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Measurement of the Normal Intervertebral Disc Space between L5-S1 in Sudanese Using MRI

قياس فضاء قرص الفقره الطبيعى بين الفقره البطنيه الخامسه والعجزيه الاولى فى السودانيين عن طريق التصوير بالرنين المغناطيسى.

A thesis Submitted for Partial Fulfillment for the Requirements of M.Sc Degree in Diagnostic Radiologic Imaging

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الأيه

(فَتَعالَى اللَّهُ ٱلمَلِكُ ٱلحَقُّ وَلا تَعْجَلْ بِٱلقُرْآن مِن قَبْلِ أَن يُقضَى إِلَيْكَ وَحْيُهُ وَقُل رَّبِّ زِدْنِي عِلْمًا)

صدق الله العظيم

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Dedications

I would like to dedicate my thesis to:

The tender man …

My Father

The Kindest woman …

My Mother

To my dearest friends

Acknowledgement

I would like to express my greatest gratitude to **Dr. Asma Ibrahim** for her supervising this work to layout.

My thanks was extended to my friend (Mugtaba Alghazali) for him helps.

My gratitude is also extended to my colleagues in Radiology Department at Alzaytouna Specialized Hospital for their continuous help and support.

Finally, my profound thanks and gratitude to everyone who encouraged me to complete this.

Abstract

This descriptive analytic study aimed to measure the Normal L5/S1 Intervertebral Disc Space in Sudanese Using magnetic resonance imaging. 50 patients (26males and24 females) at age (20 – 50) years selected randomly when they attended to MRI department for lumbar spine examination then their heights and weights were reported. The horizontal and the vertical lengths of the intervertebral disc were measured on the mid-saggital section of the vertebral body. The study found the following results: the mean of the horizontal and the vertical lengths of L5/S1 Intervertebral Disc Space of age from (20-30) years (32.20±1.79mm)(10.9±0.95mm), (30-40)years (30.81±1.8mm) (10.33±0.81mm), and (40-50) years (31.60±2.14mm) (10.32±1.04mm) respectively. Also the study found inverse strong correlation between patient's age and height and width of intervertebral disc, direct strong correlation between patient's weight and height and width of intervertebral disc, and direct week correlation between patient's length and height and width of intervertebral disc.

The study concluded that the mean of height for normal L5/S1 intervertebral disc space of Sudanese 10.49 and it's similar to other populations that compared with them. The normal L5/S1 intervertebral disc space influenced by age, patient's heights and weights, and youngest, longest and thinnest patients had wider intervertebral disc than other study groups.

ملخص البحث

هذه دراسة تحليلية وصفية هدفت إلى قياس فضاء قرص الفقره الطبيعى بين الفقره البطنيه الخامسه والعجزيه الاولى في السودانيين عن طريق التصوير بالرنين المغناطيسي. تم اخذ ٥٠ حاله (٢٦ذكوروو٢٤إناث) تتراوح اعمارهم بين [٢٠–٥٠] سنة تم اختيارهم عشوائيا عند حضورهم إلى قسم التصويربالرنين المغناطيسي لاجراء فحص(L / SS) ثم تم قياس اطوال واوزان المرضى. كما تم قياس الاطوال الأفقية والعمودية لفضاء قرص الفقره من منتصف القرص الفقري.

وخلصت الدراسة إلى النتائج التالية: متوسط الاطوال الأفقيه والرأسيه لفضاء قرص الفقره من عمر [٢٠–٣٠] [٣٢,٢٠±١,٧٩م.م] [١٠,٩±٠,٩٥م.م], [٣٠–٤٠] [٣٠,٨١±١,٨م.م] [١٠,٣٣±٠,٨١م.م], [٤٠–٥٠] [٣١,٦٠±٢,١٤م.م] [١٠,٣٢±١,٠٤م.م] على التوالي.

كما وجدت الدراسة علاقة عكسية قوية بين عمرالمريض وارتفاع وعرض فضاء القرص الفقري، وعلاقة مباشرة قوية بين وزن المريض وارتفاع وعرض فضاء القرص الفقري، وارتباط مباشر بين وزن المريض وارتفاع وعرض فضاءالقرص الفقري.

وخلصت الدراسة إلى أن متوسط ارتفاع فضاء القرص الفقري الطبيعي لدى السودانيين هو 10.49 وهو مماثل للشعوب الأخرى التي تمت المقارنه معها.

يتأثر فضاء القرص الفقري الطبيعي بعمر, وزن وطول المريض. وأن أصغر وأطول، وأنحف المرضى يكون القرص الفقري لديهم أوسع من مجموعات الدراسة الأخرى.

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List of Abbreviations

AF: Annulus Fibrosus

ALL: Anterior Longitudinal Ligament

CNS : Central Nervous System

CT : Computed Tomography

CSF : Cerebrospinal Fluid

FSE: Fast Spain Echo sequence

ISL: Interspinous Ligament

LF: Ligamentum Flavum

LSS: Lumbo-Sacral Spine

MRI : Magnetic Resonance Imaging

NM : Nuclear Medicine

NP : Nucleus Pulposus

PLL: Posterior Longitudinal Ligament

PSIS: Posterior Superior Iliac Spine

SSL : Supra Spinous Ligament

TSE: Turbo Spin Echo

TE: Echo Time TR: Repetition Time

CHAPTER ONE

Introduction

Chapter One

- **Introduction:**

The lumbar vertebrae are, in human anatomy, the five vertebrae between the rib cage and the pelvis. They are the largest segments of the vertebral column and are characterized by the absence of the foramen transversaium within the transverse process (as it only found in the cervical region), and by the absence of facets on the sides of the body. They are designated L1 to L5, starting at the top. The lumber vertebrae help support the weight of the body, and permit movement.The intervertebral discs, which separate joining vertebrae, are fastened to the roughened upper and lower surfaces of the bodies. which might otherwise fracture the vertebrae or jar the brain. Each intervertebral disc is composed of a band of fibrous fibrocartilage (annulus fibrosus) that surrounds a gelatinous core, called the nucleus pulposus.

Magnetic resonance imaging (MRI) is a noninvasive medical test that physicians use to diagnose and treat medical conditions.

MRI uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. MRI does not use ionizing radiation (x-rays).

Detailed MR images allow physicians to evaluate various parts of the body and determine the presence of certain diseases. The images can then be examined on a computer monitor, transmitted electronically, printed or copied to a CD.

An MRI examination of the spine shows the anatomy of the vertebrae that make up the spine, ligaments that hold the vertebrae together, as well as the disks, spinal cord and the spaces between the vertebrae through which nerves pass.

Currently, MRI is the most sensitive imaging test of the spine in routine clinical practice.

- **Research Problems:**

Measurement of normal L5/S1 intervertebral disc space for Sudanese was not measured before, the study attempted to find the mean of normal L5/S1 intervertebral disc space for Sudanese.

- **Objectives of study**

General objectives

To measure the normal intervertebral disc by using MRI.

1.3.1 Specific Objectives

To correlate disc height and width with patient age.

To correlate height and widthwith patient length.

To correlate height and width with patient weight.

- **Significance of the study:**

This research aim to resolve the intervertebral disc problem by giving the normal measure of intervertebral disc space in Sudanese people to differentiate between the normal and abnormal intervertebral disc space.

- **Overview of the study**

Chapter one: is an introduction, statement of the problem, and study objectives, Chapter two including a comprehensive scholarly literature reviews concerning the previous studies, Chapter three deals with the methodology, where it provides an outline of material and methods used to acquire the data in this study as well as the method of analysis approach, Chapter four presenting the results, Chapter five include discussion of results, conclusion and recommendation followed by references and appendices.

CHAPTER TWO

Literatures review

CHAPTER TWO

Literatures review

2.1Anatomy of the lumbar spine

The lumbar vertebrae are, in human anatomy, the five vertebrae between the rib cage and the pelvis. They are the largest segments of the vertebral column and are characterized by the absence of the foramen transversarium within the transverse process (as it is only found in the cervical region), and by the absence of facets on the sides of the body. They are designated L1 to L5, starting at the top. The lumbar vertebrae help support the weight of the body, and permit movement. (Snell 2012)

2.1.1Bones

The lumbar 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,The vertebral (neural) arch designed to protect the neural elements and The bony processes (spinous and transverse) which function to increase the efficiency of muscle action. The lumbar vertebral bodies are distinguished from the thoracic bodies by the absence of rib facets. The lumbar vertebral bodies (vertebrae) are the heaviest components, connected together by the intervertebral discs. The size of the vertebral body increases from L1 to L5, indicative of the increasing loads that each lower lumbar vertebra absorbs. Of note, the L5 vertebra has the heaviest body, smallest spinous process, and thickest transverse process.(Snell 2012)

The intervertebral discal surface of an adult vertebra contains a ring of cortical bone peripherally termed the epiphysial 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 epiphysial ring. Each vertebral arch is composed of 2 pedicles, 2 laminae, and 7 different bony processes (1 spinous, 4 articular, 2 transverse) (see the following image), joined together by facet joints and ligaments.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 lumbosacral muscles. The pedicle, strong and directed posteriorly, joins the arch to the posterolateral body. It is anchored to the cephalad portion of the body and function as a protective cover for the caudaequina contents. The concavities in the cephalad and caudal surfaces of the pedicle are termed vertebral notches.Fig (2.1) (Kelley, el. 2007)

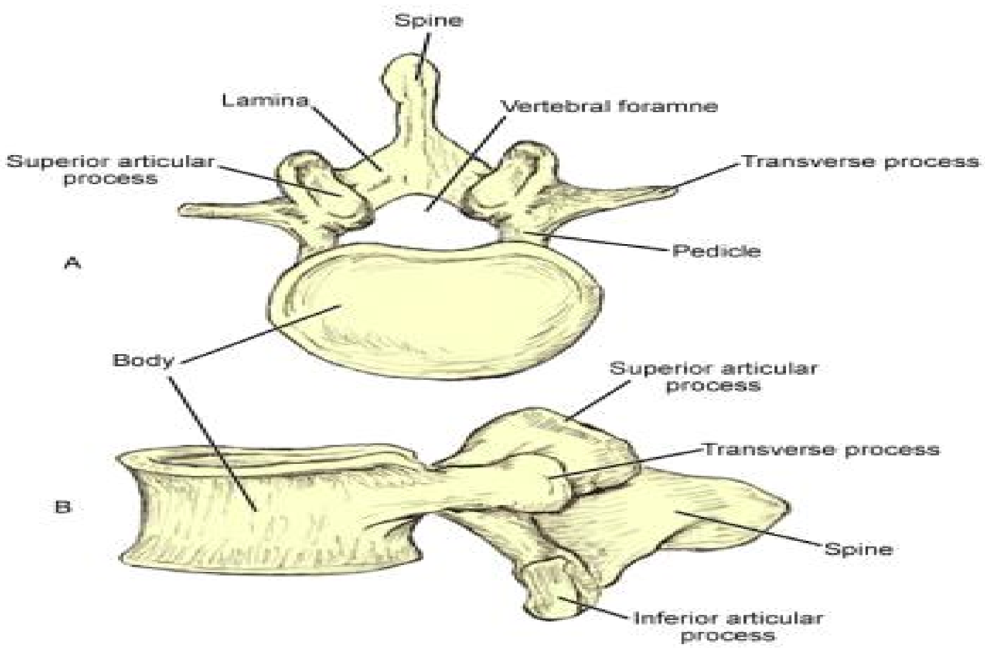

Fig (2.1): shows lumbar vertebrae anatomy

Beneath each lumbar vertebra, a pair of intervertebral (neural) foramina with the same number designations can be found, such that the L1 neural foramina are located just below the L1 vertebra. Each foramen is bounded superiorly and inferiorly by the pedicle, anteriorly by the intervertebral 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. (Kelley, el. 2007)

The broad and strong laminae are the plates that extend posteromedially from the pedicle. The oblong shaped spinous processes are directed posteriorly from the union of the laminae.

The two superior (directed posteromedially) and inferior (directed anterolaterally) articular processes, labeled SAP and IAP, respectively, extend cranially and caudally from the point where the pedicles and laminae join. The facet or zygapophyseal joints are in a parasagittal plane. When viewed in an oblique projection, the outline of the facets and the pars interarticularis appear like the neck of a Scottie dog (see the image below).Drawing of 2 lumbar segments viewed from an oblique angle. The outline of the facets and the pars interarticularis has the appearance of the "neck" of a Scottie dog.Fig (2.2)(Snell 2012)

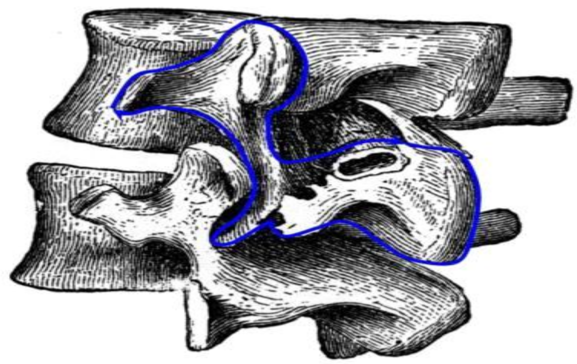

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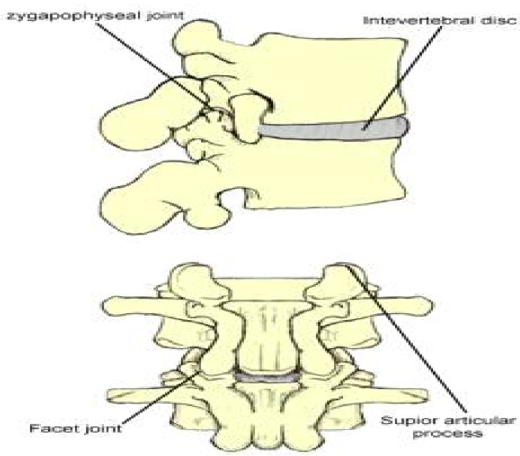
Fig (2.2) shows Scottie dog appearance

Between the superior and inferior articular processes, 2 transverse processes are projected laterally that are long, slender, and strong. They have an upper tubercle at the junction with the superior articular process (mammillary process) and an inferior tubercle at the base of the process (accessory process). These bony protuberances are sites of attachments of deep back muscles. (Kelley, el. 2007)

2.1.2 Lumbar vertebral joints

The mobility of the vertebral column is provided by the symphyseal joints between the vertebral bodies, formed by a layer of hyaline cartilage on each vertebral body and an intervertebral disc between the layers. The synovial joints between the superior and inferior articular processes on adjacent vertebrae are termed the facet joints (also known as zygapophysial joints or Z-joints *)*. They permit simple gliding movements. The movement of the lumbar spine is largely confined to flexion and extension with a minor degree of rotation Fig (2.3). The region between the superior articular process and the lamina is the pars interarticularis. A spondylolysis occurs if ossification of the pars interarticularis fails to occur. (Snell 2012)



Fig(2.3) shows Lumbar vertebral joints

The three joint complex is formed between two lumbar vertebrae. Joint one Disc between two vertebral bodies; Joint two Left facet (zygapophyseal) joint; Joint three Right facet (zygapophyseal) joint.(Snell 2012)

2.1.3 Lumbar intervertebral discs

Discs form the main connection between vertebrae. They bear loading during axial compression and allow movement between the vertebrae. Their size varies depending on the adjacent vertebrae size and comprises approximately one quarter the length of the vertebral column. Each disc consists of the nucleus pulposus, a central but slightly posterior mucoid substance embedded with reticular and collagenous fibers, surrounded by the annulus fibrosus, a fibrocartilaginous lamina. The annulus fibrosus can be divided into the outermost, middle, and innermost fibers. The anterior fibers are strengthened by the powerful anterior longitudinal ligament (ALL). The posterior longitudinal ligament (PLL) affords only weak midline reinforcement, especially at L4-5 and L5-S1, as it is a narrow structure attached to the annulus. The anterior and middle fibers of the annulus are most numerous anteriorly and laterally but deficient posteriorly, where most of the fibers are attached to the cartilage plate. Fig (2.4) (Kelley, el. 2007)

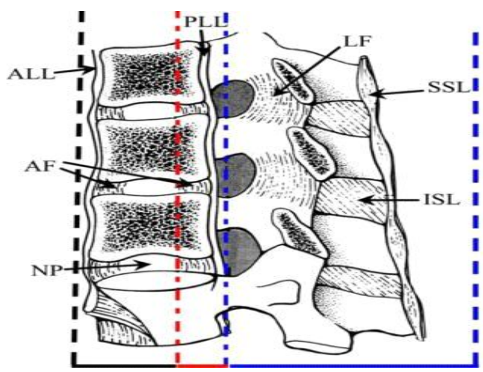


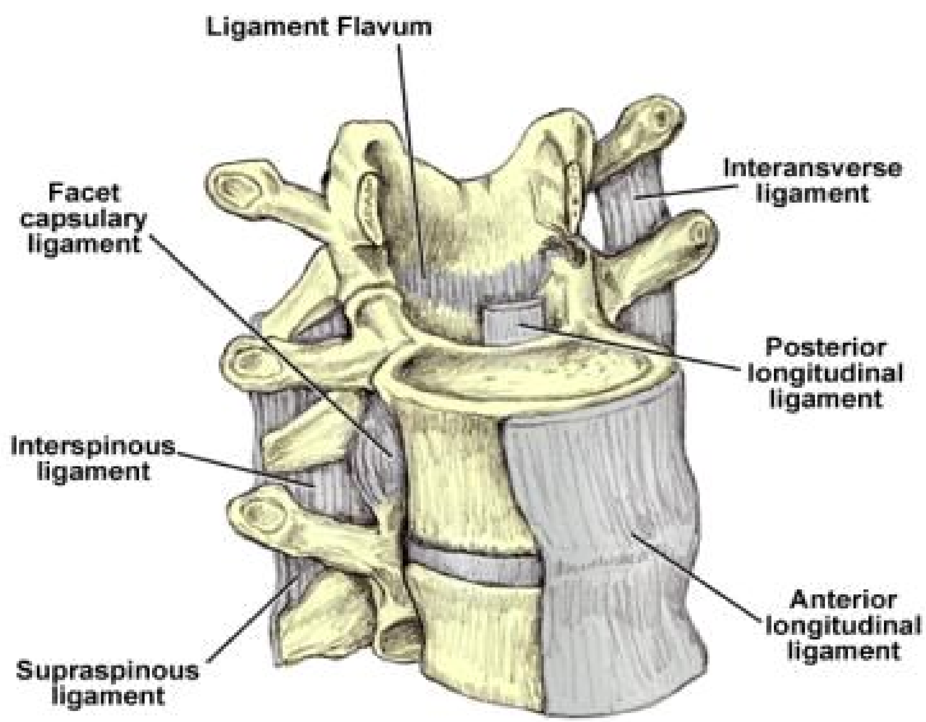
Fig (2.4) shows Lumbar intervertebral discs & ligaments

Lateral drawing of the 3 spinal columns of the thoracolumbar junction. The anterior column (black dotted line) includes the anterior spinal ligament, the anterior annulus fibrosus (AF), the intervertebral disc, and the anterior two thirds of the vertebral bodies. The middle column (red dotted line) includes the posterior aspect of the vertebral bodies, the posterior annulus fibrosus, and the posterior longitudinal ligament (PLL). The posterior column (thick blue dotted line) includes the entire spine posterior to the longitudinal ligament (thick blue dotted line). anterior longitudinal ligament (ALL); interspinous ligament (ISL);ligamentumflavum (LF); nucleus pulposus (NP); supraspinous ligament(SSL). (Snell 2012)

The annular fibers are firmly attached to the vertebral bodies and are arranged in lamellae. This annular arrangement permits limiting vertebral movements, reinforced by investing ligaments. (Snell 2012)

2.1.4 Lumbar vertebral ligaments

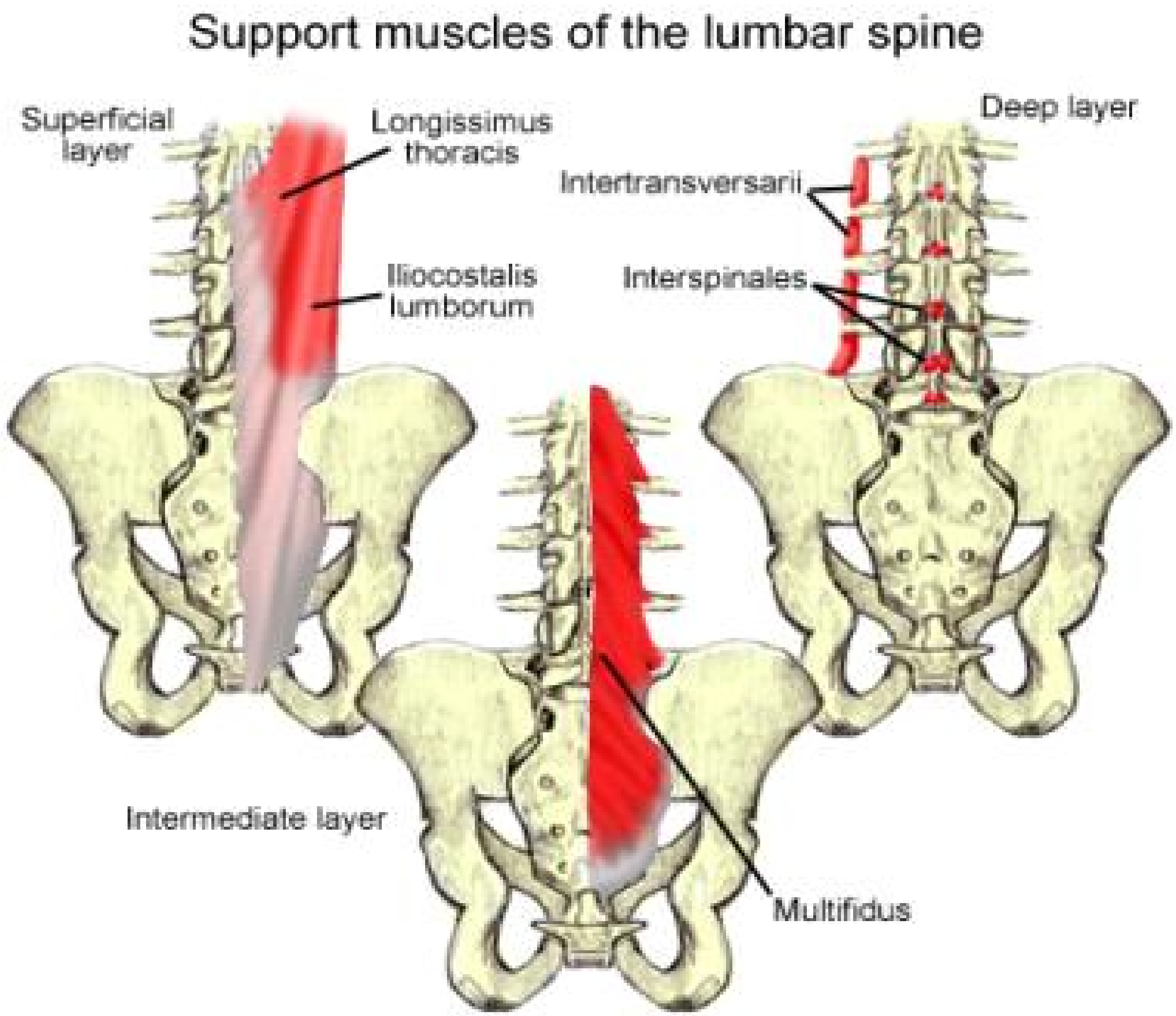
The ALL covers the ventral surfaces of lumbar vertebral bodies and discs. It is intimately attached to the anterior annular disc fibers and widens as it descends the vertebral column. The ALL maintains the stability of the joints and limits extension. The PLL is located within the vertebral canal over the posterior surface of the vertebral bodies and discs. It functions to limit flexion of the vertebral column, except at the lower L-spine, where it is narrow and weak. The supraspinous ligament joins the tips of the spinous processes of adjacent vertebrae from L1-L3. The interspinous ligament interconnects the spinous processes, from root to apex of adjacent processes. Sometimes described together as the interspinous/supraspinous ligament complex, they weakly resist spinal separation and flexion. The ligamentumflavum (LF) bridges the interlaminar interval, attaching to the interspinous ligament medially and the facet capsule laterally, forming the posterior wall of the vertebral canal. It has a broad attachment to the undersurface of the superior lamina and inserts onto the leading edge of the inferior lamina. Normally, the ligament is taut, stretching for flexion and contracting its elastin fibers in neutral or extension. It maintains constant disc tension. The intertransverse ligament joins the transverse processes of adjacent vertebrae and resists lateral bending of the trunk.The iliolumbar ligament arises from the tip of the L5 transverse process and connects to the posterior part of the inner lip of the iliac crest. It helps the lateral lumbosacral ligament and the ligaments mentioned above stabilize the lumbosacral joint. Fig (2.5)(Kelley, el. 2007)



Fig(2.5) shows Lumbar vertebral ligaments

2.1.5 Lumbar spine musculature

Four functional groups of muscles govern the lumbar spine and can be divided into extensors, flexors, lateral flexors, and rotators. Synergistic muscle action from both the left and right side muscle groups exist during flexion and extension of the L-spine. Fig(2.6) (Kelley, el. 2007)



Fig(2.6) shows Lumbar spinal muscles.

2.1.5.1 Extensors

The extensor muscles are arranged in 3 layers. The largest group of intrinsic back muscles and primary extensor is the erector spinae (or sacrospinalis). In the lower L-spine, the erector spinae appears as a single muscle. At the upper lumbar area, it divides into 3 vertical columns of muscles (iliocostalis, longissimus, spinalis). Located posterolateral to the vertebral column, they have a common origin from a thick tendon that is attached to the sacrum, the lumbar spinous processes, and the iliac crest. The iliocostalis is the most lateral, and the spinalis (smallest muscle) is the most medial. The longissimus (largest muscle) inserts on to the skull base, whereas the iliocostalis inserts onto the angles of the ribs and transverse processes of the lower cervical vertebrae. As these muscles ascend up the vertebral column, they divide regionally depending on where the muscle attaches superiorly. (Snell 2012)

A 3-layered fasciculated muscle, the transversospinal muscle group, lies deep to the erector spinae and originates on the mamillary processes in the lumbar spine. In the sacrum, it originates from the laminar area just medial to the posterior sacral foramina, from the tendinous origins on the erector spinae, and the medial surface of the posterior superior iliac spine (PSIS). Each fascicle is directed superomedially toward the inferior and medial margin of the lamina and adjacent spinous process. The superficial layer attaches from 3-4 levels above, the intermediate layer attaches 2 levels above, and the deep layer attaches 1 level above. The transversospinal muscle group acts both as an L-spine extensor and a rotator.(Snell 2012)

A multitude of small, segmental muscles are the deepest layer of the lumbar extensors. They can be divided into 2 groups, both innervated by the dorsal rami of spinal nerves. The levatorescostarum are not typically present in the lumbar spine. The second group contains the interspinales and intertransversarii. The interspinales consists of short fasciculi attached between the spinous processes of contiguous vertebrae. The intertransversarii consist of 2-3 slips of muscles, which pass between adjacent transverse processes. They are postural stabilizers and increase the efficiency of larger muscle group action.(Snell 2012)

2.1.5.2 Forward flexors

Flexors of the L-spine are divided into an iliothoracic (extrinsic) group and a femorospinal (intrinsic) group. The iliothoracic group is made up of the abdominal wall muscles: rectus abdominis, external abdominal oblique, internal abdominal obliquus, and the transversusabdominis. The femorospinal group is made up of the psoas major and iliacusmuscles. The psoas major originates from multiple areas: the anterior surface and lower border of transverse processes of L1-L5, from the bodies and discs of T12-L5. It inserts on to the lesser trochanter of the femur and is innervated by direct fibers of the lumbar plexus (L1-L3). Its primary action is hip and trunk flexion.(Snell 2012)

2.1.5.3 Lateral flexors

True lateral flexion is normally a combination of side bending and rotation. Normally, side bending is brought about by ipsilateral contraction of the oblique and transversus abdominal muscles and quadratuslumborum. Of these, only unilateral contraction of the quadratuslumborum can bring about pure lateral flexion and elevation of the ilium, whereas bilateral contraction produces some lumbar extension. The quadratuslumborum is attached below to the iliolumbar ligament and to the adjacent part of the iliac crest above the lower anterior surface of the 12th rib and to the apexes of the L1-4 transverse processes. (Kelley, el. 2007)

2.1.5.4 Rotators

Rotation of the lumbar spine is brought about by the unilateral contraction of muscles that follow an oblique direction of pull; the more oblique the course, the more important the rotational effect. Most of the extensors and lateral flexors follow an oblique course and produce rotation when their primary component has been neutralized by antagonist muscle groups. (Kelley, el. 2007)

The transversospinal muscle group, innervated by the dorsal rami of spinal nerves, is deep to the erector spinae muscle and runs obliquely (superomedially) from the transverse processes to the spinous processes. As a group, they act to extend the vertebral column. But, when contracted unilaterally, they cause the trunk to rotate in the contralateral direction. They are divided into 3 groups: the semispinalis, multifidus, and rotatoreslumborum muscles. The rotatoreslumborum are small, irregular, and variable muscles connecting the superoposterior part of the transverse process of the vertebra below to the inferolateral border of the lamina of the vertebra above.(Kelley, el. 2007)

2.1.6 Lumbar spine vasculature

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.

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.(Kelley, el. 2007)

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.(Kelley, el. 2007)

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.(Kelley, el. 2007)

2.1.7 Vertebral canal

The tubular vertebral canal contains the spinal cord, its meninges, 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, meninges, and osseoligamentous 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 (with the PLL draped over it), whereas the laminae and ligamentumflavum border the canal posteriorly. Laterally, spinal nerves and vessels travel through the intervertebral foramen. (Snell 2012)

2.1.8 Meninges and related spaces

The meninges consist of 3 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, are frail. The spinal cord, roots, and nerve rootlets are closely invested by the pia. The dura and arachnoid together form a loose sheath (termed dural/thecal sac) around these structures, separated from the canal walls by the epidural space.(Kelley, el. 2007)

2.1.8.1 Spinal dura mater

The dura is composed of tough, longitudinal, collagen fiber bundles interwoven with circular elastic fibers. The external surface is rough and blends with loose connective tissue in the epidural space. The internal surface, facing into the subdural space, is smooth and covered by a layer of mesothelium. Inferiorly, the dural sac ends at the sacral canal, usually at S2-S3 (sometimes S1).(Kelley, el. 2007)

The dura continues caudally as a fibrous thread named the filumterminaleexternum or coccygeal ligament, which blends with the PLL over the coccyx. The dural sac sends sleevelike projections into the intervertebral foramen, where the dura blends with the epineurium of the spinal nerves. Connective tissue slips in the foramen anchor the dural sleeves so that they can protect the spinal nerve roots from being stretched during L-spine movements. In addition to these tetherings, the dura is attached in places to the PLL. (Kelley, el. 2007

2.1.8.2 Epidural space

The epidural (peridural/extradural) space terminates inferiorly at the sacral hiatus, where it is sealed by the posterior sacrococcygeal ligaments. The nerve roots transverse the space as they extend into the intervertebral foramen. The entire space is occupied by loose connective tissue with variable fat content, providing padding around the dural sac and spinal cord and acting as a form to hold the thin internal vertebral plexus of veins open. The vertebral venous plexus is embedded in the epidural loose connective tissue, sometimes transmitting large amounts of blood.(Kelley, el. 2007)

2.1.8.3 Leptomeninges

The pia and arachnoid are delicate membranes composed of loose connective tissue and separated from one another by the subarachnoid space. A layer of mesothelium covers all leptomeningeal surfaces bathed by cerebrospinal fluid (CSF). The arachnoid mater lines the entire dural sac and extends into the dural sleeves. It also sends trabeculae across the subarachnoid space to the pia, facilitating CSF mixing. Along the posterior midline, the trabeculae form a well-defined subarachnoid septum. Inferiorly, it lines the dural sac within the sacral canal and ends on termination of the sac at the S2 vertebral level. The pia mater provides support for the vasculature and nerves in the subarachnoid space. It adheres intimately to the spinal cord. The pia forms a separate sheath for each nerve rootlet and root as far laterally as the foramen, blending with the epineurium. Caudally, the pia continues as the thin filum terminale internum. After reaching the lower end of the dural sac, the filum becomes enclosed within the filum terminale externum and continues to the coccyx. (Snell 2012)

2.1.8.4 Subarachnoid space

The spinal subarachnoid space is spacious in the lumbar spine, and below the level of L2 it is termed the lumbar cistern. Its CSF content (20-35 mL) is only a fraction of the total CSF volume (120-150 mL). The lower third of the arachnoid sac contains only the filumterminaleinternum and the caudaequina, which contains lumbar, sacral, and coccygeal nerve roots that hang like a horse’s tail form the lower part of the spinal cord (conusmedullaris) as they leave the vertebral canal below the lower third of the arachnoid sac.(Snell 2012)

2.1.9 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 conusmedullaris within the lumbar spinal canal at the lower margin of the L2 vertebra, although variability of the most caudal extension exists.Fig(2.7). (Kelley, el. 2007)

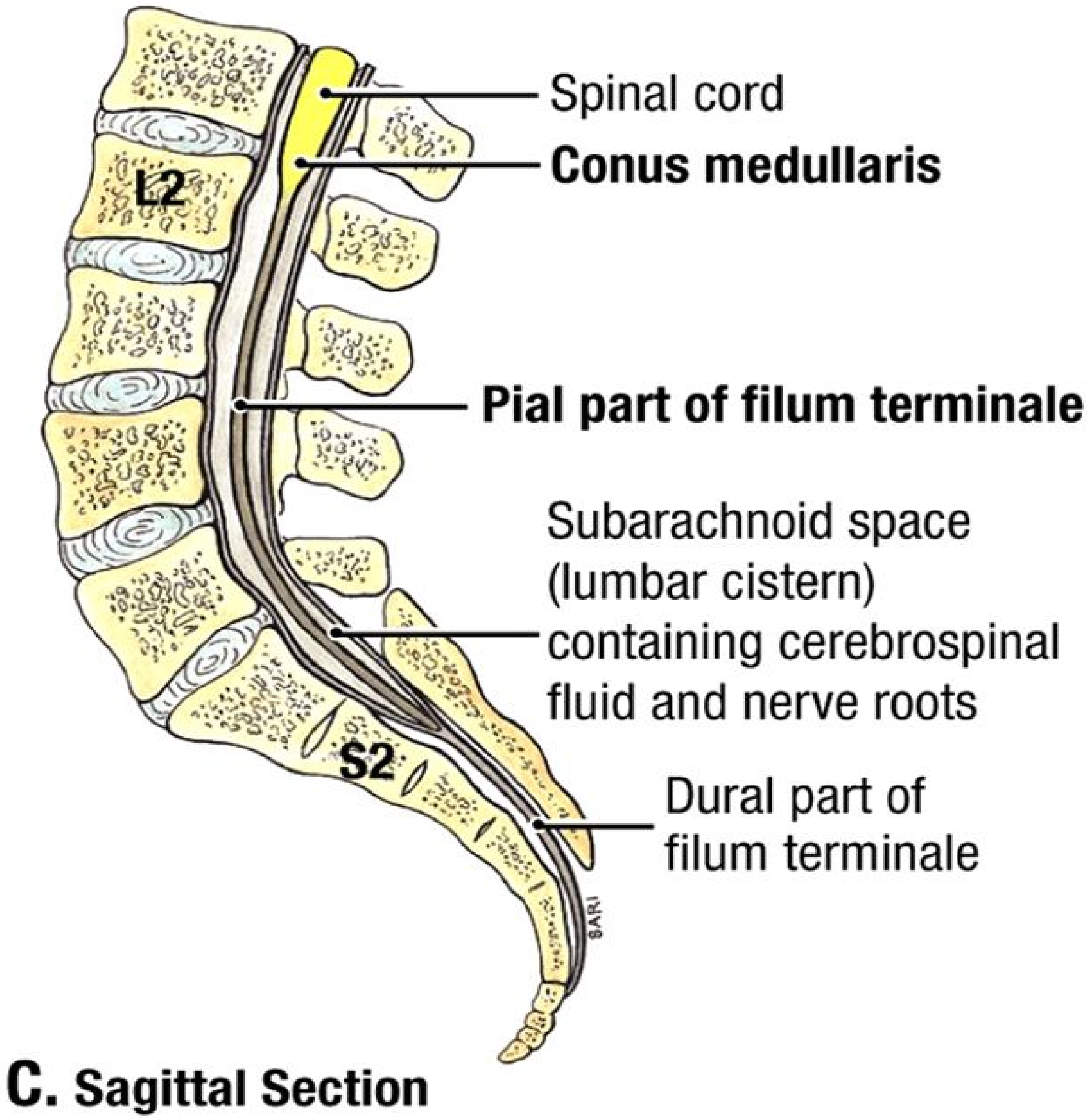


Fig (2.7) shows the relevant anatomy of the caudaequina region.

2.1.10 Spinal nerves and roots

All lumbar spinal nerve roots originate at the T10 to L1 vertebral level, where the spinal cord ends as the conusmedullaris. A dorsal or posterior (somatic sensory) root from the posterolateral aspect of the spinal cord and a ventral or anterior (somatic motor) root from the anterolateral aspect of the cord join in the spinal canal to form the spinal nerve root. The roots then course down through the spinal canal, forming the caudaequina, until they exit at their respective neural (intervertebral) foramina as a single pair of spinal nerves. Thus, the lumbar nerve roots exit the spinal canal at a lower level than where they arise.(Stanfield, el .2009)

2.2physiology of the lumbar spine:

The autonomic nervous system is divided into the sympathetic nervous system and parasympathetic nervous system. The sympathetic division emerges from the spinal cord in the thoracic and lumbar areas, terminating around L2-3. The parasympathetic division has craniosacral “outflow”,meaning that the neurons begin at the cranial nerves (specifically the oculomotornerve, facial nerve, glossopharyngeal nerve and vagus nerve) and sacral (S2-S4) spinal cord.The autonomic nervous system is unique in that it requires a sequential two-neuron efferent pathway; the preganglionic neuron must first synapse onto a postganglionic neuron before innervating the target organ. The preganglionic, or first, neuron will begin at the “outflow” and will synapse at the postganglionic, or second, neuron’s cell body. The postganglionic neuron will then synapse at the target organ.(Stanfield, el .2009)

2.3pathology of the lumbar spine

2.3.1Malignant Spinal tumors

2.3.1.1 Osteosarcoma

Osteosarcoma occurs most often in children, adolescents, and young adults. Males are more likely to be affected than females. Treatment usually consists of removal of the tumor when possible as well as chemotherapy. Radiation therapy is not effective. Older persons with Paget's disease or who have had radiation therapy may develop this type of tumor.(Park JO, et al 2007)

2.3.1.2 Chondrosarcoma

Chondrosarcoma usually occurs in adults. They usually are noticed because they cause pain and swelling. Surgery is performed to remove the tumor and any tumors that have spread, usually to the lung. In most cases, chemotherapy is not effective. (Park JO, et al 2007)

2.3.1.3 Astrocytomas

Astrocytomas are tumors that involve nerve cells within the spinal cord. They most commonly occur in children and adolescents. Neurological symptoms such as weakness and/or sensory changes may be the cause for seeking treatment. They tend to spread throughout the spinal cord and brain. Astrocytomas in the spine can usually be removed surgically. However, they are difficult to completely remove. Radiation therapy may be necessary following surgery to slow the spread of the tumor. (Park JO, et al 2007)

2.3.1.4 Multiple Myeloma

Myeloma is the most common primary malignant tumor of bone. It typically affects adults greater than 40 years of age. It tends to be generalized, involving multiple bones, but back pain and involvement of the spine is the most common presenting complaint. Treatment is palliative; meaning that disease can be controlled, but not completely cured. Chemotherapy is used to control the pain and slow the progression of the disease. Surgery may be required if pathological fractures develop or there is compression of the spinal cord. Cancer in the bone marrow is called multiple myeloma. Bone tissue is destroyed by excessive growth of plasma cells in the bone marrow. When X-rayed it appears that holes have been taken out of the bone. These are called osteolytic lesions. Plasma cells are part of the immune system and in multiple myeloma they grow uncontrolled forming tumors in the bone marrow. The spine is the most common site of involvement with multiple myeloma. Extradural compressive lesions are a well known complication of this disease. (Park JO, et al 2007)

2.3.2 Benign Spinal tumors

2.3.2.1 Osteoma

Osteoid osteoma is the most common of the benign tumors involving the bone of the spine. It is usually found during adolescence. It may be discovered because of scoliosis or curvature of the spine. It may cause pain that does not ease up, and is worse at night. Anti-inflammatory medications are used for treatment. Sometimes removal of the tumor by surgery is necessary. A newer, less invasive treatment is called radio-frequency ablation. These tumors rarely recur. (Price RI, et al.2000)

2.3.2.2 Osteoblastomas

Osteoblastomas are larger versions of osteoid osteomas. They tend to be found in people under the age of 30. They may cause scoliosis or curvature of the spine. Osteoblastomas tend to be more aggressive and require surgery to remove the tumor. There is a 10% chance that the tumor may recur.(Price RI, et al.2000)

2.3.2.3 Enchondromas&Osteochondroma

Enchondromas are tumors involving cartilage. They may grow into the spinal canal or press on the spinal nerve roots. When they cause paralysis, bowel or bladder incontinence, or other neurological symptoms they are surgically removed. They rarely can become chondrosarcomas, which are malignant tumors that can spread to other parts of the body. (Price RI, et al.2000)

Osteochondroma is a slow growing tumor of the cartilage usually affecting adolescents. It is uncommon and is usually found in the posterior (rear) spine. (Price RI, et al.2000)

2.3.2.4 Eosinophilic Granuloma

Eosinophilic Granuloma is usually seen in the vertebral bodies of children and adolescents. When this tumor is systemic it is termed Histiocytosis X. Rarely do these tumors lead to vertebral collapse and paraparesis. On occasion, they may heal spontaneously.(Kim S, et al.2006)

2.3.2.5 Hemangioma

Hemangiomas are tumors involving blood vessels that affect the vertebral body of a spinal segment. They are most commonly found in the thoracic or lumbar portion of the spine. They occur more frequently during mid-life. They are found more often in women than men. They can be a source of pain but often do not cause pain. They may be large enough to cause collapse of the vertebral body which could affect the spinal cord or nerve roots. (Park JO, et al 2007)

2.3.3 Spinal Inflammatory Disorders

Inflammatory disorders of the spine can be caused by a wide range of conditions, including arthritis, osteoporosis, Ankylosing spondylitis,Arachnoiditis,Discitisand infection. Inflammation in the spine is rare but can be a significant source of pain and disability, especially if these hard-to-diagnose conditions go untreated. (Park JO, et al 2007)

2.3.4 Congenital spinal anomalies:

2.3.4.1 Asomia (A genesis)

Complete absence of the body of a vertebra may occur despite the presence of the posterior elements (Figure 2). This anomaly results from failure of ossification centers of the body to appear. One or more vertebral segments may be involved.(Kim S, et al.2006)

2.3.4.2 Scoliosis

often present at birth. Dorsal and ventral hemi-vertebrae occur because of failure of the ventral or dorsal half of the vertebral body to ossify. The failure of ossification is believed to be secondary to ischemia during the developmental stage. A kyphotic deformity is seen at the site of a dorsal hemivertebra. A ventral hemivertebra is extremely rare and results from failure of ossification of the dorsal half of the vertebral body. Hemivertebra secondary to hemimetametric segmental displacement or persistence of the night and left halves of the vertebral body leads to the hemivente bnae being separated from each other in the sagittal plane. One such hemivertebra may fuse with the body of a vertebral segment above or below the affected segment.(KimS,et al.2006)

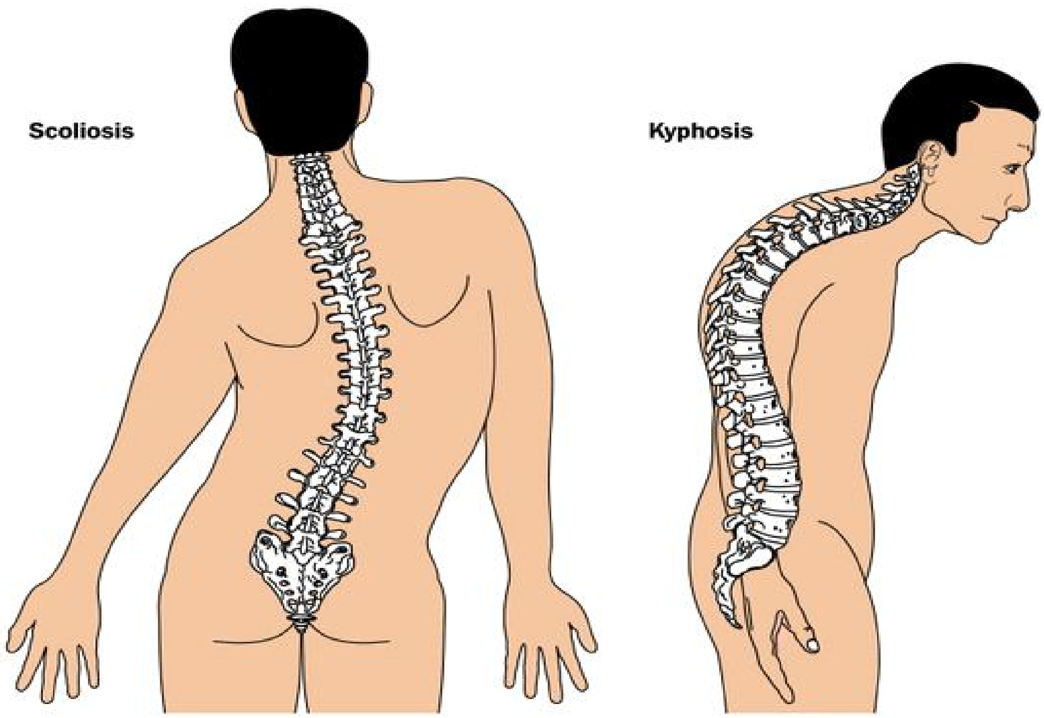


Fig (2.8) shows scoliosis and kyphosis

2.5 methods of lumber spine imaging

2.5.1 conventional x-ray

X-rays are a form of radiation, like light or radio waves, that are focused into a beam, much like a flashlight beam. X-rays can pass through most objects, including the human body. X-rays make a picture by striking a detector that either exposes a film or sends the picture to a computer. Dense tissues in the body, such as bones, block (absorb) many of the X-rays and look white on an X-ray picture. Less dense tissues, such as muscles and organs, block fewer of the X-rays and look like shades of gray on an X-ray. X-rays that pass only through air, such as through the lungs, look black on the picture. Spinal X-rays are pictures of the spine. They may be taken to find injuries or diseases that affect the discs or joints in your spine. These problems may include spinal fractures, infections, dislocations, tumors, bone spurs, or disc disease. Spinal X-rays are also done to check the curve of your spine (scoliosis) or for spinal defects.(Hsieh. 2009)

2.5.2 Computed tomography CT

Computed tomography (CT) of the spine is a diagnostic imaging test used to help diagnose—or rule out—spinal column damage in injured patients. CT scanning is fast, painless, noninvasive and accurate. In emergency cases, it can reveal internal injuries and bleeding quickly enough to help save lives. A CT scan of the spine may be performed to assess the spine for a herniated disk, tumors and other lesions, the extent of injuries, structural anomalies such as spina bifida (a type of congenital defect of the spine), blood vessel malformations, or other conditions, particularly when another type of examination, such as X-rays or physical examination, is not conclusive. CT of the spine may also be used to evaluate the effects of treatment of the spine, such as surgery or other therapy.(Hsieh. 2009)

2.5.3 MRI

An MRI uses magnets and radio waves to capture images inside the body without making a surgical incision Magnetic resonance imaging (MRI) 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.MRI differs from a CAT scan because it does not use radiation. An MRI examination of the spine shows the anatomy of the vertebrae that make up the spine, ligaments that hold the vertebrae together, as well as the disks, spinal cord and the spaces between the vertebrae through which nerves pass.Currently, MRI is the most sensitive imaging test of the spine in routine clinical practice.

2.5.4 NM

Nuclear medicine examinations hold an important position in the diagnosis of diseases of the spine. During the last decade, decisive progress has been made in the field of instrumentation and radiopharmaceutical techniques: the use of high resolution collimators and the introduction of emission computer tomography as examples of improved instrumentation as well as 99m-Technetium red blood cell labelling as a new radiopharmaceutical technique. These present some of the developments responsible for the growing importance of scintigraphical diagnosis.(Loise E 2011)

2.6 lumber spine MRI protocol

T2 tse sagittal

Plan the sagittal slices on the coronal plane; angle the position block parallel to spinal cord. Check the positioning block in the other two planes. An appropriate angle must be given in the axial plane on a tilted patient(Parallel to the line along the center of the vertebral body and the spinous process). Check the position block in the sagittal plan; FOV must be big enough to cover the whole lumbar and sacral spine from T11 down to coccyx(normally 350mm).Slices must be sufficient to cover the spine from the lateral border of RT transverse process up to the lateral border of LT transverse process. A saturation band must be placed over the abdomen (in front of the aorta) in the sagittal plane. This is to avoid the peristalsis and breathing artefacts over the spinal area. Phase direction should be head to feet to avoid further motion artefacts form abdomen.

T1 tse sagittal

Plan the sagittal slices on the coronal plane; angle the position block parallel to spinal cord. Check the positioning block in the other two planes. An appropriate angle must be given in the axial plane on a tilted patient(Parallel to the line along the center of the vertebral body and the spinous process). Check the position block in the sagittal plan; FOV must be big enough to cover the whole lumbar and sacral spine from T11 down to coccyx(normally 350mm).Slices must be sufficient to cover the spine from the lateral border of RT transverse process up to the lateral border of LT transverse process. A saturation band must be placed over the abdomen (in front of the aorta) in the sagittal plane. This is to avoid the peristalsis and breathing artefacts over the spinal area. Phase direction should be head to feet to avoid further motion artefacts form abdomen.

T2 TSE STIR sagittal

Plan the sagittal slices on the coronal plane; angle the position block parallel to spinal cord. Check the positioning block in the other two planes. An appropriate angle must be given in the axial plane on a tilted patient(Parallel to the line along the center of the vertebral body and the spinous process). Check the position block in the sagittal plan; FOV must be big enough to cover the whole lumbar and sacral spine from T11 down to coccyx(normally 350mm).Slices must be sufficient to cover the spine from the lateral border of RT transverse process up to the lateral border of LT transverse process. A saturation band must be placed over the abdomen (in front of the aorta) in the sagittal plane. This is to avoid the peristalsis and berathing artefacts over the spinal area. Phase direction should be head to feet to avoid further motion artefacts form abdomen.

T2 TSE Axial multi block and multi angle

Plan the axial slices on the sagittal plane; angle the first position block parallel to L5- S1 intervertebral disc, second position block parallel to L4- L5 intervertebral disc, third position block parallel to L3- L4 intervertebral disc and fourth position block parallel to L2- L3 intervertebral disc(only four blocks are needed in a normal spine). Additional blocks must be taken if there is a disc prolapsed in any other levels. An appropriate angle must be given in the coronal plane on a tilted or scoliotic spine (Parallel to the intervertebral disc space). Slices must be sufficient to cover the intervertebral discs(normally 5 slices for each disc space). A saturation band must be placed over the abdomen (in front of the aorta) in the sagittal plane. This is to avoid the peristalsis and breathing artefacts over the spinal area.

T1 TSE Axial multi block and multi angle

Plan the axial slices on the sagittal plane; angle the first position block parallel to L5- S1 intervertebral disc, second position block parallel to L4- L5 intervertebral disc, third position block parallel to L3- L4 intervertebral disc and fourth position block parallel to L2- L3 intervertebral disc(only four blocks are needed in a normal spine). Additional blocks must be taken In the presence of prolapsed disc in any other levels. An appropriate angle must be given in the coronal plane on a tilted or scoliotic spine (Parallel to the intervertebral disc space). Slices must be sufficient to cover the intervertebral discs(normally 5 slices for each disc space). A saturation band must be placed over the abdomen (in front of the aorta) in the sagittal plane. This is to avoid the peristalsis and breathing artefacts over the spinal area.

- **Previous Studies**

Chang Hwa Hong, 55Jong Seok Park,55Ki Jin Jung, and 55Woo Jong Kim. Measurement of the Normal Lumbar Intervertebral Disc Space of Koreans. Using Magnetic Resonance Imaging. At 2010. They found In the total 178 patients, the average distance of intervertebral space from the 1st to the 2nd lumbar vertebrae was 15.83mm (range, 18 to 32%), that from the 2nd to the 3rd was 12.92mm (range, 19 to 40%), that from the 3rd to 4th was 12.88mm (range, 19 to 41%), that from the 4th to 5th was 11.60mm (range, 21 to 43%) and that from the 5th lumbar vertebra to the 1st sacrum was 10.52mm (range, 19 to 38%).

Hong CH, Park JS, Jung KN, Kim WJ.Measurement of the normal lumbar intervertebral disc space using magnetic resonance imaging. At 2015. They found in 300 patients the mean of intervertebral disc length L1-L2 was 12.2±0.3mm, L2/L3 was 11.7±0.6mm, L3/L4 was 11.1±0.5mm, and L4/L5 was 10.0±0.7mm L5/S1 was 10.7±1.2mm respectively.

Chapter three

Materials and methods

Chapter three

Materials and Methods

- **Materials**

3.1.1 Type of study

This study was a descriptive analytical study

- **Area and Duration of study**

This study was conduct Khartoum state, will include hospitals Alzaytouna Specialized Hospital, Royal Scan Hospital. In period from August 2016 to January 2017.

- **Populations of study**

Populations of this study were normal patient that undergo lumbar spine MRI examinations.

3.1.4 Sample size

A 50 patients were attend to perform lumbar spine MRI examinations.

3.1.5 Inclusion criteria

All normal patients more than 18 years were perform lumbar spine MRI examinations.

- **Exclusion criteria**

All patients below 20 years, and more than 20 years that had abnormalities on lumbar spine.

- **Variable under study**

Age, gender, measurements

3.2 Methods

3.2.1 Machine and Protocols

A 1.5 Tesla Toshiba scanner was used for the MRI. In the sagittal planes, the T1 intensity images were constructed with a TE/TR of 10/500 ms, and the T2 intensity images were constructed with a TE/TR of 100/2800 ms, the slice thickness was 4 mm, and measurements were performed on the T1 intensity images.

3.2.2 Measurements Techniques

The measurements were performed by MRI technologist using the picture archiving communication system (PACS), The horizontal and the vertical lengths of the intervetebral disc were measured on the mid-saggital section of the vertebral body, as seen on MRI. The vertical lengths of intervertebral disc space of L5/S1 were measured from the margin of the lower fifth lumbar vertebra to the central portion of the upper margin of first sacral vertebra. The horizontal lengths was measured from central of the anterior intervertebral space in the area connected the tip of the anterior margin of the vertebra body to the central of posterior intervertebral space in the area connected the tip of the posterior margin of the vertebral body.

3.2.3 Data Collection

Data were collect randomly according to age by data collection sheets.

- **Data Analysis**

Statistics Package for Social Sciences SPSS, Microsoft word and Excel were use.

3.3 Ethical Consideration Patients consents were taken , radiology head department was adversed .

Chapter four

Results

Chapter four

Results

This study was performed to calculate L5/S1 intervertebral disc space of normal L/SS in 50 patients (26 males and24 females) at age (20 – 50) years selected randomly when they attend to MRI department for L/SS examination.

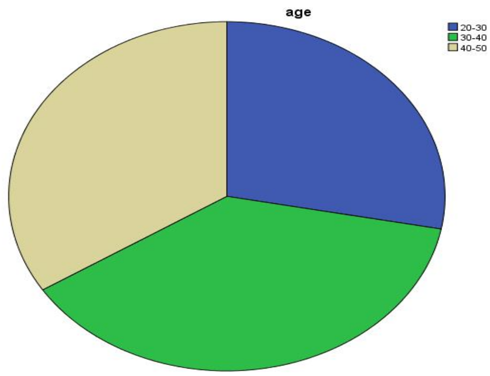


Fig (4.1) shows age groups distributions

Table (4.1) Represents age groups distributions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-30	14	28.0	28.0	28.0
	30-40	19	38.0	38.0	66.0
	40-50	17	34.0	34.0	100.0
	Total	50	100.0	100.0	

Table (4.2) Represents descriptive statistics of height compared with age

age	Mean of height	N	Std. Deviation	Minimum	Maximum	Std. Error of Mean
20-30	10.9071	14	.95954	9.60	12.20	.25645
30-40	10.3316	19	.81721	9.00	12.00	.18748
40-50	10.3294	17	1.04509	8.90	12.60	.25347

Total	10.4920	50	.95636	8.90	12.60	.13525

Table (4.3) Represents descriptive statistics of widthcompared with age						
age	Mean of width	N	Std. Deviation	Minimum	Maximum	Std. Error of Mean
20-30	32.2000	14	1.79229	28.80	34.90	.47901
30-40	30.8158	19	1.82613	26.70	33.50	.41894
40-50	31.6059	17	2.14665	26.40	34.50	.52064
Total	31.4720	50	1.97650	26.40	34.90	.27952

Table (4.4) Represents descriptive statistics of widthcompared with length						
length	Mean of width	N	Std. Deviation	Minimum	Maximum	Std. Error of Mean
150-160	31.2500	12	2.32007	26.70	34.90	.66975
160-170	31.3154	13	2.08160	27.60	34.90	.57733
170-180	32.1000	17	1.63554	29.10	34.50	.39668

180-190	30.7250	8	1.90244	26.40	32.20	.67261
Total	31.4720	50	1.97650	26.40	34.90	.27952

Table (4.5) Represents descriptive statistics of heightcompared with length

length	Meanof height	N	Std. Deviation	Minimum	Maximum	Std. Error of Mean
150-160	10.7833	12	.85369	9.60	12.20	.24644
160-170	10.4462	13	1.04372	8.90	12.60	.28948
170-180	10.2647	17	1.00744	9.00	12.10	.24434
180-190	10.1125	8	.88227	9.20	12.30	.31193
Total	10.4920	50	.95636	8.90	12.60	.13525

Table (4.6) Represents descriptive statistics of widthcompared with weight

weight	Meanof width	N	Std. Deviation	Minimum	Maximum	Std. Error of Mean
50-60	30.9000	10	2.05751	26.70	33.20	.65064
60-70	31.7900	10	2.13357	28.90	34.90	.67469
70-80	31.5143	21	1.61811	27.60	34.50	.35310

80-90	31.6556	9	2.63064	26.40	34.90	.87688
Total	31.4720	50	1.97650	26.40	34.90	.27952

Table (4.7) Represents descriptive statistics of heightcompared with weight

weight	Mean of height	N	Std. Deviation	Minimum	Maximum	Std. Error of Mean
50-60	10.6100	10	.86210	9.30	12.20	.27262
60-70	10.2900	10	.87363	9.20	12.00	.27626
70-80	10.2095	21	.93483	8.90	12.10	.20400
80-90	9.2444	9	.79876	9.10	11.60	.29959
Total	10.4920	50	.95636	8.90	12.60	.13525

Table (4.8) Represents Correlations between age And disc width

		age	Width
Age	Pearson Correlation	1	-.103-
	Sig. (2-tailed)		.476
	N	50	50
width	Pearson Correlation	-.103-	1
	Sig. (2-tailed)	.476	
	N	50	50

Table (4.9) Represents Correlations between age And disc height

		age	height
Age	Pearson Correlation	1	-.231-
	Sig. (2-tailed)		.107
	N	50	50
height	Pearson Correlation	-.231-	1
	Sig. (2-tailed)	.107	
	N	50	50

Table (4.10) Represents Correlations between length And disc height

		length	height
length	Pearson Correlation	1	-.112-
	Sig. (2-tailed)		.437
	N	50	50
height	Pearson Correlation	-.112-	1
	Sig. (2-tailed)	.437	
	N	50	50

Table (4.11) Represents Correlations between weight And disc width

		weight	height
weight	Pearson Correlation	1	.136
	Sig. (2-tailed)		.348
	N	50	50
height	Pearson Correlation	.136	1
	Sig. (2-tailed)	.348	
	N	50	50

Table (4.12) Represents Correlations between weight And disc width

		weight	width
weight	Pearson Correlation	1	.101
	Sig. (2-tailed)		.485
	N	50	50
Width	Pearson Correlation	.101	1
	Sig. (2-tailed)	.485	
	N	50	50

Table (4.13) Represents Correlations between length And disc width

		length	width
length	Pearson Correlation	1	.014
	Sig. (2-tailed)		.924
	N	50	50
width	Pearson Correlation	.014	1
	Sig. (2-tailed)	.924	
	N	50	50

Chapter five

Discussions, Conclusions and Recommendations

Chapter five

Discussions, Conclusions and Recommendations

5.1 Discussions:

The analysis in table (4.2)(4.3)represents the mean of L5/S1 intervertebral disc height and width for different study age groups, the mean of L5/S1 intervertebral disc height and width of group20-30 larger than other age groups this result due to increase procollagen type I type II in younger which associate with fibroblast of disc that decrease with age and presence type XI on elder. This result agree with literature and Hong, et al. 2015

Table (4.4)(4.5)the mean of L5/S1 intervertebral disc height and width for different length of study groups, the mean of L5/S1 intervertebral disc height(10.1125±0.88227)mm and width(30.7250±1.90244) mm of group 180-190 are smallest as compared with study length, this result similar to Chang et.al at 2010.

Table (4.6) (4.7) represents the mean of L4/S1 intervertebral disc height and width for different weight of study groups, the mean of L5/S1 intervertebral disc height (9.2444±0. 79876)mm and width(31.6556±2.63064) mm of group 80-90 are smallest as compared with study weight, on this result the mean intervertebral disc height(9.2444±0. 79876)mm are narrow as compared with Chang et.al. at 2010 and width(31.6556±2.63064) mm are near to results of Hong, et al. 2015 and Chang et.al at 2010

The correlations between age and L5/S1 intervertebral disc height and width as present in tables (4.8)(4.9) explored by Pearson or simple correlation to which indicate that inverse strong relationship between age and height and width of intervertebral disc.

The correlations between weight and L5/S1 intervertebral disc height and width as present in tables (4.10)(4.11) explored by Pearson or simple correlation to which indicate that direct strong relationship between weight and height and width of intervertebral disc.

The correlations between length and L5/S1 intervertebral disc height and width as present in tables (4.12)(4.13) explored by Pearson or simple correlation to which indicate that direct week relationship between weight and height and width of intervertebral disc.

5.2Conclusions

The study concluded that normal L5/S1 intervertebral disc space of Sudanese similar to other populations that compared with them (10.49mm). The normal L5/S1 intervertebral disc space influenced by age, patient's heights and weights. Inverse strong correlation between patient's age and height and width of intervertebral disc, direct strong correlation between patient's weight and height and width of intervertebral disc, and direct week correlation between patient's length and height and width of intervertebral disc.

The normal L5/S1 intervertebral disc spaces of youngest, longest and thinnest patients were wider than other study groups.

5.3 Recommendations

The study recommended that further studies of normal lumbar spine intervertebral disc spaces with large numbers of Sudanese to establish standard references.

The author recommended that further studies of normal lumbar spine intervertebral disc spaces with different methods and specific equations that have high accuracy measurement.

Finally more studies for measurement of normal intervertebral disc spaces of cervical spine.

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Appendix A

NO	Sex	Age	Pt length	Pt weight	Disc transverse length	Disc longitudinal length
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Appendix B

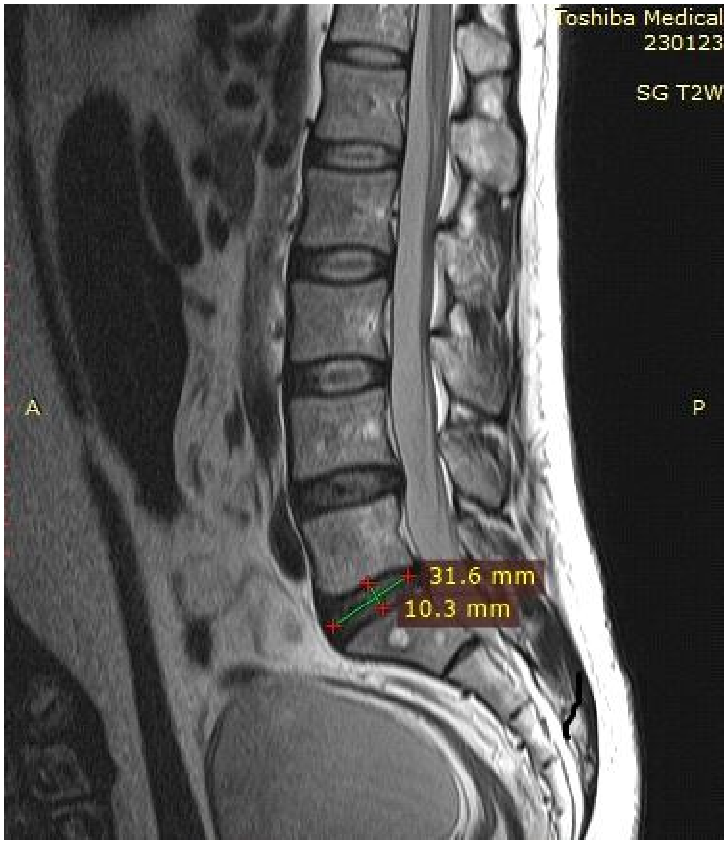

Figure shows normal Med- saggital T2 weighted image of 34 years male represents transverse and longitudinal length of L5/S1 intervertebral disc space.