MRI OF LUMBOSACRAL SPINE FOR LOW BACK PAIN ---- CORRELATION WITH CLINICAL PRESENTATION AND PLAIN RADIOGRAPH

by

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To

my husband, Dr Yeu Boon Kian

and my parents

with love

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Tesis muka surat 3 tidak

disertakan oleh penulis

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ABBREVIATIONS

AP	Anteroposterior
CT	Computed tomography
DEBIT	Disc extension beyond the interspace
FSE	Fast spin echo
HIZ	High intensity zone
MR	Magnetic resonance
MRI	Magnetic resonance imaging
PD	Proton density
SPECT	Single photon emission computed tomography
T1WI	T1-weighted image
T2WI	T2-weighted image

ABSTRAK

Bahasa Malaysia

Topik. Imbasan resonans magnetik bahagian spina lumbosakral untuk sakit belakang

---- kaitan dengan persembahan klinikal dan radiograf biasa.

Gubahan kajian. Ini merupakan satu kajian retrospektif and prospektif ke atas pesakit-pesakit yang mengalami masalah sakit belakang, yang dirujuk untuk pemeriksaan spina lumbar dengan imbasan resonans magnetik.

Objektif. Untuk menentukan kaitan antara persembahan klinikal, tanda-tanda radiograf biasa dengan tanda-tanda imbasan resonans magnetik untuk pesakit yang mengalami masalah sakit belakang.

Ringkasan data latarbelakang. Imbasan resonans magnetik telah menjadi pilihan utama untuk siasatan sebab-sebab sakit belakang. Walau bagaimanapun, sehingga kini, tidak banyak kajian yang mendalami kaitan antara persembahan klinikal, tanda-tanda radiograf biasa dengan tanda-tanda imbasan resonans magnetik untuk sakit belakang.

Tatacara dan bahan-bahan. Lima puluh tujuh pesakit yang mengalami sakit belakang yang dirujuk untuk imbasan resonans magnetik bahagian spina lumbosakral dengan tujuan mengkaji herniasi diska antara vertebra dan stenosis spina telah dirangkumi dalam kajian ini. Data klinikal, keluhan dan tanda-tanda pemeriksaan mereka diperolehi daripada fail rekod. Radiograf spina lumbosakral piawai, pandangan depan-belakang dan tepi, dengan atau tanpa pandangan oblik telah diperolehi. Imbasan resonans magnetik untuk lumbosakral dijalankan mengikut protokol jabatan. Imej dibaca oleh seorang pakar radiologi yang mempunyai pengkhususan dalam bidang muskuloskeletal. Radiograf biasa dan imej imbasan resonans magnetik untuk setiap pesakit dibaca pada masa yang berlainan oleh pakar radiologi tanpa pengetahuan data persembahan klinikal pesakit. Semua data yang telah dikumpulkan dianalisa dengan menggunakan program "SPSS for Windows version 9.0". Analisa diskriptif dibuat menurut data demografik, persembahan klinikal, kekerapan tanda-tanda radiograf biasa dan imbasan resonans magnetik. Statistik "Kappa" digunakan untuk mengkaji persetujuan antara tanda-tanda dalam radiograf biasa dan imbasan resonans magnetik. Kaitan antara parameter klinikal, tanda-tanda radiograf biasa dengan hasil pemeriksaan imbasan resonans magnetik telah dikaji.

Keputusan. Kebanyakan pesakit dalam kajian ini adalah daripada golongan produktiviti tinggi dengan purata umur 44.78 tahun. Lima puluh enam peratus pesakit mengalami sakit belakang kronik melebihi 3 bulan. Kajian ini menunjukkan bahawa defisit sensori boleh digunakan untuk jangkaan aras stenosis spina. Kedua-dua defisit sensori dan motor tidak dapat menjangka mampatan akar saraf dengan tepat. Kaitan yang bagus telah diperolehi antara umur dan aras degenerasi diska antara vertebra. Analisa univariat menunjukkan bahawa tidak ada kaitan yang bermakna di antara persembahan klinikal dengan herniasi diska, mampatan akar saraf atau stenosis spina. Walau bagaimanapun, daripada analisa multivariat, umur, jangkamasa sakit dan kewujudan "sciatica" telah didapati menjadi jangkaan bermakna bagi stenosis spina. Tanda radiograf biasa yang paling kerap dijumpai adalah pengurangan ketinggian belakang diska antara vertebra kurang daripada 6mm. Ia mempunyai kaitan yang bermakna dengan mampatan akar saraf dan stenosis spina tetapi bukan dengan herniasi diska. Kaitan yang bermakna juga diperolehi antara osteofit, sklerosis hujung plat, fenomena vakum, artropati faset, spondilolisis dan spondilolistesis dengan herniasi diska, mampatan akar saraf dan stenosis spina. Walau bagaimanapun, disebabkan saiz sampel yang kecil, kajian seterusnya dengan pesakit yang lebih ramai diperlukan untuk mengenalpasti keputusan tersebut. Sensitiviti radiograf biasa adalah 92.7% dan nilai jangkaan positifnya adalah 96.2% tetapi nilai spesifisitinya adalah rendah.

Kesimpulan. Sakit belakang didapati terutamanya dalam golongan yang mempunyai produktiviti tinggi. Kaitan yang jelas didapati antara umur dengan degenerasi diska. Tidak ada kaitan yang bermakna di antara umur, keluhan dan tanda klinikal dengan herniasi diska, mampatan akar saraf dan stenosis spina dalam imbasan resonans magnetik. Walau bagaimanapun, umur, jangkamasa sakit dan "sciatica" boleh digunakan untuk menjangka stenosis spina. Ketinggian belakang diska antara vertebra kurang daripada 6mm mempunyai kaitan yang bermakna dengan mampatan akar saraf dan stenosis spina. Osteofit belakang, perubahan hujung plat, fenomena vakum, degenerasi sendi faset, spondilolisis dan spondilolistesis juga mempunyai kaitan yang bermakna dengan herniasi diska, mampatan akar saraf dan stenosis spina. Radiograf biasa adalah sensitif tetapi tidak spesifik dalam siasatan sakit belakang.

ABSTRACT

English

Topic. MRI of lumbosacral spine for low back pain ---- correlation with clinical presentation and plain radiograph.

Study design. This was a combined retrospective and prospective study of patients who were referred for MRI of lumbar spine for low back pain.

Objective. To determine the correlation between clinical presentation, plain radiograph signs and MRI of lumbosacral spine in patients with low back pain.

Summary of background data. MRI has become the modality of choice in the investigation of causes of low back pain. However, to date, there are not many studies which looked into the correlation between the clinical presentation as well as plain radiograph signs and the MRI findings in low back pain.

Methods and materials. Fifty-seven patients who were referred for MRI of the lumbosacral spine for low back pain to look for disc herniation or spinal stenosis were studied. Their clinical data, symptoms and signs were obtained from the medical case record. Standard anteroposterior and lateral lumbosacral radiographs with or without oblique views were done. Plain lumbosacral MRI according to the department protocol were performed. The images were interpreted by a musculoskeletal radiologist. The plain radiographs and MR images for each patient were read at different time and the radiologist was blinded to patient's data and clinical presentation. All the data collected were analysed using SPSS for Windows version 9.0 software. Descriptive analysis was performed for demographic data, clinical presentation, frequency of plain radiograph and MRI findings. Kappa statistic was used to study the agreement between findings on plain radiograph and MRI. The correlation between clinical parameters, as well as plain radiograph findings with MRI outcome was also performed.

Results. The patients in this study were in the high productivity age group with a mean age of 44.78 years. Fifty-six percent of patients presented with chronic low back pain more than 3 months duration. This study showed that the presence of sensory deficit predicts the level of spinal stenosis. Both sensory and motor deficit are not accurate predictor of nerve root compression. A good linear correlation was observed between age and level of disc degeneration. Univariate analysis showed that there was no significant correlation between clinical presentation with disc herniation, nerve root compression or spinal stenosis. However, from multivariate analysis, age, duration of pain and presence or absence of sciatica were found to be significant predictors of spinal stenosis. The commonest plain radiograph finding was reduction of posterior disc height (less than 6mm). It correlated significantly with nerve root compression and spinal stenosis but not with disc herniation. There was also significant correlation between posterior osteophytes, end plate sclerosis, end plate irregularity, vacuum phenomena, facet arthropathy, spondylolysis and spondylolisthesis with disc herniation, nerve root compression and spinal stenosis. However, due to the small sample size, larger scale study may be necessary to further confirm these observations. The sensitivity of plain radiograph was 92.7% and its positive predictive value was 96.2%, but its specificity was poor.

Conclusion. Low back pain affects mainly those of high productivity age group. A good linear correlation was observed between age and disc degeneration. There was no significant correlation between age, clinical symptoms and signs with disc herniation, nerve root compression and spinal stenosis on MRI. Nevertheless, age, duration of pain and sciatica are predictors of spinal stenosis. Posterior intervertebral disc height of less than 6mm was significantly related to nerve root compression and spinal stenosis. Posterior osteophytes, end plate changes, vacuum phenomena, degenerated facet joints, spondylolysis and spondylolisthesis also showed significant correlation with disc herniation, nerve root compression and spinal stenosis. Plain lumbosacral radiograph was sensitive but not specific for the investigation of low back pain.

CHAPTER I

INTRODUCTION

1. Introduction

Low back pain is one of the common causes for consultation in casualty, clinics and hospitals. Approximately 60% to 80% of all adults will develop low back pain sometime in their life (Gaskill et al, 1991). A vast spectrum of disease and pathology is known to cause pain. Yet, despite extensive and costly investigations, at times, the cause of low back pain would sometimes remain unknown.

Good history taking and thorough physical examination are essential in making a diagnosis of the cause of low back pain. Radiology imaging can be regarded as the most important investigation and it is essential in the diagnosis, pre-surgical evaluation and follow up of patients with low back pain.

Plain radiography, myelography, conventional and computed tomography have traditionally been used to identify morphological changes in the discovertebral unit. Recent advances in magnetic resonance imaging (MRI) have dramatically improved the ability to evaluate the spinal canal and neural structures. It also has the potential to provide unique biochemical and physiologic information. Ross and Modic (1992) found an 82.6% accuracy between MR imaging and surgical findings for the type and location of the disease.

MR imaging is non-invasive and does not require ionising radiation or injection of contrast media into the thecal sac (Jayson, 1987; Macnab & McCulloch, 1990). With only supine position imaging, MRI gives excellent images in all planes, i.e. axial, sagittal and coronal. In addition, three-dimensional sequences can be applied to produce images with increase signal to noise ratio and thus improve the accuracy of diagnosis.

MRI gives superior soft tissue detail due to its ability to manipulate soft tissue contrast by altering repetition time (TR) and time to echo (TE) (Jayson, 1987). This enables the distinction of nucleus pulposus from the annulus fibrosus and subsequently increases the pick-up rate for significant pathology in the intervertebral disc. The status of surrounding ligaments, facet joints and neural structures are well demonstrated. Abnormal encroachment of intervertebral disc on thecal sac and nerve root is well defined by MRI. As compared to computed tomography, MRI has the advantage of absence of beam hardening artefacts and artefacts from surgical clips or other metallic densities.

Compared to conventional imaging, MRI of the lumbosacral spine gives higher yield in the investigation of low back pain, particularly in terms of disc degeneration. However, due to the relatively high cost of MR imaging, a cost-effective diagnostic plan is necessary for the management of patients with low back pain. The correlation between clinical presentation, plain radiographic signs and MRI findings should also be made well known so that maximum benefit can be achieved from MR imaging of the lumbosacral spine.

CHAPTER II

LITERATURE REVIEW

2. Literature Review

2.1 What is low back pain?

Low back pain is not a diagnosis. It is a symptom complex in which pain is localised to the lumbar spine or referred to the leg or foot and where other specific conditions causing such pain have been excluded (Frank, 1993). The term radiculopathy refers to pain, weakness, or dysaesthesia in the distribution of a spinal nerve due to compression of a nerve root. In the lumbar region, radiculopathy is often referred to as sciatica (Haughton, 1988).

Acute low back pain is defined as pain of up to 7 days duration. Subacute low back pain is that of 7 days to 3 months duration, whereas chronic refers to those with symptoms of more than 3 months duration (Mooney, 1989; Frank, 1993). Other authors have also described acute pain as 0 to 6 weeks, subacute as 6 to 12 weeks and chronic low back pain as more than 12 weeks (Frymoyer, 1988; Bratton, 1999). Whichever classification one follows, it is generally agreed that any pain for more than three months is chronic.

The risk factors for low back pain have been well described (Pope, 1989). Environmental factors are found to be responsible for more than 80% of the aetiology of sciatica. However, genetic factors are relatively more significant in individuals under the age of 40 years (Heikkilä et al, 1989). Occupational influence also has an important role in accelerating lumbar degeneration (Videman & Battié, 1999).

Despite the availability of sophisticated imaging technology, the definitive diagnosis is not achievable in as many as 85% of patients who present with low back pain (Jarvic & Deyo, 2000).

2.2 Epidemiology of low back pain

Low back pain syndrome has a strong impact on individuals and on society as a whole (Heliövaara et al, 1989). It is the commonest musculoskeletal complaint seen in an ambulatory care setting (Liang et al, 1982) and one of the top ten problems encountered by family physician (Bratton, 1999).

The lifetime prevalence of low back pain ranges from 60 - 90% and the annual incidence is 5% (Frymoyer, 1988; Jensen, 1994). As for sciatica, the lifetime prevalence is 40% but only 1% of patients with acute back pain have nerve root symptoms (Frymoyer, 1988)

2.3 Anatomy of the lumbar spine

The lumbosacral spine consists of five lumbar vertebrae, the sacrum and the coccyx. It is made up of bony elements linked by joint capsules and ligaments. This complex structure is protected by multiple layers of muscles.

2.3.1 Body of lumbar vertebrae

The lumbar vertebral body is a kidney-shaped structure with its posterior surface varies from concave at the first lumbar segment to flat or slightly convex at the fifth segment. It is large and heavy with increasing size from L1 to L5. This is because of the increasing load each vertebra has to carry as it descends. Lumbar vertebral body is made of dense cancellous bone enclosed in a thin cortex. Anteriorly and laterally, multiple small foramina for arterial supply and venous drainage pierce the cortex. Posteriorly, a number of larger arterial foramina and one or more large orifices accommodate the basivertebral veins. The superior and inferior end plates are flat and rough except for a smooth peripheral ring originating from the fusion of the ring apophysis at maturity.

2.3.2 Vertebral arch

The vertebral arch is made of lamina and pedicles. It has a horseshoe shape. There are seven processes projecting from the vertebral arch: paired superior and inferior articular facets, a spinous process and paired transverse processes. The pedicles are attached to the cranial half of the vertebral body. The laminae are broad, flat structures blending in medially with the spinous process. The spinous process is flat and rectangular and projects backward. The transverse processes project laterally and posteriorly from the junction of the pedicles and lamina. Together with the spinous process, the transverse processes form the levers for the muscles and ligaments that attached to them. The articular processes project from the lamina. Superior facets face medially and posteriorly whereas the inferior facets face laterally and anteriorly.

2.3.3 Facet joints

The lumbar facet joints are synovial joints formed by the articulation of the superior and inferior articular processes (Grenier et al, 1987). Superior facet is anterolaterally located and faces posteromedially; inferior facet is posteromedially located and faces anterolaterally. Its articular surfaces are made of hyaline cartilage. Their capsules are thick and fibrous and cover the dorsal aspect of the joint. Its ventral capsule is made of an extension of the ligamentum flavum.

2.3.4 The spinal canal

The spinal canal evolves from an oval shape in the upper lumbar region to a triangular shape in the lower lumbar and upper sacral region. It is bounded by the vertebral bodies and intervertebral disc anteriorly, the pedicles superiorly and inferiorly, and the facet joint posteriorly. The content of the spinal canal includes ligaments, an organised venous plexus, the dural sac, spinal cord, cerebrospinal fluid and nerve roots (Yu S et al, 1991).

2.3.5 The radicular canal

The radicular canal contains the lumbar spinal nerve. Normal radicular canal is divided into 3 segments: retrodiscal, parapedicular and foraminal. The first 2 segments together made up the lateral recess of the medullary canal (Grenier et al, 1987). Anteriorly the radicular canal is delimited by the annulus fibrosus and at the posterolateral aspect, it is bounded by soft tissues, which are composed of ligamentum flavum and articular capsule.

2.3.6 Intervertebral disc and end plates

The intervertebral disc joins two adjacent vertebral bodies. It contributes about one third of the length of the lumbar spine. Besides providing stability and allowing force transmission, intervertebral disc also allows spinal movement. The intervertebral disc is a hydrostatic load-bearing structure. It has two main components: a central confined semifluid mass, the nucleus pulposus, and a peripheral laminar fibrous structure, the annulus fibrosis (Modic et al, 1984). The nucleus pulposus is a remnant of the embryonic notocord. It is composed of a proteoglycan matrix and type-II collagen. It is made up of approximately 88% of water in the young and 70% in the elderly. The function of nucleus pulposus is to redistribute compressive force (Morgan & Saifuddin, 1999).

The second component of the intervertebral disc is the annulus fibrosis. The annulus fibrosus has an outer and inner layer. The outer layer is tough and composed of bundles of tightly packed type-I collagen fibres laid down in a concentric fashion forming thin lamellae that are thickest anteriorly. They are attached to the adjacent hyaline cartilage, and more firmly to the ring apophysis periosteum as Sharpey fibres. The inner layer of annulus fibrosus is composed of fibrocartilage and contains a high proportion of type-II collagen. The annulus fibrosus unites the vertebral bodies and functions as the limiting capsule of the central nucleus pulposus. Its main purpose is to withstand tension (Modic et al, 1984) and to resist radial tension induced by axial loading force.

The vertebral end plates are made of hyaline cartilage resting on a flat subchondral bone plate and supported by the spongiosa of the vertebral body. On the bony end plate, there are multiple small orifices that allow direct contact between the vascular buds of the bone marrow and the cartilage plate. This serves as a main nutritional pathway for the intervertebral disc.

2.3.7 Ligaments of the lumbar spine

The anterior and posterior longitudinal ligaments are thick bands of fibres extending along the anterior and posterior surfaces of the vertebral bodies from the skull base to the sacrum. They link the vertebral bodies to the discs. The function of these ligaments is to provide strength and resistance to sagittal flexion and extension.

Another important ligament in the lumbar spine is the ligamentum flavum. This is a thick band of fibrous and elastic tissue that abuts the laminae and lines the posterior surface of the spinal canal and neural foramina. It also covers the medial surfaces of the facet joints (Yu et al, 1991). The name ligamentum flavum is derived from the light yellow colour it gets from its elastin content. In each lumbar segment the ligamentum flavum extends from anteroinferior border of the lamina above to the upper posterior border of the lamina below. Other ligaments in the lumbosacral structure include the interspinous ligament, supraspinous ligament, intertransverse ligaments, iliolumbar ligament and sacroiliac ligaments.

2.4 Basic biomechanics of lumbar spine

The vertebral bodies are the main load-bearing structures of the lumbar spine. The core of vertebral body consists primarily of cancellous bone with a honeycomb like construction. The direction of trabeculae reveals the forces acting on the vertebra. The vertically directed trabeculae support compressive load. At the superior and inferior surfaces of the vertebral body, there are oblique trabeculae to aid in the compressive load-bearing function. The trabeculae converge to the pedicles and there they resist the tensile forces. Besides bony trabeculae, the vertebral body is also filled with bone marrow and blood. This feature enables it to act as hydraulically strengthened shock absorbers.

The pedicles link the vertebral arch to the vertebral body. The sites where the lamina originates from the pedicles are called pars interarticularis or isthmus. This is a relatively weak area. It is the frequent site of fatigue fracture and the site for spondylolysis.

The facet joints are diarthrodial joints. They play an important role in resisting torsion and shear. They are also important in bearing compressive load. In normal situation, the facets, together with the discs, contribute about 80% of torsional resistance, with the facets contributing 50% of that amount. It is also found that approximately 25% of an axial compressive load transmitted through the facets.

The intervertebral disc plays an important role in withstanding stress and to redistribute compressive load. In axial compression, the intradiscal pressure will increase and this is counteracted by the annular fibre tension. Some amount of disc space narrowing also occurs. In torsion or axial rotation, the annular fibres in one direction are stretched, whereas those on the opposite site are shortened. This torsional loading may produce fissures in the annulus. However, it does not cause a frank rupture.

The ligaments are important for stability of the lumbar spine. They are the primary tensile load-bearing elements. Because of their viscoelastic nature, the deformation and type of failure of the spinal ligaments depend on the rate at which loads are applied and also the number of deformations that are applied. Repetitive loading cycles can cause fatigue and failure. The anterior and posterior longitudinal ligaments support the vertebral bodies and discs whereas the remaining ligaments support and link the posterior elements. The ligamentum flavum is particularly important. It is very elastic and strong. It has high elastin content allowing it to lengthen with spine flexion and shorten with extension.

The capsular structures around the facet joints are also functionally important and in fact they are the strongest ligamentous structures supporting the spine. The spine is not stable without muscular support. Thus, the flexor and extensor muscles also have an important part to play in the whole biomechanic of the lumbar spine.

2.5 Pathoanatomy of low back pain

2.5.1 Degeneration

Degenerative changes commence as early as after the adolescent growth spurt and emerge rapidly throughout adult life. There appears to be a positive correlation between degenerative lumbar disc disease and low back pain in adolescence (Erkintalo et al, 1995).

In degenerative process, the concentration of water and proteoglycans content of the nucleus pulposus decreases and instead its collagen content increases. This results in disc dessication. Degeneration also implies the development of an annular tear follow by loss of fibrocartilage from the nucleus pulposus. The collagen content of the annulus fibrosus is also increased. This is accompanied by reduction in its elastin content. These changes cause stiffening of the annulus. Intervertebral disc height is slightly diminished in the early stage. In the late stages, fibrocartilage in the disc is replaced with fluid and dense, disorganised fibrous tissue.

With degeneration, the vertebral body is less capable in absorbing shock. The end plates become deformed and irregular. The vertebral body marrow changes associated with degenerative disc disease are well documented by Modic and co-workers (1988) using MRI. In addition, osteophytes also start to form anterior and posteriorly. As a result of all these changes, the spinal canal and neural foramina may be narrowed. Patient may develop back pain and weakness or numbness of the lower limbs. However, in most people, pain caused by purely degenerative changes is not severe to warrant medical attention.

Plain radiographic manifestations of disc degeneration are osteophytes formation, loss of intervertebral disc height, disc calcification, vacuum phenomenon, and end plate sclerosis or irregularity (Modic et al, 1988).

The MR imaging appearance of the degenerative processes is similar regardless of symptoms. However, these processes are noted to be more common in symptomatic adolescents and develop at an earlier age (Erkintalo et al, 1995).

2.5.2 Disc disorders

With age and degeneration, tears occur in the annulus fibrosus. There are three types of annular tear (Cassar-Pullicino, 1998). Type 1, concentric tears are thought to be caused by delamination of longitudinal annular fibres whereas type 2 radial tears involve all layers of the annulus from the pulpy nucleus of intervertebral disc to the disc surface. The third type is transverse annular tear involving the insertion of Sharpey fibres into the ring apophysis. In the majority of the adult discs, transverse or concentric tears were present in the annulus. Thus it is thought that type 1 and type 3 annular tears are probably incidental findings (Weishaupt et al, 1998). However, it is found that radial annular tears are an important hallmark in disc degeneration (Yu et al, 1989).

Discogenic pain refers to chronic back pain thought to be due to leakage of the nucleus pulposus into the outer annulus or epidural canal without frank herniation (Ross et al, 1990). A disc tear may cause pain radiating to the lower limb in the absence of any direct contact between disc material and a nerve root. Such pain may result from radial annular tears with nuclear material invading the innervated outer third of the annulus (Mooney, 1989; Milette, 1997). On T2-weighted MR images, these tears often cause a detectable decrease in signal intensity. It is sometimes associated with a peripheral focus of increased signal intensity, called the high intensity zone.

Disc herniation is an important factor in the aetiology of low back pain. Patients with disc herniation can present with low back pain, sciatica or both. The American Academy of Orthopaedic Surgeons published the Glossary on Spinal Terminology. In this glossary, herniated nucleus pulposus or intervertebral disc rupture was defined as displacement of nuclear material and other disc components beyond the normal confines of the annulus. Five categories of disc displacement were described. They are intraspongy nuclear herniation (Schmorl's nodes), protrusion, incomplete herniation, extrusion and sequestration (Milette, 1997). However, currently a new concept has been used to define the type of disc herniation (Milette, 1997; Modic & Ross, 1991). In this new concept, an intervertebral disc is described as normal, bulge, protrusion and extrusion according to their shape and the observed "disc extension beyond the interspace" (DEBIT).

A disc is normal when there is absence of disc extension beyond the interspace. Disc bulge refers to circumferential, symmetric extension of disc material beyond the end plates, in a generalised and outwardly convex fashion (Brant-Zawadzki & Jensen, 1995).

Disc protrusion occurs when there is focal or asymmetric herniation of nuclear material through a defect in the annulus fibroses, producing a focal, angular extension of the disc margin, some portion of the outer annulus posterior longitudinal ligament complex fibres may remain intact. In disc protrusion, the base against the parent disc is broader than any other diameter of the protrusion.

Disc extrusion is described as a larger herniation through a defect in the annulus posterior longitudinal ligament complex and is usually no longer bounded by the annulus posterior longitudinal ligament complex. It remains attached to the parent disc with the base against the parent disc narrower than the diameter of the extruded material itself.

Sequestered disc is defined as a herniation through a full-thickness defect in the annulus posterior longitudinal ligament complex that is no longer attached to the parent disc.

Thus, the term "disc herniation" is actually a loose and non-specific term, which is used to refer to any other type of disc extension beyond the interspace besides disc bulge (Brant-Zawadzki & Jensen, 1995).

Generally, in the upper lumbar region, the main type of disc herniation is central or centrolateral herniation with no posterior longitudinal ligament rupture. In contrast in the lower lumbar region, disc herniation is characterised by centrolateral or posterolateral herniation with ruptured posterior longitudinal ligament (Ohshima et al, 1993).

2.5.3 Facet arthropathy

Facet joint degeneration is found responsible in some of the patients presented with low back pain. Facet arthropathy can be assessed in plain radiography and also other cross sectional imaging such as CT scan and MRI. It is evidenced by loss of joint space, sclerosis, osteophytes, synovial cyst or subluxation.

2.5.4 Spinal stenosis

Spinal stenosis is defined as a local, segmental, or generalised narrowing of the central spinal canal or neural foramina by bone or soft tissue elements (Herzog et al, 1995). Besides congenital bony canal stenosis, disc herniation, posterior osteophytes, facet hypertrophy and ligamentum flavum hypertrophy can all lead to spinal stenosis. It represents an abnormality of passageways for the spinal cord or the nerve roots which demands imaging that portray spaces.

2.5.5 Spondylolysis

Spondylolysis is defined as a bone defect in the pars interarticularis. The estimated prevalence of spondylolysis is about 6% in adults. It occurs more frequently in male with a male to female ratio of 3:1. It is found that pars interarticularis defects occur at L5 level in 90 - 95% of patients and it is bilateral in about 96%. 25% of patients with spondylolysis will eventually have significant low back pain or radiculopathy (Ulmer et al, 1995; Ulmer et al, 1997).

With plain radiography, pars interarticularis defect is best shown in the oblique projection. On MRI sagittal plane is the best for evaluating the entire pars interarticularis because of the minimum obliquity of pars interarticularis in this plane. Actual distraction of the dislocated bony elements at the pars interarticularis, or a step-off pattern, is a specific indicator of spondylolysis (Jinkins et al, 1992). On axial or sagittal T1 and T2WI, pars interarticularis defects may be recognised as an area of focally decreased signal intensity. When there is anterolisthesis, a fat-filled gap between the fragments of the pars interarticularis may be appreciated.

2.5.6 Spondylolisthesis

Spondylolisthesis is defined as an anterior displacement of a vertebral body in relation to the segment immediately below. Degenerative spondylolisthesis of L4 on L5 without a break in the pars interarticularis is found in 5.8% of men and 9.1% of women (Frymoyer, 1988). Many of these people are asymptomatic.

Meyerding classification of spondylolisthesis requires that the vertebral body below is divided into 4 equal quarters and the posterior aspect of the displaced vertebra is compared to this division.

Grade 1 -- when the posterior aspect of the vertebral body above lies within the first division.

Grade 2 -- corresponds to the posterior vertebral body margin positioned within the second division.

Grade 3 -- within the third division.

Grade 4 -- within the forth division.

2.5.7 Other causes of low back pain

There are various other causes of low back pain. The commoner one include infection, malignancy, either primary or metastatic, metabolic disorder and trauma. These patients usually present with insidious onset of back pain not relieved by rest. Often there are other tell-tail signs in clinical history and physical examination to suggest the underlying cause.

2.6 Imaging of the lumbar spine

2.6.1 Plain radiography

Back in early twentieth century, radiography had started to be used for evaluation of musculoskeletal problems. Plain radiograph of the lumbosacral spine remains the first step in radiological investigative process of patients with low back pain (Simmons et al, 1995). This is because of its excellent demonstration of bony structures and its ability to give an idea on the intervertebral disc space narrowing and facet joints changes. It allows the evaluation of the configuration and alignment of the spine. With plain radiography, the functional component of the lumbar spine in flexion and extension can be assessed (Kormano, 1989).

Classically five views were recommended in the investigation of low back pain (Deyo et al, 1989). They are the anteroposterior, lateral, both oblique views and a coned lateral view for the lumbosacral junction. However, studies have found that oblique views are rarely necessary as they add little important information to the anteroposterior and lateral views (Boden et al, 1990; Kormano, 1989). The monograph issued by the World

Health Organisation recommended that oblique views be obtained only in special circumstances.

Similar as other radiation, the disadvantages of radiography is that it carries a theoretical risk of carcinogenesis and teratogenesis. In an adult patient, the average absorbed radiation dose for a standard two views lumbosacral radiographs is about 2.2mSv which is near 40 times the dose of a chest radiograph (Halpin et al, 1991). Additional right and left oblique views will increase the gonadal dose by about 100%. Thus, oblique lumbosacral radiographs should only be performed if symptoms persist or if there is suspicious lesion requiring further assessment after reviewing the standard anteroposterior and lateral views (Rhea et al, 1980).

2.6.2 Magnetic resonance imaging

MRI is a safe, non-invasive means of evaluating lumbosacral spine disease. It does not involve radiation and can be performed as an outpatient basis. It provides high quality images of the spine and adjacent neural structures. The lack of risks and the multiplanar capability have made MRI a popular option in the study of the spine. In addition, the great advances in surface coil technology have enabled the use of thin slice and 3-dimensional imaging.

In the study on MRI sequences of spine, Georgy and Hesselink (1994) found that T2 weighted sequence, especially Fast Spin Echo technique is very important in differentiating the nucleus pulposus from the annulus fibrosus and the annulus fibrosus from the subarachnoid space. Thus, in the evaluation of lumbar spine, three sequences are usually obtained: (a) sagittal T1 weighted images (T1WI); (b) sagittal T2 weighted images (T2WI) and (c) axial images. T1WI is best for evaluation of the anatomy. T2WI can depict the degree of disc hydration. As cerebrospinal fluid is of high signal intensity in T2WI, this gives good contrast with the extradural tissue producing the so-called "contrast myelography" (Kormano, 1989). Axial images are helpful in defining the type of disc herniation and its relation to the nerve roots. The spinal canal and facet joints can be assessed well in the axial sequences. Although the time taken to perform all three sequences is relatively longer, study proved that the additional information obtained from a standard three-sequence examination is of greater benefit than the time saved in omitting some of the sequences particularly the T2-weighted sequence (Rankine et al, 1997).

In addition to the aforementioned sequences, contrast enhanced MRI using Gadolinium-DTPA to differentiate fibrosis and scaring from recurrent or residual disc prolapsed in those patients who have undergone laminectomy (Kormano, 1989).

With the increasing use of MRI for the evaluation of the lumbar spine, understanding of the normal appearance and signal intensity of various structures in different sequences is important. On T1WI, the signal intensity of the spinal cord is intermediate in contrast with the low intensity of cerebrospinal fluid. The cortical bone has negligible signal intensity but the fat-containing bone marrow is of high signal intensity. The ligaments have intermediate signal intensity, and the intervertebral disc has a nearly homogeneous, low to intermediate signal intensity (Yu et al, 1991). On T1WI, the nerve root sheaths and radicular veins within the neural foramen can be demonstrated well as they have lower signal intensity in contrast to the higher signal intensity of the surrounding fat.

On T2WI, cerebrospinal fluid has high signal intensity. The spinal cord has lower signal intensity than cerebrospinal fluid. The fat in the bone marrow in this sequence has lower signal intensity compared with T1WI. Fibrocartilage in the nucleus pulposus and central portion of the annulus fibrosus on T2WI has high signal intensity due to the higher water content, whereas the peripheral collagenous portion of the annulus fibrosus manifest a low signal intensity (Yu et al, 1991).

In older subjects, well-defined foci of higher signal intensity can sometimes be seen in the vertebral body. These represent fatty replacement of the bone marrow. The conus medullaris has relatively higher signal intensity and is readily separated from the less intense cauda equina on T1WI. However, on T2WI the conus medullaris and cauda equina are not separable.

An average normal adult lumbar intervertebral disc measures 8 to 15mm in height and 30 to 50mm in diameter. In axial anatomic sections, the configuration of the discs varies from the higher level to the lower level. The posterior borders of L1 to L4 discs are slightly concave or flat, whereas L5 disc has a flat or slightly convex posterior border. On T1WI the annulus fibrosus and the nucleus pulposus in normal adult discs have homogeneous moderate signal intensity. The periphery Sharpey's fibres have low signal intensity. Proton density or T2WI show the internal structures of the disc in greater detail. Sharpey's fibres have low signal intensity in both proton and T2WI whereas fibrocartilage in the nucleus pulposus and inner annulus fibrosus has high signal intensity. A dark signal zone within the central high signal of the nucleus and annulus represents the fibrous plate in the nucleus pulposus (Yu et al, 1991).

The facets and intervening joints are best visualised in the axial plane. The vacuum phenomenon and calcification appear as signal void areas on spin echo images (Modic & Ross, 1991). Radial tear appears as high intensity zone, which is an area of brightness or high signal intensity located in the posterior annulus fibrosus. It can be distinctly separated from the nucleus pulposus and appears brighter than the nucleus pulposus on T2WI (Schellhas et al, 1996). MRI is able to accurately and precisely categorised the subtypes of disc herniation. Such information is valuable in management planning.

Although safe, MRI is not without limitations. Major limitations include the section thickness, spatial resolution, examination time, and lack of signal from cortical bone. MR scanning apparatus induces claustrophobia more frequently than the CT scanner (Modic et al, 1984). In terms of accuracy, Modic et al (1986) reported 83% agreement between MR and surgical findings for both location and type of pathology. Even though it is much more superior than other conventional imaging, MRI, as shown by Ackerman et al (1997), remains as an add-on rather than a substitute for other imaging modalities in the evaluation of low back pain. Beattie and Meyers (1998) suggest that MRI must also be related to data from clinical examination for optimal use of the information obtained. This was supported by Jensen et al (1994) and Herzog et al (1995) concluded that a MRI finding in itself, is not an indication for surgical or other specific treatment.

2.6.3 Computed tomography

Before the introduction of MRI, CT scanning, either on its own or in combination with myelography was the main imaging modality in the evaluation of a number of spinal disorders. CT gives excellent cross sectional images of the lumbar spine. CT scanning can reliably detect bony lesion as well as soft tissue component such as disc bulge, herniation and calcification. It is the best imaging technique for facet joint pathology (Kormano, 1989).

With older generation of CT scanner, lumbar spine imaging was limited to axial plane. Sagittal and coronal reconstructions do not give high quality images. However, with the advent of spiral and multislice CT scanner, multiplanar and 3-dimensional reconstruction is possible. This makes the main limitation of CT being its poor soft tissue contrast compared with MRI. Other disadvantages of CT include the use of radiation and the potential beam hardening artefacts. However, compared to MRI, CT scan is a more widely available modality and it has fewer problems with claustrophobia and motion artefacts.

2.6.4 Myelography and discography

Traditionally, myelography was the imaging of choice for investigation of spinal canal pathology. It can be performed either individually or in combination with CT scan - CT myelography. Myelography can demonstrate the anatomy of the subarachnoid space and it is almost as sensitive as CT (Kormano, 1989). It was reported that the surgical correlation with myelography findings ranges from 80 to 90% (Modic et al, 1988). However, myelography has much higher risk as it involves administration of iodinated contrast media into the subarachnoid space via lumbar puncture. Besides the complications posed by lumbar puncture itself, introduction of contrast media carries the risk of arachnoiditis, particularly in those days when myodil was used. Nevertheless, myelography or CT myelography still plays a role in those patients with contraindication for MRI or those who have metallic implant in the lumbar spine.

Discography requires expertise and is associated with many technical difficulties. The use of discography in the evaluation of low back pain has greatly reduced since the introduction of MRI. However, currently, there is a resurgence of interest in this procedure. When lumbar discography is followed by CT scanning, it yields useful additionally information. CT discography can accurately delineate the exact location of annular fissure as well as herniation (Modic et al, 1988). The indications of discography are to evaluate equivocal abnormalities detected on other imaging, to isolate a symptomatic disc among multiple levels of abnormalities and to establish contained discogenic pain. It can also be used to select fusion level. To date, discography still remains the only pain-provocative test to determine the significance of a radiographic abnormality.

2.6.5 Radionuclide scintigraphy

Radionuclide imaging has the advantage of providing physiological activity in additional to anatomy. Bone scintigraphy can identify area of metabolic changes. The first radioisotope used for bone imaging was Strontium-85. In 1971, technetium-99m was introduced and since then it has become the main agent of choice for bone scintigraphy till now. Bone scan using technetium-99m diphosphonate, can detect degenerative changes in the spine (Modic et al, 1988). When there is high bone turnover such as in osteophytes and discogenic sclerosis, there will be increased tracer uptake. However, radionuclide imaging has no apparent role in detecting intervertebral disc degeneration. Isotope imaging can detect bony changes earlier than plain radiography. Nevertheless, it has relatively poor resolution and low specificity (Kormano, 1989). SPECT (single photon emission computed tomography) imaging was started in early 1960s. Comparing with planar imaging, SPECT imaging has improved contrast and tomographic effect. With SPECT imaging, radionuclide bone imaging for patients with low back pain has become more sensitive and more accurate for anatomical localisation of pathology.

CHAPTER III

OBJECTIVES AND HYPOTHESIS

3. Objectives and hypothesis

3.1 Objectives of the study

General objectives

To study the correlation between clinical presentation, plain radiograph signs and MRI of lumbosacral spine.

Specific objectives

1. To collect demographical data of patients presenting with low back pain.
2. To study the spectrum of clinical presentation (duration of pain, type of pain and presence or absence of neurology manifestation) in patients with low back pain .
3. To determine the predictive value of the clinical presentation on the outcome of MR imaging on intervertebral disc herniation, nerve root compression and spinal stenosis.
4. To correlate radiographic signs with the MRI findings.