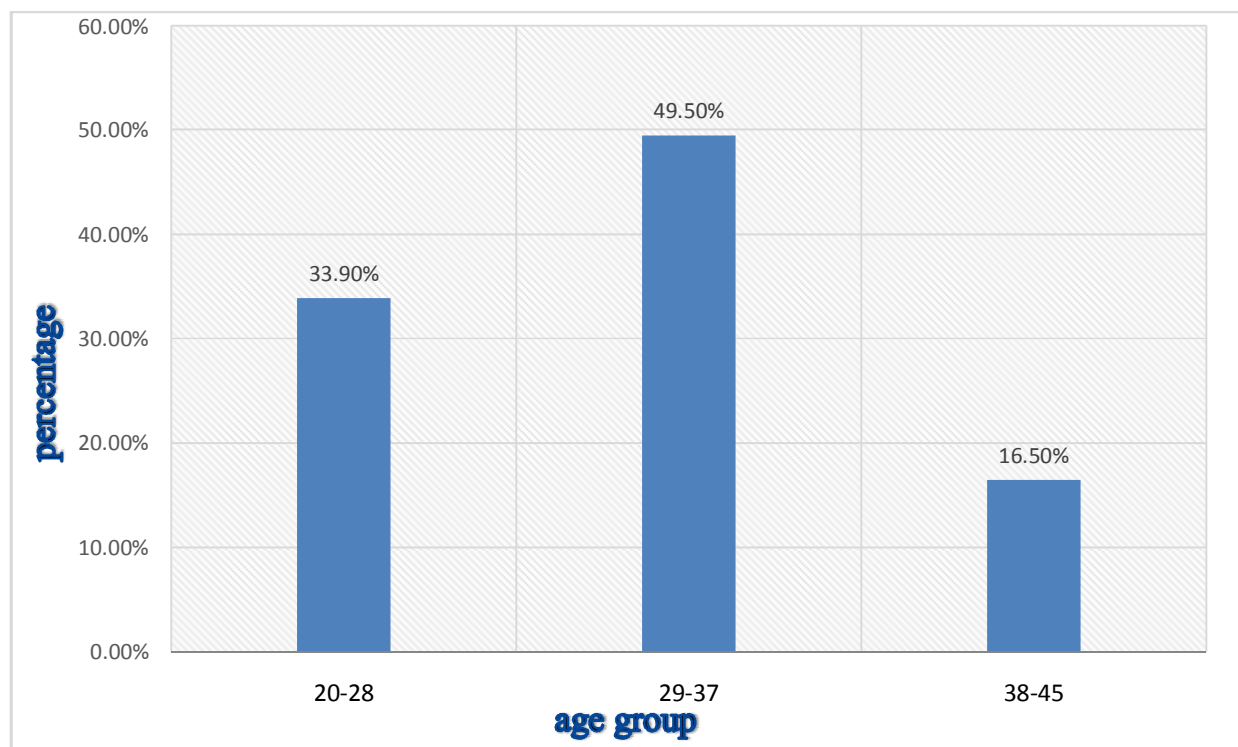


Figure 4.2 show age group distribution among the study sample

Table 4.3 the range of patinet's weight and number of patients

Range of weight(Kg)	No of patients	Percentage
50-59	36	18%
60-69	40	20%
70-79	72	36%
80-89	36	18%
90-99	8	4%
100-109	8	4%

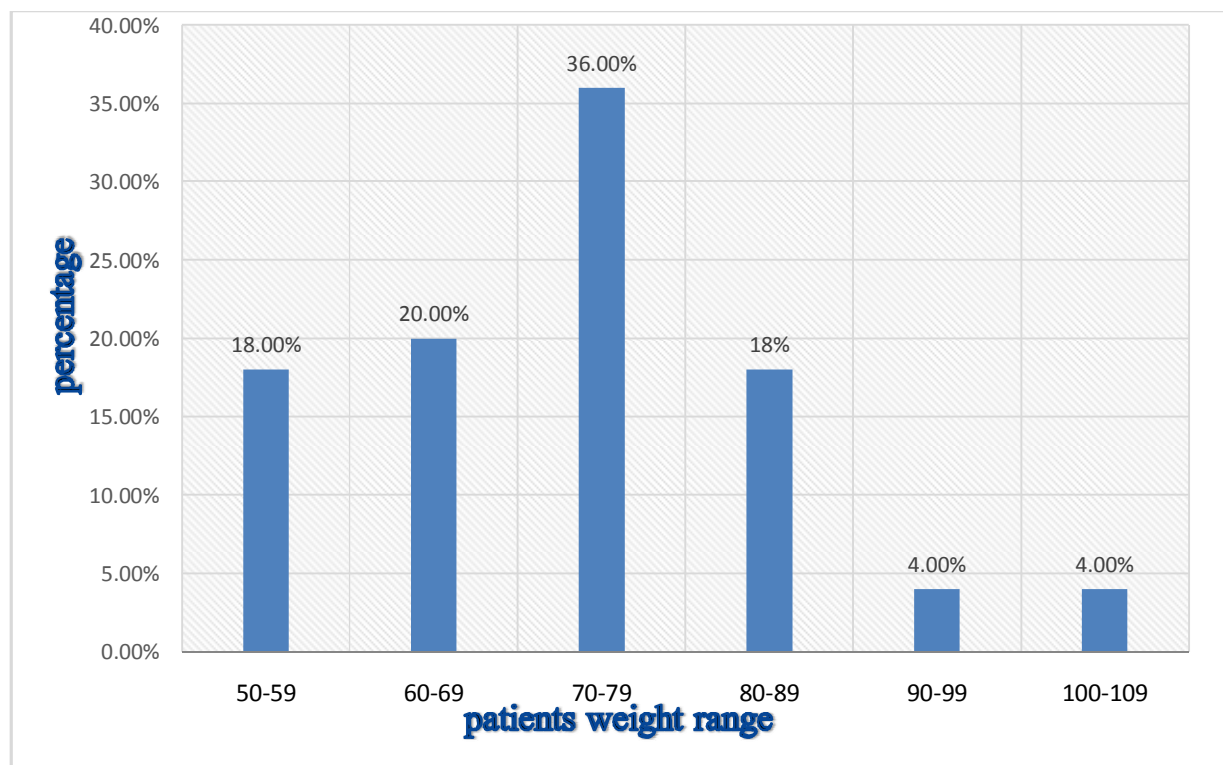


Figure 4.3 show the range of patient's weight and number of patients

Table 4.4 shows anteroposterior diameter of lumbar spinal canal among the both gender

AP diameter					
Level	Male Mean	Male Standard deviation	Female Mean	Female Standard deviation	<i>P</i> value
L1	17.4	2.0	17.9	2.7	0.177
L2	17.2	4.7	17.7	3.1	0.436
L3	16.2	2.6	17.1	3.2	0.059
L4	16.2	2.5	17	2.9	0.086
L5	16.6	2.7	17	2.5	0.475
S1	15.9	3.3	15.5	3.1	0.397

***P value ≤ 0.05 if there is significant relationship**

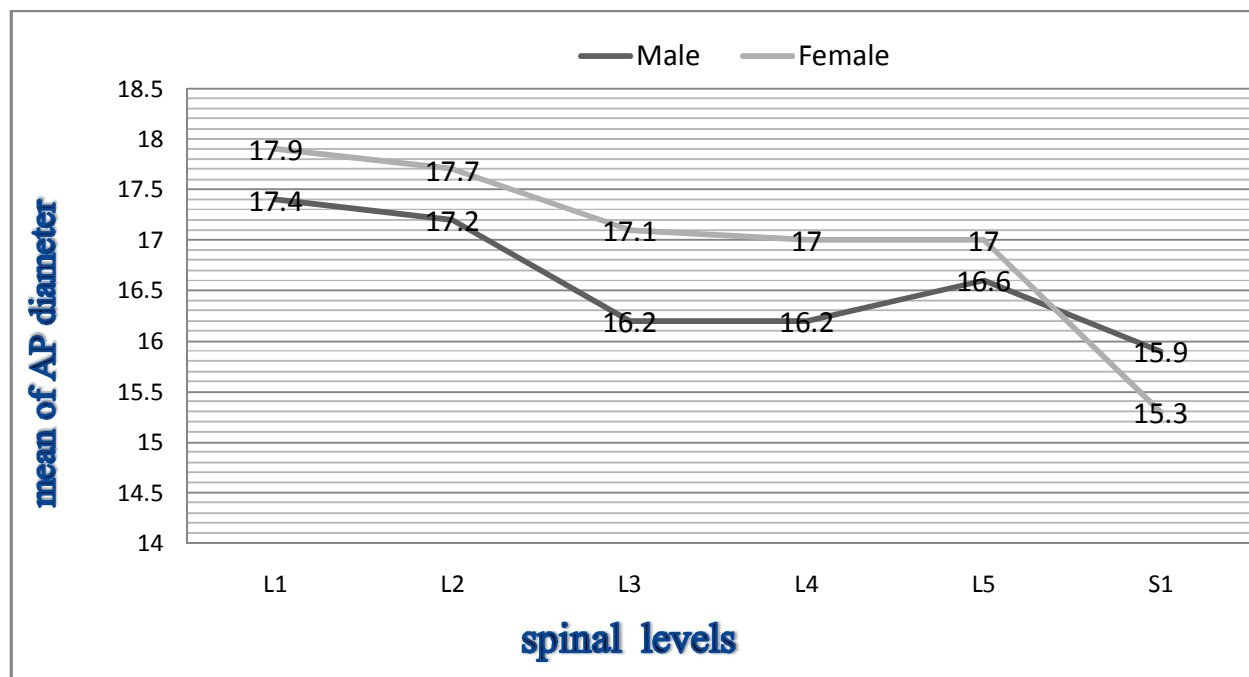


Figure 4.4 the mean of spinal canal diameter of both gender in all lumbar levels

Table 4.5 shows association between age groups and AP canal diameters

Level	Age group	Mean	Standard deviation	P value
L1	20-28	18.20	2.5	0.031
	29-37	17.64	2.2	
	38-45	16.69	1.8	
L2	20-28	17.72	2.7	0.039
	29-37	17.74	5.5	
	38-45	16.31	1.9	
L3	20-28	17.17	3.1	0.041
	29-37	16.31	2.8	
	38-45	15.46	1.9	
L4	20-28	17.07	2.9	0.059
	29-37	15.91	2.5	
	38-45	16.34	1.9	
L5	20-28	17.43	2.5	0.026
	29-37	16.45	2.6	
	38-45	15.92	2.1	
S1	20-28	16.92	3.01	0.040
	29-37	15.42	3.1	
	38-45	14.36	3.2	

***P value ≤ 0.05 if there is significant relationship**

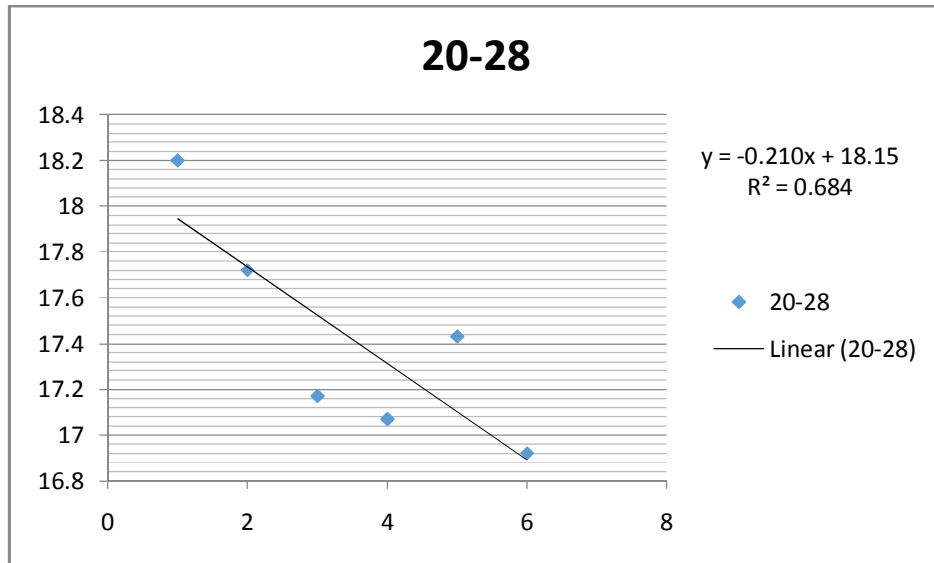


Figure 4.5 shows the relationship between mean of AP diameter and age group(20-28).

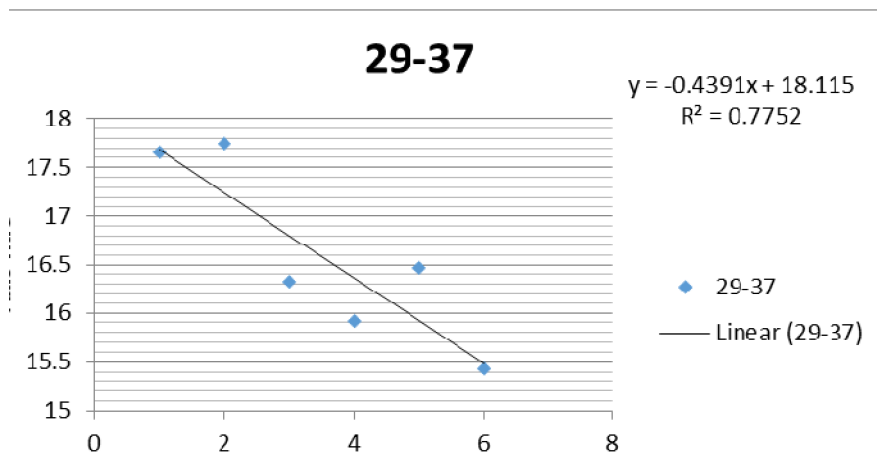


Figure 4.6 shows the relationship between mean of AP diameter and age group(29-37).

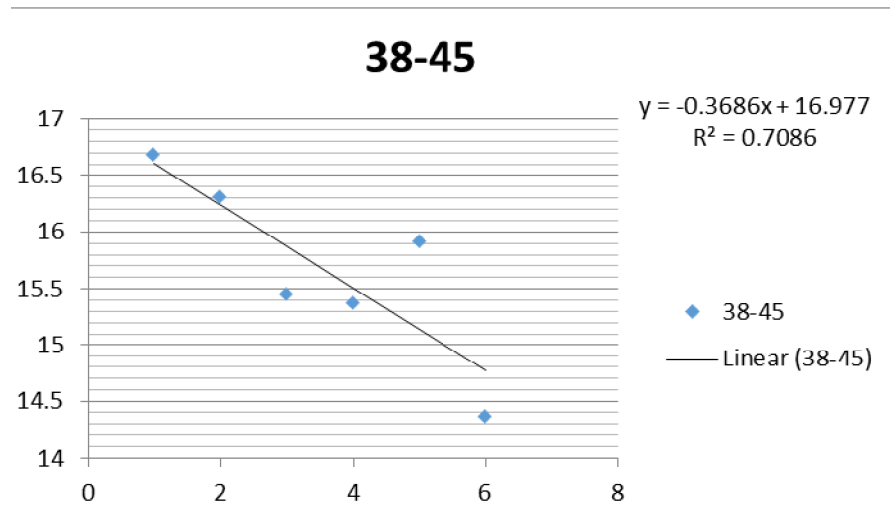


Figure 4.7 shows the relationship between mean of AP diameter and age group(38-45).

Table4.6 association between weight and AP canal diameter

Level	Chi test	Weight
L1	Pearson correlation Sig.(2-tailed)	0.085 0.313
L2	Pearson correlation Sig.(2-tailed)	0.031 0.710
L3	Pearson correlation Sig.(2-tailed)	0.002 0.982
L4	Pearson correlation Sig.(2-tailed)	0.015 0.858
L5	Pearson correlation Sig.(2-tailed)	0.054 0.520
S1	Pearson correlation Sig.(2-tailed)	0.093 0.272

***Sig (2-tailed) closed to 1 or -1 if there is significant relationship but if closed to zero there is no relationship.**

***P value(Pearson correlation) ≤ 0.05 if there is significant relationship.**

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion:

Accurate anatomic descriptions of vertebral anatomy are necessary for the diagnosis of various spinal diseases. In this study, MRI was used, which is considered the mainstay imaging investigation in patients suspected with spinal canal disease to make lumbar canal measurement in Sudanese population.

All measurements was done in the axial sections of the vertebrae allowed the best view for studying the normal morphology of the vertebra.

Table and Figure (4-1) shows gender distribution among study sample as 109 (55%) in male and 91(45%) in female.

Table and Figure (4-2) shows age group distribution by numbers and percentage.

Table and Figure (4-3) shows weight range in Kg and numbers of patients with percentage.

Table and Figure (4-4) shows The average spinal canal AP diameter at each level and according to gender . The AP diameter in male were(17.4 ± 2),(17.2 ± 4.7),(16.2 ± 2.6),(16.2 ± 2.5),(16.2 ± 2.7)and (15.9 ± 3.3) at L1,L2,L3,L4,L5 and S1.while the AP diameter in female were (17.9 ± 2.7),(17.7 ± 3.1),(17.1 ± 3.2),(17 ± 2.9),(17 ± 2.5) and (15.5 ± 3.1) at L1,L2,L3,L4,L5 and S1. The longest mean AP diameter was at L1 (17.4 ± 2.0 mm) in male while (17.9 ± 2.7) in female. The shortest mean AP diameter was at S1 (15.9 ± 3.3 mm) in male and (15.5 ± 3.1) in female, the AP diameter gradually decreased from L1 to S1 in female while decrease from L1 to L4 in male then

slightly increase at L5 and again decrease at S1 . The female mean AP diameter was larger than the male.the different was statistically not significant at all lumbosacral levels.This result similar to study of Yassirelhassan(2014)that saidthe longest mean AP diameter was at L1 ($17.5\pm2.0\text{mm}$) in male while (18.1 ± 2.7) in female. The shortest mean AP diameter was at S1 ($15.9\pm3.2\text{mm}$) in male and (15.4 ± 3.2) in female. The AP diameter gradually decreased from L1 to S1.also, similar in no relation between two gender.

Table (4-5)shows The relationship between the patient age and AP diameter was found to be a week direct relationship , with person correlation coefficient(0.031)in L1,(0.329)in L2,(0.041)in L3,(0.059)in L4,(0.026)in L5 and (0.040)in S1.This results are different to study of MehmazMashoufi ,etal(2010) that said there was no relation with age.

Figures 4.5, 4.6 and 4.7shows the relationship between mean of AP diameter and age groups with the equation of each one .

Table (4-6)shows The relationship between weight and AP diameter was found to be a week direct relationship with person correlation coefficient (0.085),(0.031), (0.002),(0.015),(0.054),(0.093) inL1,L2, L3,L4,L5,S1 respectively. This results are different to study of MehmazMashoufi ,etal(2010) that said there was no relation with weight but similar to study of yasirelhassan.

The measurement of this study is larger than Indian and Azerbaijan but smaller than Korean measurements of spinal canal diameter.

All this measurements were said to be normal for the study group, in comparison to other studies , the different in population (body type) and sample size but the pattern of changes in AP diameter was similar to this study results. So this measurements may taken as normal spinal canal diameter for Sudanese population.

5.2 Conclusion:

The study concluded that the longest mean AP diameter was at L1 (17.4 ± 2.0 mm) in male while (17.9 ± 2.7) in female. The shortest mean AP diameter was at S1 (15.9 ± 3.3 mm) in male and (15.5 ± 3.1) in female. longest mean AP diameter was at L1 that gradually decreased from L1 to S1. The equation of AP diameter with age is described in ($y=0.02106x+18.155$) for ages 20-28, ($y=0.4391x+18.155$) for ages 29-37 and ($y=0.3686x+16.977$) for ages 38-45. There was no significant statistical difference between both gender. There were significant statistical differences exist between AP canal diameter and the age and weight of the study sample.

5.3 Recommendations:

The researcher recommended for the following:

.Testing the suggested clinical diagnosis and patients with lumbar canal measurements from this research.

.The technologist should know the normal range of lumbar canal diameter by seminars and training to correct image interpretation.

. Further similar study using other patient's information height, subject's work and different living zone.

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Appendices

Appendix A

MRI Report

Date:

Patient's Name:

Age :

Ref,Doctor:

Procedure : MRI of L/S Spine

Protocol: Sagittal T1, Sagittal T2 & Axial T2

Report:

*No bone injury seen.

*Normal signal intensity of the spinal cord.

*Normal vertebral signal intensity, height and alignment.

*No abnormality seen in para spinal region.

Dr ,.....

Consultant Radiologist

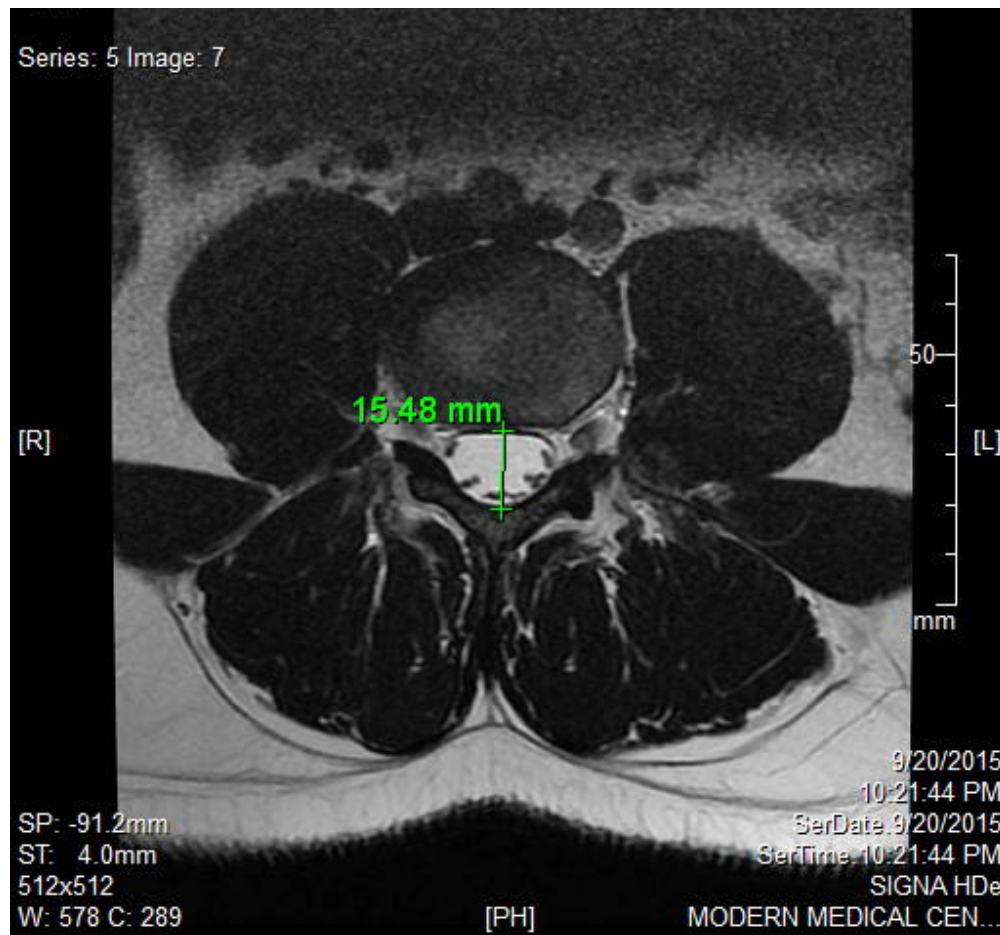
Appendix B

Data collection sheets

No	gender	Age	weight	L1canal diameter	L2canal diameter	L3canal diameter	L4canal diameter	L5canal diameter	S1canal diameter
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
.... 200									

Appendix C1

Measurement of AP diameter in axial T2 image in male



Appendix C2

Measurement of AP diameter in axial T2 image in female

