بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Medical Radiological Science

Measurement of Normal Dimension Range of Lumbar Spinal Canal in Sudanese Population by Computed Tomography

قياس المدي الطبيعي لأبعاد العمود الفقري البطني لدي السودانيين بإستخدام الاشعه المقطعيه

A thesis Submitted for Partial Fulfillment of B.Sc. Degree in Diagnostic Radiology Technology

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الآية

قال تعالى:

﴿قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ﴾

صدق الله العظيم

البقرة الأية (٣٢)

Dedication

TO

Our teachers

For their advice and support

our parents

For their love and unconditional support

our friends and colleagues

For their Encouragement

Acknowledgments

*We are **t**hankful to Almighty Allah for His blissful granting that gave us strength for carrying out this work.*

We are also thankful to :Dr.AsmaIbrahiemour supervisor for her advices and support and for our teacher and guider AbdoALrahman Hassan for his patience and sharing us his knowledge.

For Sudan University for providing us the needed guidance and work letters.

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We are also thankful to all unnamed people who helped us during this study.

Table of content

List of abbreviation

abbreviation	Mean
CT	Computerize Tomography
LSS	Lumbar Spinal Stenosis
MRI	Magnetic Resonance Imaging
T1	T1 Weighted Image
T2	T2 Weighted Image
CNS	Central Nervous System
VBL	Vertebral Body Length
VBH	Vertebral Body Height
VCH	Vertebral Canal Height
VCW	Vertebral Canal width
VBW	Vertebral Body Width
PACS	Picture Archiving and Communication System
MDCT	Multi Detector Computed Tomography
SD	Standard Diviation

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Abstract

This was an analytical study aimed to determine and measure the normal dimension range of lumbar spinal canal in Sudanese population by using of multi-detector computed tomography in order to assess the normal variant between the Sudanese populations. This study was performed in 40 patients in Khartoum state diagnostic centre (modern diagnostic medical centre in period(from August To October) who underwent CT for any investigation other than lumbar spine but showing lumbar spine in the images. The measurement of lumbar canal were taken at L3 in axial cut from CT images. The mean value of anterior-posterior measurement in the axial cut (2.498±0.3711 cm), and the meanvalue of transverse measurement in the axial cut (1.458±0.2500cm).

In this study the relationship between the patient age, height, weight and BMI measurement in the axial cut was found to be indirect relationship.

ملخص البحث

الهدف الرئيسي من هذه الدراسه هو تحديد المعدل الطبيعي لأبعاد قناه العمود الفقري البطني في السودانيين باستخدام جهاز الاشعه المقطعيه .

هذه الدراسه اجرت في ٤٠ مريض في ولاية الخرطوم (المركز الطبي الحديث) في مده تتراوح من أغسطس إلي اكتوبر.

وتم أخذ قياس واحد في مستوي الفقره البطنيه الثالثه في صوره الأشعه المقطعيه للعمود الفقري البطني في مقطع واحد .

مقدار القياسات في القياس الطولي (**2.498±0.3711سم**) وفي القياس العرضي(**1.458±0.2500سم**).

في هذه الدراسه تم العثور علي أن العلاقه بين عمر المريض وطوله ووزنه والقياسات المختلفه في المقطع العرضي للقناه الشوكيه علاقه غير مباشره .

Chapter One

Introduction, problem, objectives, significant and overview of the study

1.1 Introduction

The lumbar spine is consist of five movable lumbar vertebrae numbered L1_L5. The complex anatomy of lumbar spine remarkable combination of these strong vertebrae ,multiple bony element linked by joint capsule ,and flexible ligaments/tendon, large muscles and highly sensitive nerves , it also has complicated innervations and vascular supply (Pansky B.1996).

The lumbar canal stenosis is the narrowing of the spinal lumber canal, which was associated with low back pain and motor defects of lower limbs. The main causes of lumber stenosis are congenital narrowing, vertebral disc herniation , or thickness of the posterior vertebral longitudinal ligament. The determination of normal diameter of the lumbar spinal canal is essential in a reliable evaluation of lumber stenosis. In this research we measured the diameter of the lumber spinal canal in the normal adults and stenosis patients with symptoms of low back pain and lower limb motor defect, then the measurements was compared at different lumber levels, and the causes of lumbar spinal canal stenosis was also investigated in this study (Drake R et al.2009)

The diagnosis of lumber done by many imaging modalities so that CT is one of these modalities.CT scan also called x-ray computed tomography marks use of computer. Processed combination of many x-ray image taken from different angles to produce cross sectional “tomographic” image of specific areas of scanned object allowing the user to see inside the object without cutting (William M.2003).

This is used to determine the normal diameter range of lumbar spinal canal in Sudanese population, so as to diagnose the lumbar spinal stenosis properly(Drake R et al.2009)

M.mida and Z.miabi (2007)found that the Mean age and height of patients were 30 ± 6 yearand 167 ± 9.15 cm, respectively. Mean area ofvertebral body of L3 and L4 was 1515 ± 254.6 $mm^2$and 1470 ± 255.4mm^2, respectively.

1.2. Problem of the study:

Low backache is a common clinical problem. The etiology in many of these patients is narrowing of the lumbar canal. The incidence and implication of lumbar canal stenosis are gaining attention. The values of normal transverse (inter-pedicular) and sagittal (mid-sagittal) diameters are different at various levels of lumbar spinal canal in individuals of the same race and differ at identical levels in individuals of various races. Therefore the measurement of canal diameters is considered as important issue in order to classify the normal and abnormal measurement.

1.3 Objectives:

1.3.1 General objective:

The general objective of this study was to measure the normal range of lumber spinal canal in Sudanese population.

1.3.2 Specific objectives:

- To determine the mean values of normal lumber spinal canal diameter in Sudanese population.
- To determine the effect of age in lumber spinal canal measurement.
- To correlate between age, weight, height, and BMI.

1.4. Significance of the study:

Lumber canal measurement are important diagnostic information for many orthopedic and neurological disease. This study determines the normal diameter range of lumber canal by using CT in Sudanese population.

1.5. Overview of the Study:

The research was contain five chapters; chapter one include introduction, problem of the study, objectives, significant of the study and overview.

Chapter two include anatomy, physiology, pathology, previous studies, chapter three material and methodology , image interpretation, chapter four include result of study and chapter five include discussion, conclusion, recommendation, references and appendix.

Chapter Two

Anatomy, physiology ,pathology and previous studies

2.1 Anatomy

The lumber spine consists of 5 moveable vertebrae number L1-L5. The complex anatomy of the lumber spine is a remarkable combination of these strong vertebrae, multiple bony elements linked by joint capsules, and flexible ligaments/tendons, large muscles, and highly sensitive nerves. it also has a complicated innervation and vascular supply(Drake R et al.2009).

The lumbar spine is designed to be incredibly strong, protecting the highly sensitive spinal cord and spinal nerve roots, At the same time, it is highly flexible, providing for mobility in many different planes including flexion, extension, side bending, and rotation(Kirkaldy WH et al.1999).

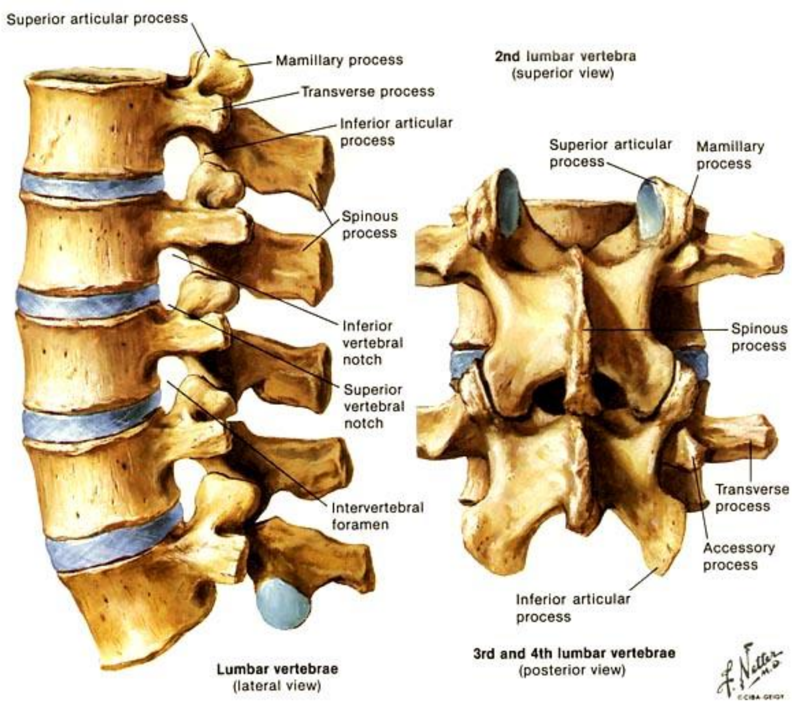

Figure2.1: image show lumbar spineand normal anatomical structure(L. drake et.al 2014).

2.1.1Bones

The lumber vertebrae, numbered L1-L5, have a vertical height that is less than their horizontal diameter. They are composed of the following 3 functional parts:The vertebral body, designed to bear weight, thevertebral (neural) arch, designed to protect neural elements and the bony processes (spinous and transverse), which function toIncrease the efficiency of muscle action. The lumber vertebral bodies (vertebrae) are the heaviest components, connected together by the intervertebral discs. The size of the vertebral body increase from L1 to L5, indicative of the increasing loads that each lower lumber vertebra absorbs. Of note, the L5 vertebra has the heaviest body, smallest spinous process, and thickest transverse process. The inter vertebral disc surface of an adult vertebra contains a ring of cortical bone peripherally termed the epiphyseal ring. This ring acts as a growth zone in the young while anchoring the attachment of the annular fibers in adults. A hyaline cartilage plate lies within the confines of this epiphyseal ring. Each vertebral arch is composed of 2 pedicles, 2laminae, and 7 different bony processes, joined together by facet joints and ligament, the pedicle, strong and directed posteriorly, joins the arch to the postero-lateral body. It is anchored to the cephalic portion of the body and function as protective cover for the caudaequinecontents. The concavities in the cephalic and caudal surfaces of the pedicle are termed vertebral notches.Beneath each lumbar vertebra , apair of inter vertebral foramina with the same number designations can be found, such that the L1 neural foramina are located just below the L1 vertebra .Each foramina is bounded superiorly and inferiorly by the pedicle ,anteriorly by the inter vertebral disc and vertebral body ,and posteriorly by facet joints .The same numbered spinal nerve root, recurrent meningeal nerves , and radicular blood vessels pass through each foramen .five lumbar spinal nerve roots are found on each side. The broad and strong laminae are the plates that extend posteromedial from the pedicel .The oblong shaped spinous processes are directed posteriorly from the union of the laminae.The two superior and inferior articular processes ,labeled SAP and IAP,respectively,extend cranially and caudally from the point where the pedicles and lamina join. The facet or zugapophyscal joints are in parasagittal plane.When viewed in an oblique projection, the outline of the facets and the pars inter articularis appear like the neck of a Scottie dog (Rosse C and Gaddum_ P .1997).Between the superior and inferior articular processes ,2transverse processes are projected laterally that are long ,slender ,and strong .they have an upper tubercle at the junction with the superior articular process and an inferior tubercle at the base of the process .These bony protuberances are sites of attachment of deep back muscles(Pansky B. 1996).

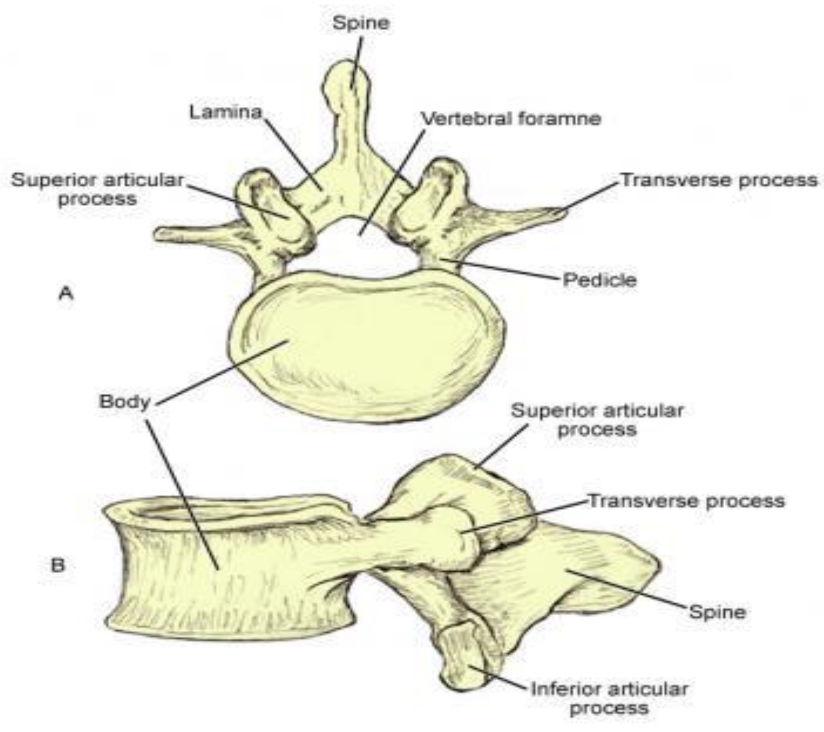

Figure 2.2: Image show anatomical structure of lumbar vertebra(L. drake et.al 2014).

2.1.2 Vertebral canal

The tubular vertebral canal contains the spinal cord, itsmeninges, spinal nerve roots, and blood vessels supplying the cord,meninges,vertebrae, joints, muscles, and ligaments. Both potential and real spaces intervene between the spinal cord, meanings, and Osseo ligamentous canal walls. The canal is enclosed within its column and formed by the juxtaposition of the vertebral foramen, lined up with one another in series .The vertebral bodies and discs make up the anterior wall, whereas the laminae and ligamentum flavum border the canal posteriorly. Laterally, spinal nerves and vessels travel through the intervertebral foramen (Pansky B. 1996).

2.1.3 Meninges and Related spaces

The meninges consist of three layers: the pia, arachnoid, and dura mater. Together, they enhance the protection of the spinal cord and roots. The dura is the most superficial but resilient layer .The pia and arachnoid, together termed the leptomeninges, arefrail. The spinal cord, roots, and nerve rootlets are closely invested by the pia. The dura and arachnoid together forma loose sheath (termed dural/thecalsac) around these structures, separated from the canal walls by the epidural space (Pansky B. 1996).

2.1.4 Spinal cord

Other than the brain, the spinal cord is one of the 2 anatomic components of the central nervous system (CNS). It is the major reflex center and conduction pathway between the brain and the body, As noted earlier, the spinal cord normally terminates as the conus medullaris within the lumbar spinal canal at the lower margin of the L2 vertebra, although variability of the most caudal extension exists (Pansky B. 1996).

In a cadaveric study of 129 cadaveric specimens, the spinal cord terminated at L2 in 60%, L1 in 30%, and L3 in 10% of specimens. Differential growth rates in the spinal cord and the vertebral canal are the cause of these disparities. Exceptions also include patient with congenital spinal deformities known as spina bifide ,in such patient, the conus medullaris can be displace downward to the middle or lower lumbar spine(Lippincott W& Wilkins. 2007).

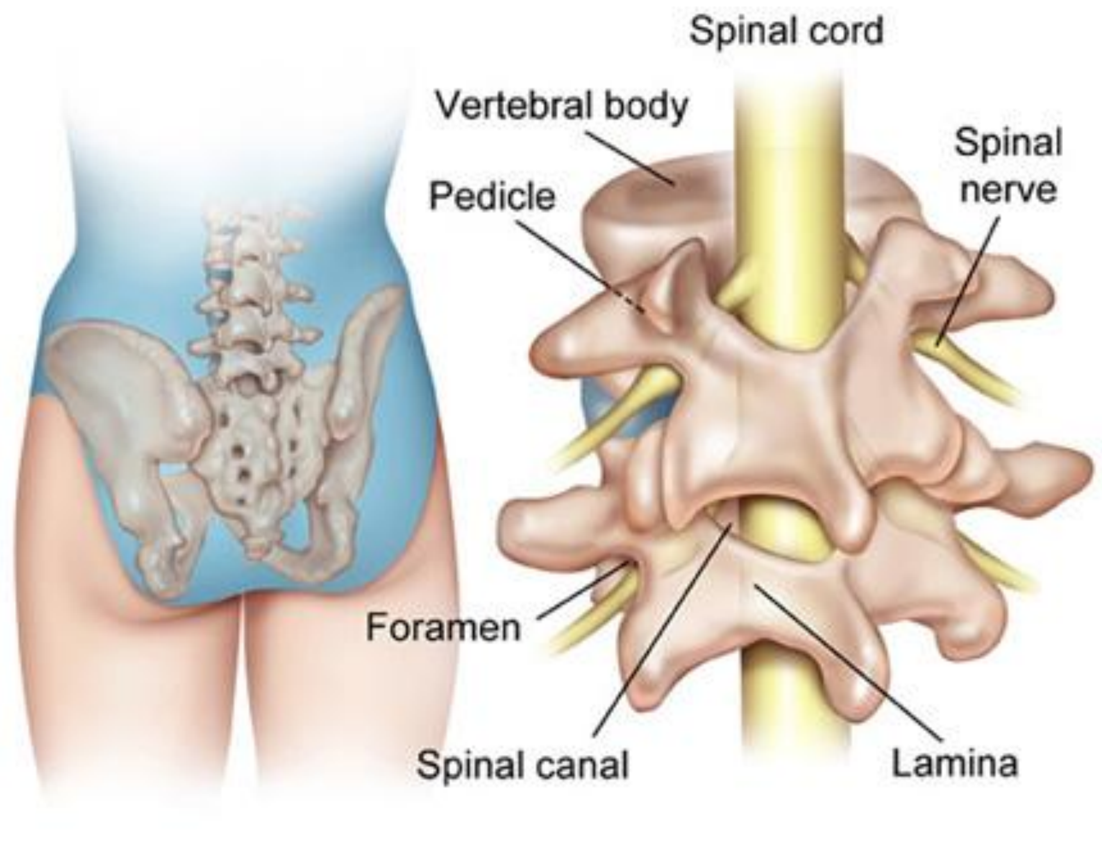

Figure2.3: image show transformational lumbar in tear body fusion 3(L. drake et.al 2014).

2.2 Physiology of the spine

The spinal column protects the delicate nerve tissue of spinal cord. The spinal cord is a highly organized and complex part of the central nervous system. Its complexity is due to the role it plays in the 3 most important functions of the individual: sensation, autonomic and motor control. If it was to simply report to the brain the information that it receives from the large number and variety of afferent inputs and relay back to the moto-neurons and pre ganglionic neurons the outcome of processing performed by the supra spinal centres the situation would be more straight forward. However, as is well established, this is not the case and the spinal cord has, in addition to relaying information from the rest of the body to the brain and receiving efferent commands from varied portions of the brain the ability to integrate and modify both afferent signals from the periphery, and efferent signals from segmental afferents and supra spinal centres. Thus there is a complicated network of neurons that normally operates in conjunction with the rest of the CNS to allow perfect control of sensory, autonomic and motor functions. This complex circuitry is critically dependent on its connections with the brain and it cannot function appropriately when it is either completely or even partially disconnected from it. It is rather regrettable, that we understand so little of the potential of the complex intrinsic circuitry of the spinal cord that when it loses connection with the brain we are unable to exploit its' potential function and restore deficits caused by spinal cord lesions.

In spite of the fact that the physiology of the spinal cord has been intensively investigated for at least a century it keeps revealing new surprising phenomena. In this chapter only a brief account will be given of its main functions (M.Y. Sukkar et.al 2000).

2.2.1Sensory Processing

In an oversimplified manner it can be stated that the somatic afferent functions that are processed in the spinal cord constitute the following: (a) pain and temperature, (b) touch, and (c) proprioception. Different sense organs in the peripheral structures initiate these sensory modalities, but the processing of them is usually carried out by a network of neurons in the spinal cord that are common to several of these different modalities of sensation (M.Y. Sukkar et.al 2000).

2.2.2. Pain and Temperature

The peripheral receptors for various modalities of sensation are specialised sense organs that are contacted by axons from dorsal root ganglion neurons. These neurons have a peripheral process and a central branch that enters the spinal cord where they branch. These neurons that are directly linked with the peripheral structures are called first order neurons, and their role in processing of sensory information is largely determined by their branching pattern. Illustrates some of the sense organs of the first order neurons that are involved in pain and temperature sensation and also shows that the main target of the branches of the central portion of this first order neuron terminates and synapses on neurons in the substantial gelatinase. It is from this part of the dorsal horn where the second order neurons give rise to their processes which convey the information to other parts of the spinal cord and brain. However, there are ascending and descending branches of the second order neurons that synapse on cells in different segments of the spinal cord and on more ventral interneurons that are concerned with control of movement and integration of somatic afferent inputs with those from other parts of the central nervous system. Thus these second order neurons play a crucial role in the processing of sensory information within the spinal cord. Not only somatic afferent fibres converge into the neurons in the substantial gelatinosa, but visceral sensation and pain also converges onto this group of second order neurons. In addition there is a strong input from various structures of the brain that impinge upon neurons in the substantial gelatinosa modify the input from the periphery and in this way the outcome of sensation .It is partly because of this convergence of inputs to this part of the spinal cord that sensation is not simply the result of particular peripheral inputs (M.Y. Sukkar et.al 2000).

2.3 Pathology:

2.3.1 Lumbar spinal stenosis:

Iumbar spinal stenosis is a condition whereby either the spinal canal (central stenosis (or one or more of the vertebral foramina (foraminal stenosis)becomes narrowed .if the narrowing is substantial ,it causes compression of the soinal nerves ,which cause painful symptoms of lumbar spinal stenosis , including low back pain ,buttock pain , and leg pain and numbness that is made worse with walking and relived by resting. Lumbar spinal stenosis can cause low back pain , weakness, numbness, pain , and loss of sensation in the leg .in most situation , the symptom improve when the patient is sitting or leaning forward .typically ,painful sensation shoot down the leg with continued walking and diminish with resting The (Lippincott Williams and Wilkins, 2007).

Particular activity-related symptom is sometimes referred to as pseudo claudication because it mimics the true claudication of poor circulation from peripheral vascular disease.Standing and bending backward can make the symptoms worse. this is because bending forward increase the space in the spinal canal and vertebral foramina, while bending back ward decrease this space .it is therefore more comfortable for patient to sit or lean forward .patients are frequently unable to walk for long distances and often state that their symptoms are improved when bending forward while walking with the support of a walker or shopping cart. The symptoms commonly worsen with time .this is because degenerative arthritis is progressive disease that gradually becomes more severe with time. If left untreated, the compression on the nerves from lumbar spinal can also lead to loss of bowel and bladder control and loss of sexual function. Many other disorders can cause similar symptoms that mimic lumbar spinal stenosis including: diabetic neuropathy, peripheral vascular disease, and vascular claudication (Lippincott W and Wilkins, 2007).

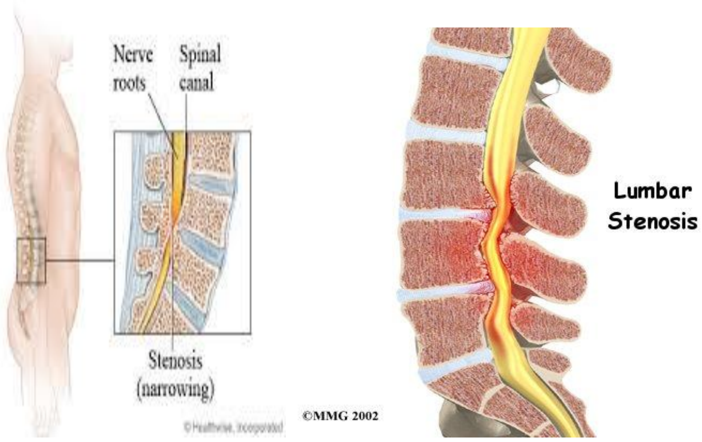

Figure 2.4 image show lumbar spine stenosis (L. drake et.al 2014).

2.3.1. Causes of lumbar spinal stenosis:

While some people are born with a small spinal canal, most spinal stenosis occurs when something happens to reduce the amount of space available within the spine. Causes of spinal stenosis may include:

Overgrowth of bone. Wear and tear damage from osteoarthritis on your spinal bones can prompt the formation of bone spurs, which can grow into the spinal canal. Paget's disease, a bone disease that usually affects adults, also can cause bone overgrowth in the spine, Herniated disks. The soft cushions that act as shock absorbers between your vertebrae tend to dry out with age. Cracks in a disk's exterior may allow some of the soft inner material to escape and press on the spinal cord or nerves and Thickened ligaments. The tough cords that help hold the bones of your spine together can become stiff and thickened over time. These thickened ligaments can bulge into the spinal canal (Drake R et al.2009).

Also tumours Abnormal growths can form inside the spinal cord, within the membranes that cover the spinal cord or in the space between the spinal cord and vertebrae and spinal injuries. Car accidents and other major trauma can cause dislocations or fractures of one or more lumbar spine (Drake R et al.2009).

2.3.2 Lumbar spinal stenosis diagnosis:

When a patient presents with the typical symptoms of lumbar spinal stenosis (leg pain, with or without back pain, which is aggravated by walking), a conclusive diagnosis is made using imaging studies from an MRI scan or a CT scan with myelogram (using an x-ray dye in the spinal sack fluid). Physical examination alone does not yield a conclusive lumbar stenosis diagnosis.There are three major types of stenosis and accurate identification is vital to stenosis treatment:**Lateral stenosis**. The most common type of spinal stenosis, lateral stenosis occurs when a nerve root that has left the spinal canal is compressed by either a bulging disc, herniated disc or bone protrusion beyond the foramen (a bony, hollow archway through which all spinal nerve roots run), **Central stenosis**.

Occurring when the central canal in the lower back is choked, central stenosis may lead to compression of the caudaequina nerve roots (the bundle of roots that branch off at the bottom of the spinal cord like a horse's tail) and Foraminal stenosis. When a nerve root in the lower back is pressed on and trapped by a bone spur in the foramen, or the opening where the nerve root leaves the spinal canal and displaced bone from a spinal fracture may damage the contents of the spinal canal. Swelling of adjacent tissue immediately following back surgery also can put pressure on the spinal cord or nerves (Drake R et al.2009).

2.4. Previous studies

Shrestha B and Dhungana S(2013) Size of the canaldiameter is oneamong several factors responsible for lumbarcanal stenosis. The study aims to measure thetransverse and sagittal diameter of the lumbarvertebral canal in people from Western region of Nepal and compare with the published results .Fifty young patients(24 males and 26 females) complaining of LBPwere done X-ray of lumbar spine in Antero-Posterior (AP)/ Lateral in supine views. From theimages, midsagittal (AP) dimensions, transverse(interpedicular) distances and width of vertebralbody were measured at each level with the help ofelectronic calipers.The mean transverse diameter oflumbar canal ranged from 24.8 mm at L1 to 33.25mm at L5. This gradual increase in the transversediameter from L1 to L5 was statisticallysignificant. Measurement of lumbar vertebralwidth ranged from 41.37 mm at L1 and 52.96 mmat L5. There was gradual increase in the size fromL1 to L5. But the measurement of AP distanceshowed a gradual decrease in diameter from L 1 toL 5. The decrease in the AP diameter from L 1 to L2 and Canal body ratio was not constant at all levels. Their hospital based data showedthat the patients from western region of Nepalhave smaller canal size. Therefore, the patientsfrom western region of Nepal may be more proneto develop spinal canal stenosis.

Zhou et.al 2000 stated that the precise dimensions of the lumbar vertebrae and discs are critical for the production of appropriate spinal implants. Unfortunately, existing databases of vertebral and intervertebral dimensions are limited either in accuracy, study population or parameters recorded. The objective of this study is to provide a large and accurate database of lumbar spinal characteristics from 126 digitised computed tomographic (CT) images, reviewed using the Picture Archiving Communication System (PACS) coupled with its internal measuring instrumentation. These CT images were obtained from patients with low back pain attending the spinal clinic at the Hammersmith Hospitals NHS Trust. Measurements of various aspects of vertebral dimensions and geometry were recorded, including vertebral and intervertebral disc height. The results from this study indicated that the depth and width of the vertebral endplate increased from the third to the fifth lumbar vertebra. Anterior vertebral height remained the same from the third to the fifth vertebra, but the posterior vertebral height decreased. Mean disc height in the lower lumbar segments was 11.6 ± 1.8 mm for the L3/4 disc, 11.3 ± 2.1 mm for the L4/5, and 10.7 ± 2.1 mm for the L5/S1 level. The average circumference of the lower endplate of the fourth lumbar vertebra was 141 mm and the average surface area was 1492 mm2. An increasing pedicle width from a mean of 9.6 ± 2.2 mm at L3 through to 16.2 ± 2.8 mm at L5 was noted. A comprehensive database of vertebral and inter vertebral dimensions was generated from 378 lumbar vertebrae from 126 patients measured with a precise digital technique. These results are invaluable in establishing an anthropometric model of the human lumbar spine, and provide useful data for anatomical research. In addition this is important information for the scientific planning of spinal surgery and for the design of spinal implants.

Vega et.al 2009 stated that it is necessary to have precise anatomical knowledge of lumbar pedicles for the safe placement of screws. There are not reports about the morphometry of lumbar pedicles in a Mexican population exist. A descriptive, observational and cross-sectional study was done in 60 cadavers from the dissection lab of the Human Anatomy Department of the Medicine School. The aim of the study was to quantify the morphometric characteristics of the pedicles of the lumbar spine in a Mexican population. A total of 60 cadavers were evaluated by fluoroscopy and CT from L1 to L5, in the age range of 40 to 78 years. Each vertebral pedicle was measured in the axial,sagittal and coronal planes. The measurements included the minimum pedicle width, the pedicle angle, the distance to anterior cortex, and anteroposterior and inter pedicular spinal canal diameters. CT evaluation showed a progressive and gradual increase in the width of the pedicles from L1 (7.81 ±1.30 mm) to L5 (14.36 ±14.36 mm). A progressive and gradual decrease of pedicle length from L1 (20.92±2.62 mm) to L5 (17.23 ±1.35 mm). When fluoroscopy was used there was the same relationship, but the values were higher than thoseobtained by CT. The values for widths and lengths are slightly higher in males than in females, but do not reveal any significant difference($p<0.05$). The data in this study indicates that pedicle screws (5.5-6.5mm) may be used in the lumbar region.

Cheung et.al 2013 his retrospective study the aimed of this study was to determine the intra- and inter-reader reliability of MRI measurements of the lumbar spine and the reliability of measurements usingT1- andT2-weightedMRI films. Forty-two randomly selected patients who underwent spinal stenosis surgery. Lumbar spinal canal measurements and reliability analysis between T1- and T2-weighted MRI. Qualitative ratings of MRI features were performed according to previously publishedcriteria by 2 independent readers (JP-YC, HS). Measurements in axial scan included midline anteroposterior (AP) vertebral body diameter, mid-vertebral body width, midline AP spinal canal diameter, midline AP dural sac diameter, spinal canal width/interpedicular distance, pedicle width (right and left), and lamina angle. Measurements in the sagittal scan included midline AP body diameter, mid-vertebral body height, and AP spinal canal diameter. Cronbach alpha was used to characterizeintra- and inter-reader reliability for qualitative rating data. Similarly, T1 and T2 comparison also was performed in the same manner. His study resulted in; good to excellent intra- and interobserver reliability was obtained for all measurements.

Reliability analysis of all T1 and T2 measurements was excellent. Either T1 or T2 images can be used for measurements of spinal canaldimensions.These findings are of importance, as not every patient undergoing preoperative MRI assessment willnecessarily have both sequences performed and only a single sequence is required for research studies.Our findings are also of relevance in measurement of lumbar canal diameters.

Decker S et.al 2010 aimed to evaluate agreement and repeatability of vertebral column measurements using computed tomography (CT) and magnetic resonance imaging (MRI). Dogs (n=18) with disc associated wobbler syndrome; Dog cadavers (n=3). Five measurements of the 5th cervical vertebra were performed: vertebral body length (VBL), vertebral canal height (VCH), vertebral body height (VBH), vertebral canal width (VCW), and vertebral body width (VBW). Measurements were performed independently twice by 2 observers. Bland-Altman plots were created to evaluate agreement. Cadaveric vertebrae with soft tissue removed had the same variables and actual dimensions measured. The largest discrepancy between CT and MRI measurement was for VBL (mean difference+/-SD=1.262 mm+/-1.245; P<.001), with the difference for all the other variables being acceptable. The 1st measurement was significantly higher than the 2nd only for VBL using CT (mean difference=0.476 mm+/-1.120; P=.009), with all other variables having acceptable differences. Mean difference for all measurements between 2 observers was small, except for VBL using CT (mean difference=0.762 mm+/-1.042; P<.001). Only the difference for VBL between CT and cadaver specimens was statistically significant. Their results suggest high repeatability and good agreement for most vertebral measurements of interest. VBL measurement using CT was considered problematic. Provided limitations are understood, linear measurements of vertebral dimensions from CT and MRI images can be used clinically.

Chapter Three

Materials and methods

3.1 materials:

For all patient axial plane are obtained using slice thickness 3 mm for all planes, the study was executed using multi-detector computed tomography scanner MDCT 8-Slice scanner (0.625mm slices): 8-slice 0.625mm collimation, table feed 10 mm/rotation, effective tube current 685 mAs at 120 kV. Pitch = 10/40 mm collimation = 0.25. Average scan time = 5 s, to scan the patient with flank pain problems with 8-slice, detector array, fan beam shape, CT monitor for controlling scanning and processing and K-PACS system for diagnosis images and reconstruction and volume rendered purposes in addition to the measurement of spinal canal.

3.2. Methods

The transverse diameter of osseous spinal canal was measured from inner border of the pedicles in axial image and the antero-posterior diameter was measured posterior from the junction of lamina and anterior from border of body of vertebra in axial image .the antero-posterior diameter of osseous diameter also measured from the posterior border of vertebra to the pedicles in the mid sagittal image.

3.2.1. Study area:

This study was conducted at Khartoum state, modern medical diagnostic center.

3.2.2. Study duration:

This study was carried out from august 2015 to October 2015

3.2.3. The study population:

This study was conducted on Sudanese population especially Khartoum state population.

3.2.4. Study sample:

The study sample was consist of 40 patients normal lumber spine study.

3.2.5. Inclusion criteria:

The study was include all patient with normal lumber spine CT scan

3.2.6. Exclusion criteria:

All patients with lumber spine canal stenosis and traumatic patient were excluded.

3.2.7. Statistical analysis:

All data were presented as mean±SD values by using of the SPSS (IBM SPSS version 21.0).

3.2.8. Method of data collection:

The data were collect on master data sheet from the diagnostic stations which was include all parameters need for evaluations and measurement.

3.2.9. Variables of the study:

Patient gender, Age, AP and transvers diameter.

3.2.9.1. Example of standard master data sheet will be used in data collection

Pt age	sex	weight	Hight	BMI	AP(cm)	Transeverse (y) cm	Clinical diagnose
58	female	70	172	23.66	2.5	1.3	Fibroid

3.2.10. Ethical issues:

- There was official written permission to Khartoum state diagnostic centers to take the data.
- No patient data were published also the data was kept in personal computer with personal password.

Chapter four

Results

Table 4.1:shows frequency of gender

Gender	Frequency	Percent
Male	22	55.0
Female	18	45.0
Total	40	100.0

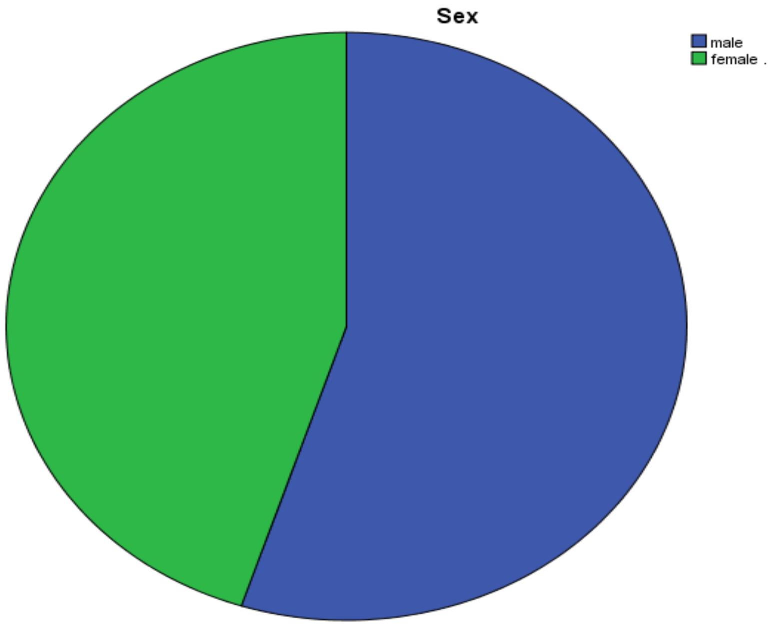

Figure 4.1: shows gender frequency

Table4.2: shows frequency table of age group

Age group	Frequency	Percent
20-29	4	10.0
30-39	7	17.5
40-49	13	32.5
50-59	9	22.5
60-69	6	15.0
70-80	1	2.5
Total	40	100.0

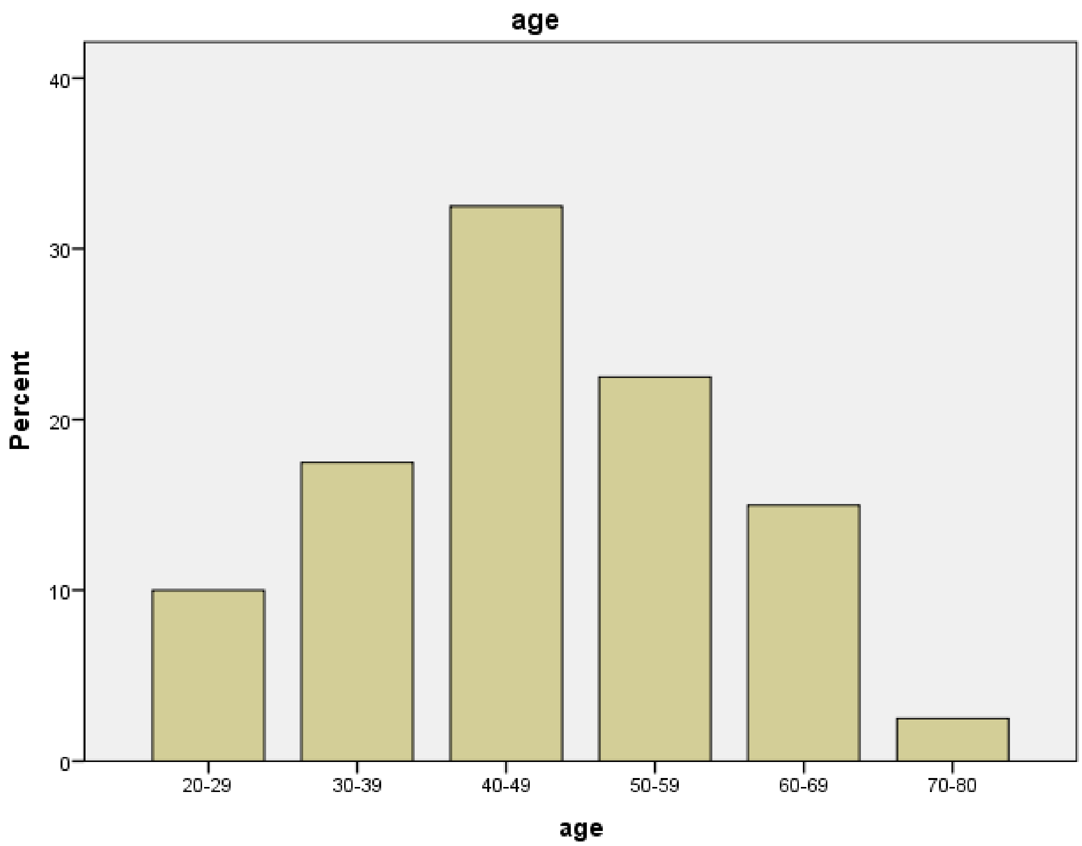

Figure4.2 : bar graph showed the frequency distribution of age frequency

Table 4.3: shows frequency and percent of clinical diagnose

Clinical diagnose	Frequency	Percent
Ureteric stone	2	5.0
kidney stone	12	30.0
Fibroid	4	10.0
Normal	9	22.5
Cyst	3	7.5
Lymphadenopathy	1	2.5
renal mass	4	10.0
gall stone	3	7.5
liver abscess	2	5.0
Total	40	100.0

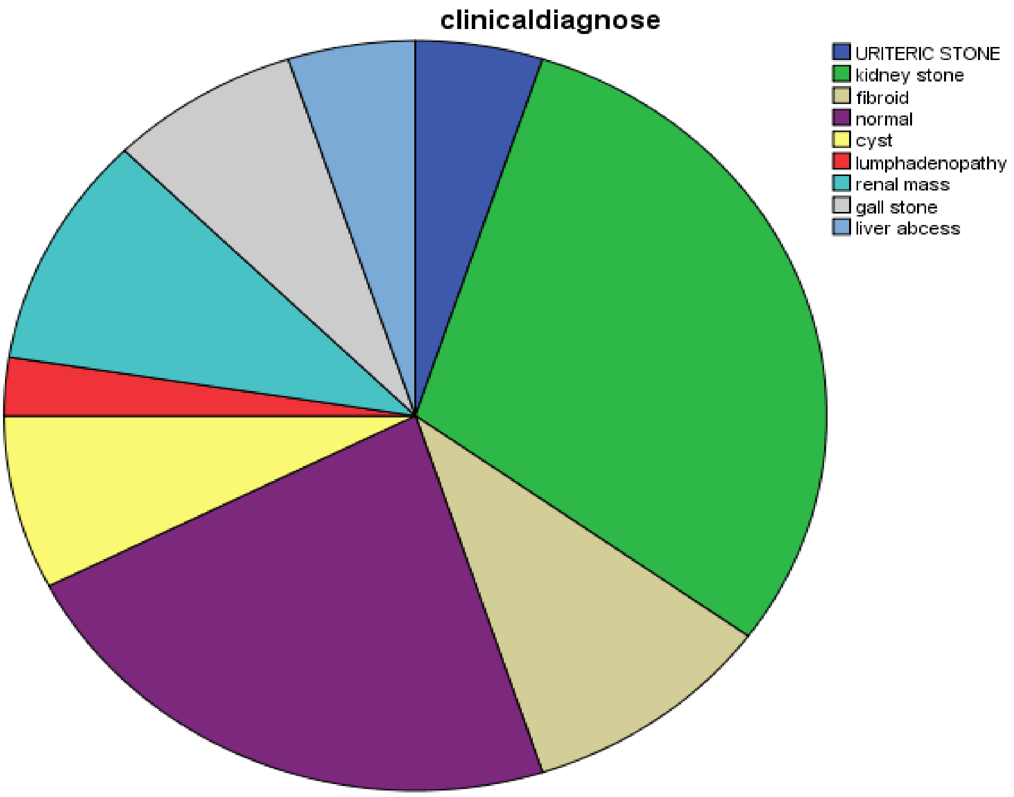

Figure4.3: pie chart shows frequency of clinical diagnose

Table 4.4: shows age and weight and height and AP Transverse and BMI distributions

Age	Minimum	Maximum	Mean	Std. Deviation
Age	22	70	46.15	13.061
Weight	45	84	66.03	10.294
Height (cm)	150	186	169.33	9.071
AP (cm)	1.2	2.9	2.498	.3711
Transvers (Y)cm	1.1	1.9	1.458	.2500
BMI	16.70	29.37	23.009	3.09004

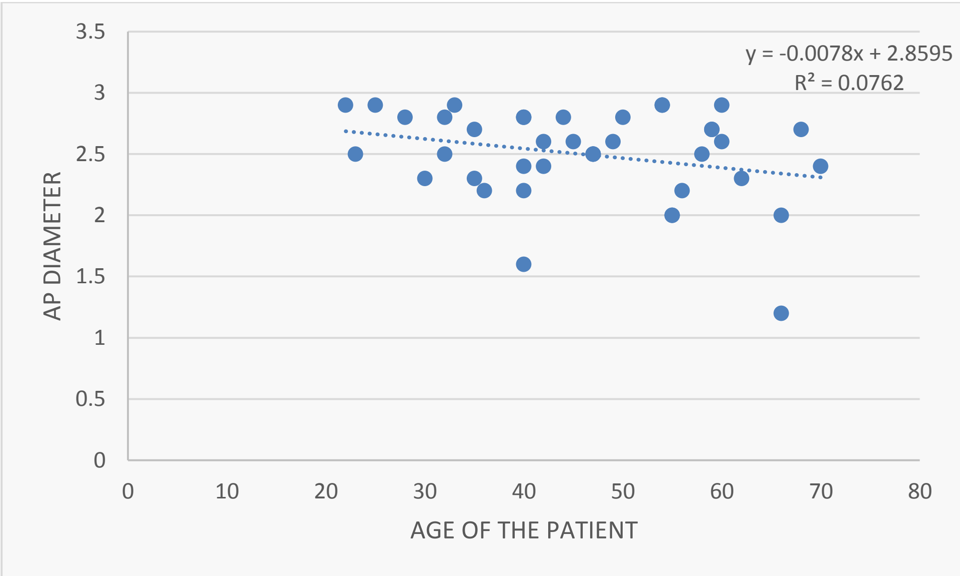

Figure 4.4:shows the relationship between age and antero-posterior diameter in axial cut.

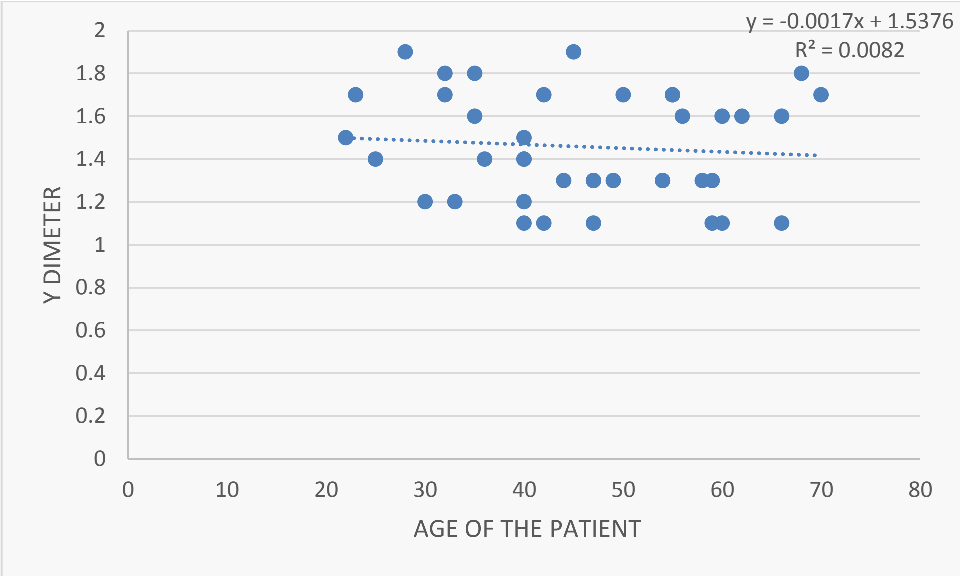

Figure4.5: shows the relationship between age and transverse diameter in axial cut

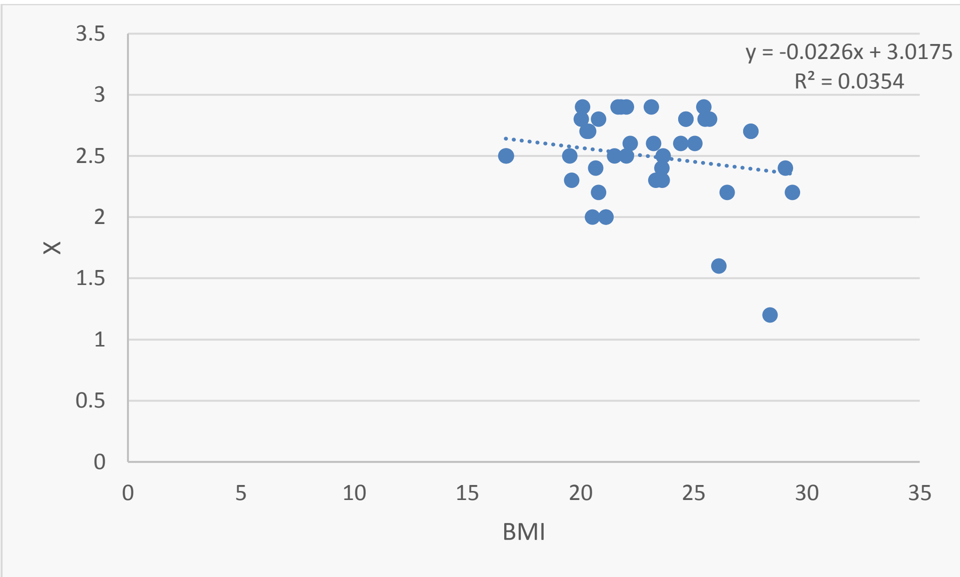

Figure 4.6:show relationship between BMI and anteroposterior diameter in axial cut

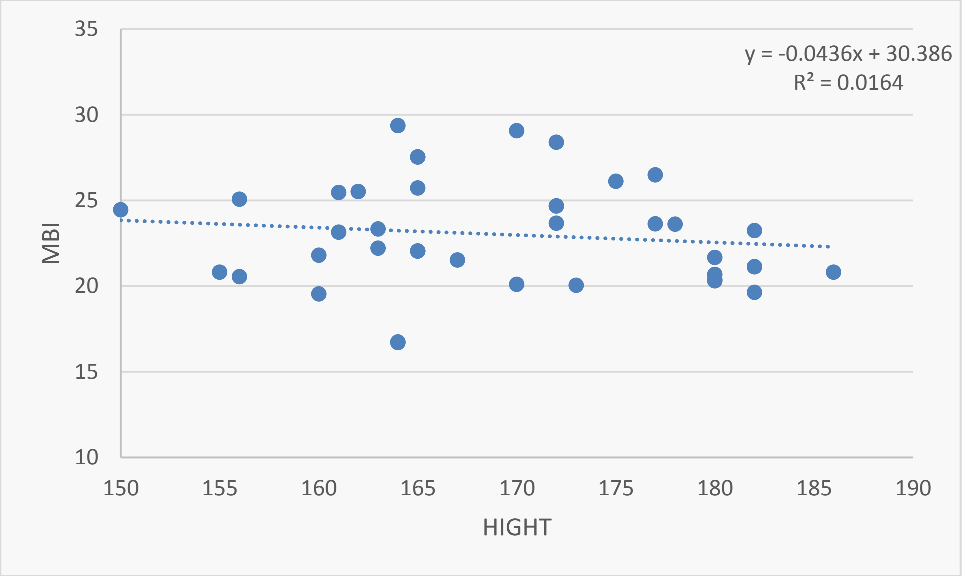

Figure 4.7**:** shows relationship between height and BMI

Chapter five

Discussion, conclusion and recommendations

5.1 Discussion:

The CT was performed to measure the intervertebral canal in Sudanese population in patient diagnosed other pathological disease and with normal lumbar spinal canal. No fractures or pathological problem such as patient indicated for lumbar spinal canal stenosis. The measurement was performed in 40 patient(55% male and 45% female). The frequency of age group and class was calculated in order to show the most frequent age group presented for CT scan with normal spinal study which age group 40-49,frequency 13 and percent 32.5%.

In this study the mean ±standard deviation in collected data which are age, weight, hight, BMI are respectively 46.15±13.061cm ,66.03±10.294cm ,169.33±9.071cm and 23.009±3.09004 cm. In this study the mean±SD of antero-posterior measurement in the axial cut 2.498±0.3711 cm. The mean±SD of transverse measurement in the axial cut 1.458±0.2500 cm.

In this study the relationship between the patient age and antero posterior measurement in the axial cut was found to be indirect relationship where the AP diameter decrease by 0.007 cm for every one year increasing in age , and the relationship between the patient age and transeverse in axial cut was found to be a indirect relationship Where transverse diameter decrease by 0.001 cm for every one year increase in age. the relationship between BMI and antero-posterior diameter in axial cut was found to be indirect relationship where AP diameter decrease by 0.022 cm for every increase in BMI.

The relationship between height and BMI was found to be indirect relationship where BMI decrease by0.043 cm for every increase in height .

All this measurement were said to be normal for the study group, in comparison to other studies, the different in population (body type)and sample size .

So this measurement may take as normal spinal canal diameter for Sudanese population.

5.3 Conclusion:

The study conclude that:

This was an analytical study aimed to determine and measure the normal diameters range of lumbar spinal canal in Sudanese population by using of multi-detector computed tomography in order to assess the normal variant between the Sudanese populations. This study was performed in 40 patients in Khartoum state diagnostic centre (modern diagnostic medical centre in period(from August To October) who underwent CT lumbar spine with normal study results. The measurement of lumbar canal were taken at L3 in axial cut from CT lumbar spine images. The mean value of anterior-posterior measurement in the axial cut 2.498±0.3711 cm, and the mean value of transverse measurement in the axial cut 1.458±0.2500cm. In this study the mean ±standard deviation in collected data which are age, weight, hight, BMI are respectively 46.15±13.061cm, 66.03±10.294cm, 169.33±9.071cm and 23.009±3.09004cm.

In this study the relationship between the patient age, height, weight and BMI measurement in the axial cut was found to be a weak indirect relationship.

Lumbar canal measurement are important diagnostic information for many orthopedic and neurological disease.

This study determined the normal diameter rang of lumbar canal by using CT in Sudanese population.

In this study the relationship between the patient age and the tow different measurements was found to be indirect relationship.

5.2 Recommendations:

- Further similar study using sagittal cut is recommended.
- Testing the suggested clinical diagnose and patient with lumbar canal measurements.
- The technologist should know the normal range of lumbar canal measurement to have correct image interpretation.

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Appendix

A/table 5.1 master Data sheet was used in data collecting and analysis:

Pt.no	Age	Sex	weight	hight	BMI	AP(X) cm	Transeverse (y) cm	clinical diagnose	image done
1	40	M	75	178	23.6	2.4	1.5	lymph node	axial
2	35	M	66	180	20.3	2.7	1.8	uritric stone	axial
3	60	F	56	160	21.8	2.9	1.6	kidney stone	axial
4	68	M	66	180	20.37	2.7	1.8	normal	axial
5	32	M	60	173	20.04	2.8	1.7	cyst	axial
6	58	F	70	172	23.66	2.5	1.3	fibroid	axial
7	22	M	60	165	22.03	2.9	1.5	cyst	axial
8	40	F	83	177	26.49	2.2	1.1	fibroid	axial
9	59	F	75	165	27.54	2.7	1.3	normal	axial
10	40	F	73	172	24.67	2.8	1.4	normal	axial
11	47	M	45	164	16.7	2.5	1.3	Lt renal mass	axial
12	54	F	60	161	25.46	2.9	1.3	gall stone	axial
13	42	F	84	170	29.06	2.4	1.7	normal	axial
14	70	M	67	180	20.67	2.4	1.7	lt renal stone	axial
15	66	M	84	172	28.39	1.2	1.1	Lt lower uritric stone	axial
16	50	M	67	162	25.52	2.8	1.7	renal stone	axial
17	55	M	70	182	21.13	2	1.7	lt renal stone	axial
18	45	F	61	156	25.06	2.6	1.9	AAA	axial
19	36	M	72	186	20.81	2.2	1.4	lt renal stone	axial

20	35	M	65	182	19.62	2.3	1.6	kidney stone	axial
21	56	M	79	164	29.37	2.2	1.6	liver abcess	axial
22	28	F	70	165	25.71	2.8	1.9	renal stone	axial
23	30	M	62	163	23.33	2.3	1.2	renal stone	axial
24	49	F	55	150	24.44	2.6	1.3	normal	axial
25	66	M	50	156	20.54	2	1.6	liver cirrohsis	axial
26	23	F	60	165	22.03	2.5	1.7	cyst	axial
27	40	F	80	175	26.12	1.6	1.2	fibroid	axial
28	47	F	50	160	19.53	2.5	1.3	renal mass	axial
29	33	F	70	180	21.66	2.9	1.2	gall stone	axial
30	55	M	70	182	21.13	2	1.7	renal stone	axial
31	54	F	60	161	23.14	2.9	1.3	gall stone	axial
32	47	M	45	164	16.73	2.5	1.1	renal mass	axial
33	40	M	73	172	24.67	2.8	1.4	normal	axial
34	59	F	75	165	27.54	2.7	1.1	normal	axial
35	32	F	60	167	21.51	2.5	1.8	normal	axial
36	42	M	59	163	22.2	2.6	1.1	renal mass	axial
37	44	F	50	155	20.81	2.8	1.3	fibroid	axial
38	62	M	74	177	23.62	2.3	1.6	stock horn stone	Axial
39	25	M	63	170	20.1	2.9	1.4	normal	Axial
40	60	F	77	182	23.24	2.6	1.1	kidney stone	axial

Figure 5.1 : show diameter range of lumbar spinal canal in axial cut: