



St. Paul's Hospital Millennium Medical College
Department of Radiology and Medical Radiology Technology

**Magnetic resonance imaging patterns of lumbar spine
degeneration in patients presented with low back pain at Saint
Paul's Hospital Millennium Medical College**

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**A research thesis submitted to the Department of Radiology and Medical Radiology
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August 2024

Addis Ababa, Ethiopia



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List of acronyms

CT	Computed Tomography
DD	Disc Degeneration
EMR	Electronic Medical Recording
FSU	Functional Spinal Unit
L (level)	Lumbar Vertebrae (Level)
LBP	Lower Back Pain
MC	Modic Changes
MOH	Ministry of Health
MRI	Magnetic Resonance Imaging
PACS	Picture Archiving and Communication System
RIS	Radiology Information System
S (level)	Sacral Vertebrae (Level)
SPHMMC	Saint Paul's Hospital Millennium Medical College
SPSS	Statistical Package For Social Sciences
STIR	Short Tau Inversion Recovery
T	Tesla (MRI Magnetic Field Strength)
T1W	T1 Weighted Image (T-a measure of time, Longitudinal relaxation time)
T2W	T2 Weighted Image (T- a measure of time, Transverse relaxation time)
WHO	World Health Organization

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Abstract

Background: Low back pain is a common and challenging health problem causing a decrease in quality of life and significant economic impact. The most common cause of low back pain is the degeneration of the lumbar spine segments. Studies indicate the large burden of the problem in Ethiopia. All elements of the spine can undergo morphological changes that can be classified as degenerative. Magnetic resonance imaging (MRI) is the modality of choice for the evaluation of low back pain because of its anatomical detail, tissue contrast and lack of ionizing radiation.

Objectives: To assess MRI patterns of lumbar spine degeneration in patients who presented with low back pain at Saint Paul's Hospital Millennium Medical College who had lumbar MRI

Methods: An institutional based cross-sectional study (retrospective record review) was conducted. The study included 400 patients with low back pain who had lumbar MRI from April 2024 to June 2024 at St. Paul's Hospital Millennium Medical College. A systematic random sampling technique was used. Sociodemographic data was collected from the patient charts as well as EMR (electronic medical recording) and their lumbar spine MRI findings were accessed from the radiology information system (RIS) and Picture archiving and communication system (PACS). Descriptive and correlation analysis was done using SPSS version 27.

Results: The study included 400 patients with a mean age of the patients was 43.4 ± 14 years with age range of 13 to 86 years. Among participants, 68.3% were females and 31.8% were males. MRI findings of lumbar spine degeneration were very common among patients with low back pain with a prevalence of 86.3%. Among these intervertebral disc degeneration was the most common finding. Even though the prevalence varies, no statistically significant sex difference in prevalence seen for most of lumbar spine degeneration types. However, aging has statistically significant correlation for most types of lumbar spine degeneration. L4/L5 and L5/S1 lumbar spine levels were the most commonly affected by degenerative changes.

Conclusion and recommendation: MRI findings of lumbar spine degeneration were very common among patients with low back pain with strong correlation with aging. No statistically significant sex correlation was seen. Multi-centered and population-based studies with longer study period that includes factors associated with lumbar spine degeneration are recommended to make conclusion on general population.

Keywords: *degeneration, low back pain, lumbar spine, MRI*

1. Introduction

1.1. Background

Chronic low back pain is a common and challenging problem. The patients describe pain in the center of the lower back with minimal radiation, usually to one or both buttocks (1). Most lower back pains are associated with degenerative lumbar spine. As part of our body, the spine has three major functions: to provide structural support, enable trunk movement and protect the neural elements. A spine is a multiarticular structure comprising numerous segments or units, enabling multidirectional motions and the absorption of large complex loads. Two adjacent vertebrae, the intervertebral disc, spinal ligaments and facet joints between them constitute a functional spinal unit (2).

Degenerative change is considered a response to insults, such as mechanical injury (2). The intervertebral disc, which consists of a firm collagenous exterior annulus fibrosis and a gelatinous interior nucleus pulposus is the most vulnerable element of the spine (1,3). In response to insults there will be the breakdown of the intervertebral discs proteoglycans and increasing loss of fluid which progresses to the disc height loss. Herniation of parts of the disc may also occur which can cause pain or neurological problems due to the compression of spinal nerves (3). Other elements of the spine than the intervertebral discs including facet joints, ligaments and bony structures can also undergo morphological changes that can be classified as degenerative (2).

From the time initially described by Wilhelm Conrad Roentgen in 1895 to the 1980s the evaluation of spine was done by x-ray/radiography and computed tomography (CT) imaging. The introduction of exogenous contrast material into the subarachnoid space followed by radiographic imaging (myelography) was also used for imaging the spinal canal and indirectly imaging the spinal cord and nerve root compression (4). However, the invention of magnetic resonance imaging (MRI) revolutionized the imaging of low back pain because of its anatomical detail, tissue contrast and lack of ionizing radiation (4). Degenerative changes can be visualized as an abnormal finding on MRI and we can accurately demonstrate morphologic findings of degenerative disk disease (4). Knowledge of these morphologic findings with better anatomic detail visualized on MRI and their distribution will guide us to select a type of treatment needed for the patient.

1.2. Statement of the problem

Lower back pain is one of the most common disorders requiring diagnosis and treatment (3). It is estimated that up to 90% of people experience significant lower back pain in their lifetime usually between the ages of 30 and 50 years (4). The pain can be debilitating and is one of the major causes of absence from work (1). It is also one of the large contributors to national health expenditure. The expenditure can be due to direct costs related to medical care and indirect costs related to productivity loss. Indirect costs are typically much higher than direct costs. Worldwide lower back pain was estimated to cause 22 million disability-adjusted life years in 2010 (5). In addition, it is also related to depression and decreased quality of life (6). Psychological distresses like anxiety and depression have been described to be associated with persistent or debilitating lower back pain in adults of all ages (7). Studies also indicate individuals with higher depressive symptom scores will have doubled the risk of having lower back pain a few years later (7).

Studies done in Africa including Ethiopia also indicates the rampant nature of the problem. A multisystemic review from studies done in various African countries showed the average lifetime prevalence of lower back pain at 36% and 62% among adolescents and adults respectively. The mean LBP point prevalence among adolescents was 12% and among adults was 32%(8). In Ethiopia, studies indicated 12-month prevalence of self-reported work-related LBP was 54.05% while the seven-day LBP prevalence was about 37.48%. The point prevalence of lower back pain was 40.82% (9).

In most cases of acute lower back pain, a definite pain generator cannot be defined. However, it is estimated that 39% of chronic low back pain is attributed to the intervertebral disk which is the most affected site of degenerative lumbar spine (1). Other elements of lumbar spine can also contribute to the low back pain. When imaging is in need, magnetic resonance imaging (MRI) is the ideal modality for the evaluation of degenerative lumbar spine due to its anatomical detail, tissue contrast, and lack of ionizing radiation(4). It has also an advantage of directly visualizing spinal cord and nerve roots which is important in patient treatment (4). Simple low back pain is usually a benign and self-limited condition. However, 10%-15% of low back pain radiating to buttock with persistent or severe symptoms require surgery (10). So, the knowledge of the types and severity of degenerative lumbar spine visualized on MRI has paramount importance in patient treatment.

1.3. Rationale of the study

Lower back pain most of which is caused by degenerative changes of the lumbar spine is a very common complaint among the adult population in both developed and developing countries. Magnetic resonance imaging (MRI) is the best imaging modality for the evaluation of lumbar spine degeneration changes because of its excellent characterization of the anatomy involved. Different patterns of MRI findings are associated with different degree of lower back pain.

Lumbar spine degeneration is a poorly researched area in our country due to inadequate resources like the availability of MRI in only a few hospitals. There are only a few studies done in Ethiopia on lumbar spine degeneration. The studies only described disc degeneration and its correlation to lower back pain. In Saint Paul's Hospital Millennium Medical College, there is no known study done at all on this area to the best of my knowledge. So, the study aims to evaluate all patterns of lumbar spine degeneration beyond disc degeneration; where there is no known study done to date in Ethiopia.

The knowledge generated will be useful and applicable to the study area and nationwide at a large scale. Understanding different patterns of degenerative changes in the lumbar spine is crucial for clinicians to know available treatment options and disease prognosis hence improving patient care and outcomes. It also helps as baseline data for comparison with other studies elsewhere and assists in planning for further research areas on lumbar spine degenerative disease.

2. Literature Review

2.1. Introduction

Lower back pain is defined as pain in the center of the lower back usually with minimal radiation to the buttocks. It could have an absent or intermittent radicular component (1). It is among the most common outpatient complaints requiring diagnosis and treatment (11). About 90% of people experience significant lower back pain in their lifetime (1). The pain commonly causes a considerable decrease in quality of life, while it has also a significant economic impact (3,12). The most common cause of lower back pain is the degeneration of the lumbar spine segments (3). The prevalence correlates with increasing age in multiple studies (12–15). Studies done in India indicate male predominance of the disease (13,15). When imaging is required, Magnetic resonance imaging (MRI) is very helpful in the evaluation of patients with lower back pain since it helps us to evaluate the morphology of the lumbar spine accurately (12). For this reason, it is considered the best imaging modality to evaluate lumbar spine degeneration (16). All elements of the spine, including the intervertebral discs, facet joints, ligaments and bony structures, may undergo morphological changes that can be classified as degenerative (2).

2.2. Intervertebral disc degenerative changes

Degenerative processes begin in the disc which is the most vulnerable element of the spine (3). It usually starts within the nucleolus pulposus of the disc and extends to the annulus fibrosus, end plates, and bone marrow of the adjacent vertebral bodies (2). Disc desiccation is a common degenerative change of intervertebral discs resulting from the breakdown of the proteoglycans and increasing loss of disc fluid which eventually leads to disc height loss (3,12,15). Annular fissures can also occur as a primary event in the process of disc degeneration or secondary to vertebral endplate fracturing (17). Herniation of parts of the disc material may occur which leads to pain or neurological problems due to the compression of spinal nerves (2,3). With the progressive degeneration of the disc, compensatory reactions may occur in the surrounding bone which includes ventral or dorsal bone spurs (osteophytes) and Modic endplate changes which start with edema and later progress to sclerosis (3). Advanced degeneration may eventually involve distant structures and lead to facet joint osteoarthritis, ligamentum flavum hypertrophy and spinal canal stenosis (2).

2.3. End-plate degenerative changes and osteophytes

Endplate changes which include Modic changes (MC), Schmorl nodes and osteophytes are also common. A Schmorl node represents a localized displacement of disc material into the adjacent endplates, either in an upward or downward direction (17). Anterior and lateral marginal vertebral body bony growths (osteophytes) are found in all individuals over 40 years of age indicating consequences of normal aging, whereas posterior osteophytes are found in only a minority of individuals (18).

2.4. Posterior elements degenerative changes

Degenerative changes of facet joints and ligamentum flavum are other patterns of spine degeneration that often accompany degenerative disc disease (17). Facet joint arthropathy appears early in the lumbar spine causing low back pain in 30% of the adult and 52% of the elderly population (19). It is characterized by narrowing of the facet joint space, sclerosis of the articular facets, hypertrophic osteophyte formation, cartilage destruction and bone erosion. Arthropathy of the inferior articular facets results in a reduced transverse diameter of the spinal canal while the involvement of superior articular facets leads to lateral recess and foraminal stenosis (17).

The ligamentum flavum with high content of elastin extends from the second cervical vertebra to the first sacral vertebrae connecting two adjacent laminae. In response to abnormal motion and instability elastin fibers will degenerate leading to hypertrophy and thickening of the ligament (2). It is often associated with facet joint arthropathy causing posterolateral narrowing of spinal canal (17,20).

2.5. Canal stenosis and spondylolisthesis

The combination of facet joint arthropathy, thickening of the ligamentum flavum, disc bulging, and traction osteophytes contribute to the development of spinal stenosis (17). Lumbar spinal stenosis can involve the central canal, lateral recess, neural foramina or combination of these (20). Central spinal canal stenosis can be graded as mild, moderate and severe depending on how aggregated cauda equina nerve roots on MRI. Lateral recess and neural foraminal stenosis also graded similarly depending on how flattened nerve roots and effaced epidural fat is on MRI (2).

Degenerative spondylolisthesis occurs when there is abnormal displacement of one vertebra relative to the subjacent vertebra. The displacement could be anterior (anterolisthesis) or

posterior (posterolisthesis) (2). The degree of displacement can be graded from I-IV by Meyerding classification with each grade corresponding to 25% more subluxation (17). In the degenerative spine, anterolisthesis is most often caused by facet joint degeneration, whereas retrolisthesis is predominantly caused by disc disease (17).

2.6. Distribution of patterns of lumbar spine degenerative changes

2.6.1. Global

Lumbar degenerative changes are common. The study done in India showed overall prevalence of degenerative lumbar spine to be at 93.21% (13). Among lumbar spine degenerative changes, intervertebral disc is the most affected one (3). Disc bulging, protrusion and extrusion occurs but to lesser frequency than disc desiccation (20). According to various studies done, the prevalence of disc degenerative findings increases with age with statistically significant correlation (3,13). Males are more affected by degenerative spinal disease (15). Disc degeneration is also more common in males even though sex difference is not statistically significant (3,13). However, study done in Japan showed higher female prevalence that was not statistically significant (21). Distribution along lumbar spine levels is also variable. Caudal levels degenerated earlier than cephalad levels. Various studies indicate L4/L5 level as the most affected level (15,20). However, a study done at University of California, USA indicated L5/S1 was the most common affected in single-level disc degeneration even though L4/L5 level was more affected in multilevel degeneration (22).

Endplate degenerative changes are also common. The study done by population based Finnish twin cohort showed that the prevalence of Modic changes at 55.6% (23) Type 2 was the most common among Modic changes types followed by type 1 (13,23). About three-quarters of end plates with Modic changes involves the lower lumbar region, adjacent to L4/L5 and L5/S1 discs levels (23). Population based study done in China that included large numbers of volunteers also supported these findings (24). According to study done in India, Schmorl nodes which are another type of endplate changes were observed in 16.4% of patients with chronic low back pain, most commonly at L1/2 and L2/3 levels (25). They are more common in males than females; however, no significant relationship with age was seen (17,26). A study done in Denmark also supported upper lumbar predominance of Schmorl nodes, however no significant correlation with gender and age was noted (26). Osteophytes are commonly found at L3 / L4 and L5 / S1 vertebral levels (15).

Posterior elements are also commonly affected by degenerative changes. A study done in Pakistan showed facet joint arthropathy in 55.2% of patients (20). The study done in US also showed higher prevalence of facet arthropathy (27). It commonly involves L4/L5 level followed by L5/S1 level according to studies done in India, Pakistan and USA (15,20,27). An anatomic epidemiological study done at Rush University Medical Center in Chicago, USA showed men have a greater prevalence and degree of facet arthropathy than women at all levels (27). However, study done in Switzerland shows similarity in male and female prevalence (28). Ligamentum flavum hypertrophy is also common. The studies done in India and Pakistan showed the higher prevalence of ligamentum flavum hypertrophy occurring in 38% of patients with disc desiccation most commonly at L4/L5 level followed by L5/S1 level (15,20). Posterior element degenerative changes prevalence increases with age (27,29).

Spinal canal and neural foraminal stenosis are also commonly seen in patients with degenerative lumbar spine (20). Studies done in Nepal and India showed the prevalence of 49.1% and 50% respectively (13,30). Neural foraminal narrowing is also common, seen in up to 76.9% of patients (30). Studies done in India showed male predominance of the problem, however it was not statistically significant. This study also showed increasing of both spinal canal and neural foraminal narrowing with ageing and indicated that L5/S1 was the most commonly affected level (13).

Degenerative spondylolisthesis is most commonly seen in the lumbar spine (2). Anterolisthesis is more common than posterolisthesis and L5/ S1 level is common in both types (15). Study in Pakistan showed the prevalence of spondylolisthesis to be 9.2% of patients, of which 6.1% was at the L5/S1 level (20). In study done in USA spondylolisthesis has significant age correlation (31).

2.6.2. Regional

Various studies have also been done in Africa in the area. A study done in Tanzania showed high prevalence of disc degeneration which was 83% (32). Disc bulging was the most common form of disc degeneration according to the studies done in Nigeria and Cameroon (33,34). However, a study done at Ain Shams University in Cairo Egypt indicated disc desiccation was more common (35). Disc protrusion, extrusion and sequestration are also common disc degeneration types (33–35). The studies done in Cameroon and Tanzania indicated that the commonest affected site to be L4/L5 level (32,34). Other studies done in Nigeria and Kenya also supported this finding (33,36). Disc degeneration was noted to increase with age in many studies

(32,33,37). There was statistically insignificant higher male prevalence in studies done in Nigeria and Tanzania by (32,37).

Endplate Modic changes, osteophytes, facet joint arthropathy, ligamentum flavum hypertrophy, spondylolisthesis and spinal canal stenosis are also other common lumbar spine degenerative patterns seen in patients with low back pain (33,35). Modic changes were more common among males compared to females (32). Spinal canal narrowing was seen in 30.3% while neural foraminal narrowing was seen in 77% of participants in the study done in Tanzania with slight male predominance (32). Both spinal canal and neural foraminal narrowing noted to increase with age and L4/L5 level was the most common affected level by spinal canal stenosis followed by L5/S1 and L3/L4 levels (32). Spondylolisthesis was not commonly seen. Study done in Egypt in 2017 showed the prevalence of spondylolisthesis to be at 10.8% (35). Another study done in Cameroon also showed low prevalence of spondylolisthesis in patients with low back pain (34).

2.6.3. National

A study to assess the correlation between disability and lumbar disc degeneration was done at the University of Gondar Comprehensive Specialized Hospital indicated disc bulge, foraminal stenosis, disc desiccation, disc herniation, spinal canal stenosis and Modic Changes were the most frequent MRI findings in decreasing order (38). However, the study didn't mention ligamentum flavum hypertrophy, facet joint arthropathy, Schmorl nodes and osteophytes which are also common patterns of lumbar spine degenerative changes leading to the spinal canal, lateral recess and neural foraminal stenosis contributing to lower back pain. Another hospital based cross-sectional study was done in 2009 at Tikur Anbessa Hospital indicated most of the patients presented to the neurosurgical clinic with pain, numbness and neurological claudication had disc degeneration on myelography, CT and MRI (39). L4/L5 and L5/S1 were the most affected levels in both studies (38,39).

According to the literature reviewed there are few studies done on the area in other hospitals in Ethiopia. However, no research done regarding various MRI lumbar spine degeneration patterns other than disc degeneration and Modic changes in patients with low back pain in Ethiopia to the best of my knowledge. In Saint Paul's Hospital Millennium Medical College, no known study on lumbar MRI degenerative patterns so far. Considering the high burden of this disease and the availability of MRI in our institution researching this topic, hopefully will add evidence-based decision in managing our patients.

3. Objectives

3.1. General Objectives

- To assess MRI patterns of lumbar spine degeneration among patients with low back pain who had lumbar MRI at Saint Paul's Hospital Millennium Medical College.

3.2. Specific objectives

- To assess the frequency distribution of variable MRI patterns of lumbar spine degenerative changes in relation to lumbar spine levels in patients with lower back pain at SPHMMC.
- To assess the frequency distribution and correlation of variable MRI patterns of lumbar spine degenerative changes in relation to age and sex in patients with lower back pain at SPHMMC.

4. Methodology

4.1. Study setting and study period

The study was conducted in June 2024 at Saint Paul's Hospital Millennium Medical College (SPHMMC), which is one of the largest hospitals in Ethiopia's capital city Addis Ababa. It is a teaching hospital for health science students enrolled in various undergraduate and postgraduate programs. The hospital also provides tertiary-level clinical services in various disciplines with over 700 beds and is open 24 hours for emergency services. The college sees an average of 1200 emergency and outpatient clients daily. More than 6000 imaging investigations are being done monthly of which around 800 are MRI. Lumbosacral MRI accounted for more than one-third of the visits to MRI imaging unit (retrieved from <https://sphmmc.edu.et/about/>)

4.2. Study design and period

An institutional based cross-sectional study (retrospective record review) of patients with low back pain who had lumbar MRI from April 2024 to June 2024 at St. Paul's Hospital Millennium Medical College was conducted.

Source population: All patients who had low back pain and had undergone lumbar MRI imaging in St. Paul's Hospital Millennium Medical College between April 2024 and June 2024.

Study Population: All selected patients who had low back pain and had undergone lumbar MRI imaging in St. Paul's Hospital Millennium Medical College between April 2024 and June 2024 and fulfill inclusion criteria.

Inclusion Criteria:

- Patients with low back pain and those who had undergone lumbar MRI
- Patients with good image quality

Exclusion criteria:

- Patients with previous spine surgery
- Patients with active or sequelae of lumbar spine infection
- Patients with a history of previous lumbar spine trauma
- Patients with spine tumor
- Underlying spine anomaly

4.3. Sample Size and Sampling Procedure

The sample size was estimated using the sample size determination formula of a single population proportion for an infinite population. Data on SPHMMC radiology information system (RIS) indicated that around 300 lumbosacral spine MRI was done each month most of the indication being low back pain. As there was no similar study done including the prevalence of all MRI patterns of degenerative lumbar spine among patients with low back pain who had lumbar MRI in Ethiopia, 50% was taken to be the proportion of patients with positive lumbar degenerative findings, with 95 % certainty, 0.05 type I error and a maximum discrepancy of 5% between the sample and the underlying population and non-response rate was not added to the sample since secondary data was used. A total of 400 patients were selected with a systematic random sampling method. An ascending order in time of list of patients' lumbosacral MRI report was found from RIS system. Data of every other patient that fulfils the criteria was collected. Sample size was calculated using the formula indicated below.

$$n = (Z \alpha/2)^2 \frac{P(1 - P)}{d^2}$$

Where

n = the desired sample size

P = Proportion of patients with positive lumbar spine degenerative MRI findings

$Z \alpha/2$ = Critical value at 95% confidence level of certainty (1.96) and

d = 0.05

$$n = (1.96)^2 \frac{0.5(1-0.5)}{0.05^2} = 384$$

4.4. Study variables

4.4.1. dependent Variables

Patterns of lumbar vertebrae degeneration-

- Disc degeneration
 - Disc desiccation
 - Disc height loss
 - Disc bulging
 - Disc protrusion

- Disc extrusion
- Disc sequestration
- Annular fissure
- End plate pathologies
 - Modic changes
 - Schmorl nodes
- Osteophytes
- Facet joint arthropathy
- Ligamentum flavum thickening
- Spondylolisthesis
 - Anterolisthesis
 - Posterolisthesis
- Canal stenosis
 - Spinal canal narrowing
 - Neural foraminal narrowing

4.4.2. Independent variables:

- Age, Sex and lumbar spine level

4.5. Operational definitions of variables

Taken from North American Spine Society, American Society of Spine Radiology and the American Society of Neuroradiology version 2.0 of lumbar disc nomenclature as follows (40).

Asymmetric disc bulge-

- Disc material extending beyond the limits of the disc space between 90° and 180°

Disc degeneration-

- Changes in a disc are characterized to varying degrees by one or more of: desiccation, cleft formation, fibrosis, gaseous degradation, fissuring and loss of integrity of the annulus.

Disc desiccation-

- Decreased disc T2W signal intensity on T2-weighted images as a consequence of the loss of water content and changes in the concentration of glycosaminoglycan. It is graded from 1 to 5 by Pfirman grading.

Disc height loss

- Decrement in disc space between the vertebral endplates. It should be measured at the center of the disc

Disc herniation-

- Focal (less than 90° of the disc circumference) displacement of disc material extending beyond the disc's normal margins. It can be classified as either a protrusion or an extrusion.

Disc protrusion-

- Localised displacement of disc material and the distance between the corresponding edges of the displaced portion must not be greater than the distance between the edges of the base of the displaced disc material at the disc space of origin. Anatomically a focal displacement of disc material with intact overlying annulus fibrosus and posterior longitudinal ligament

Disc extrusion-

- similar to protrusion but has a dome wider than the neck (similar to a saccular aneurysm)

Disc bulging-

- Disc material extending beyond the limits of disc space extending >180° of the disc.

Disc sequestration-

- Separated disc material from its parent disc to become a fragment, which may migrate inferiorly or superiorly.

Endplate changes-

- End plate is anatomically discrete structures that form the interface between the vertebral bodies and the adjacent intervertebral discs. It includes endplate irregularity, Modic changes and Schmorl nodes.

Modic changes-

- Vertebral body endplate and subchondral marrow MRI signal changes. There are three types of Modic changes. Modic I represents vertebral body endplate and subchondral marrow edema, while Modic II and Modic III represent fatty metaplasia and fibrosis respectively.

Schmorl nodes-

- Intravertebral disc material herniation through the gap in the cartilaginous endplate

Osteophytes-

- Cartilage-capped bony proliferations (bony spurs) that develop at the margins joint, most commonly synovial joint

Facet joint arthropathy-

- Also called facet hypertrophy is a facet joint degenerative process that includes larger synovial joints, including cartilage loss, osteophytes, sclerosis, and subchondral cystic changes. It is graded as mild, moderate and severe.

Spondylolisthesis

- Anterior displacement (**anterolisthesis**) or posterior displacement (**posterolisthesis**) of a vertebral body relative to the one below. The degree of displacement can be graded from I-IV by Meyerding classification.

Annular fissure-

- Linear hyperintense signal on T2-weighted images in the annulus fibrosis of the intervertebral disc

Ligamentum flavum thickening-

- Ligamentum flavum lines the lamina at the posterior aspect of the spinal canal. Its thickening (measuring more than 4mm) can contribute to spinal canal stenosis.

Spinal canal narrowing/stenosis-

- Decrease the total area of the spinal canal. It is graded as mild, moderate and severe depending on how aggregated cauda equina nerve roots on MRI.

Neural foramen narrowing/stenosis-

- Decrease in the total area of the neural foramina. It is also graded as mild, moderate and severe depending on how effaced epidural fat is on MRI.

4.6. Data collection method and procedure

The imaging portion of the patient's data which was approved by consultant radiologists was accessed from patient record in radiology information system (RIS) and Picture archiving and communication system (PACS) which was done with Siemens 1.5T MRI by a well-trained Medical Radiology Technologists with the patients in a supine position. The following MRI sequences were used; Axial T2W, sagittal T1W, sagittal T2W, and sagittal STIR. Only good quality images were used in this study. Imaging data was collected and revised by the principal investigator with clinical advisor consultation. The patients' demographic data which collected by treating physician was accessed from the patient's record chart and electronic medical

registration (EMR). The data collection template was prepared based on literature review and advisors consultation. The format was piloted and amended based on comments received from advisor.

4.7. Data quality control

Structured English version data collection check-list was adopted from previous studies and was used to collect data from patient's record chart, electronic medical registration (EMR), radiology information system and Picture archiving and communication system (PACS). Before the actual data collection, pre-test was carried out on 5% of the sample size and an amendment was made accordingly.

4.8. Data analysis procedure

The data was entered into Statistical Package for Social Sciences (SPSS), version 27. Data cleaning and preparation were conducted to correct any errors, address missing values, and standardize data formats. Descriptive statistics using measures of frequency was used to summarize categorical variables. Then the information was presented by using simple frequencies, summary measures, tables and figures. The correlation between the independent (age and sex) and dependent variables was analyzed using Chi-Square tests.

4.9. Ethical clearance

Ethical clearance was obtained from the SPHMMC research review board. The privacy and confidentiality of individual patient's data was respected. There was no risk or benefit in taking part in the survey by individual patients.

4.10. Dissemination of Results

Oral presentations will be made to the Department of Radiology and Medical Radiology Technology. The findings of this study will be shared with all relevant bodies in SPHMMC and other health facilities. The key findings will be shared with stakeholders. Publications will be made in peer-reviewed reputable journals.

5. Results

5.1. Sociodemographic data

A study included a total of 400 patients with the complaint of low back pain who had undergone lumbar MRI with a 1.5T Siemens machine at Saint Paul Hospital Millennium Medical College over a period of 3 months. The majority were females, 273 (68.3%) and males were 127 (31.8%), with M:F ratio of 1:2.15 (Figure 1).

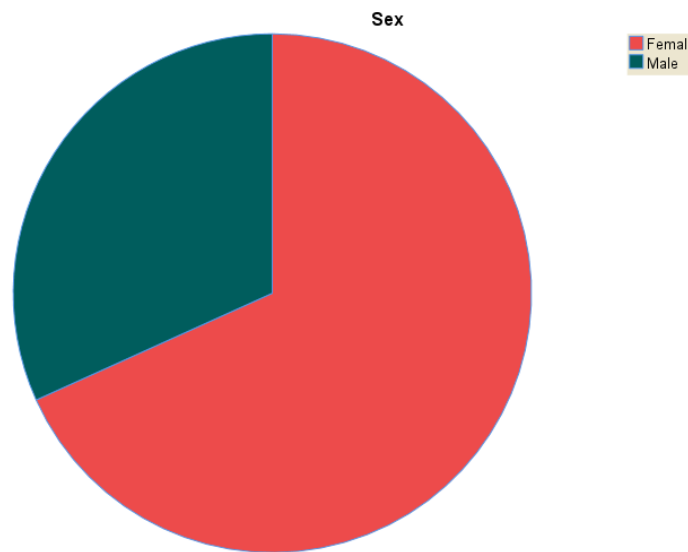


Figure 1. A pie chart showing sex distribution of study participants

The mean age of the patients was 43.4 ± 14 years with age range of 13 to 86 years. The commonest age group was between the 30-39 years accounting for 26.5% followed by 40-49 years which was 22.8% of the participants (Figure 2). In both males and females, the commonest age group was 30-39 years followed 40-49 years in decreasing order.

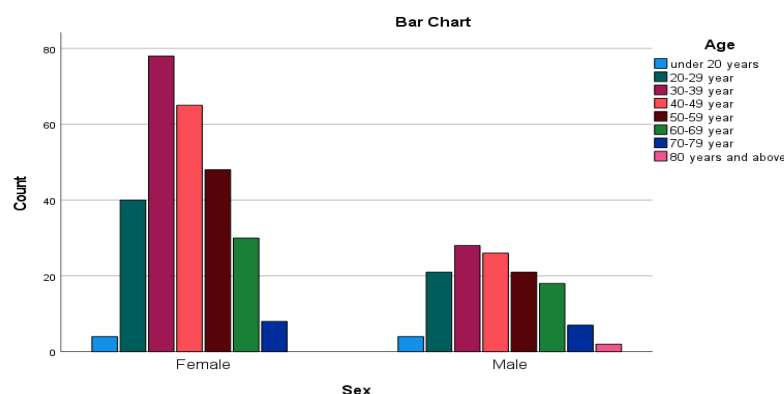


Figure 2. A bar chart showing the age distribution of study participants

5.2. Proportion of degenerative changes

Among the 400 study participants, 345(86.3%) had MRI findings that was classified as positive for lumbar spine degeneration, where disc degeneration was the most commonly found (83.8%). The most common disc pathology was disc desiccation occurring in 75.4% of patients. It was followed by diffuse disc bulge, annular fissure and disc height loss affecting 73%, 28.7% and 21.8% of participants respectively. Anterior osteophytes were common, found in 54% of patients. Among endplate pathologies, Modic changes and Schmorl nodes were seen in 36.8% and 12% of patients respectively. Facet joint arthropathy and ligamentum flavum thickening were also common affecting 47.7% and 25.8% of participants respectively. Neural foraminal and spinal canal narrowing was noted in 58.2% and 56.7% of patients respectively. Spondylolisthesis was uncommon with anterolisthesis seen in 19 (4.7%) and posterolisthesis in 9(2.2%) of participants.

5.2.1. Intervertebral disc degeneration

In this study 335 (83.8%) of individuals had MRI findings of intervertebral disc degeneration. The most commonly found disc degeneration type was disc bulge (78.8%), followed by disc desiccation, annular fissure, disc height loss and disc protrusion each found in 75.8%, 28.7%, 21.3% and 7.2% of participants respectively. Disc extrusion was seen only in 21 (5.3%) participants, while sequestration was seen only in one participant.

Disc degeneration was found to be slightly more common in male 107 (84.3%) than female 228 (83.5%) participants but no statistically significant difference was noted (p-value 0.853) (Figure 3). Other than disc desiccation all types of disc degeneration were more common in males as described in Table 1 below, but there was no statistically significant sex difference noted for all subtypes. The prevalence of disc degenerative findings was increased with age (p-value- <0.001). All patients above 50 years had degenerated disks, while in at 30 to 39 years and 40 to 49 years of age, the prevalence was 70.8% and 90.1% respectively. This was true for a few subtypes of disc degeneration, including disc desiccation, disc height loss and disc bulging (p-value- <0.001 for all). Other subtypes of disc degeneration were also seen to increase with age but were not statistically significant.

L4/L5 level was the most commonly affected level by intervertebral disc degeneration seen in 295 (73.8%) of participants followed by L5/S1 level seen in 284 (71%). L4/L5 level was the most commonly affected level followed by L5/S1 level by disc degeneration subtypes other than

disc protrusion and extrusion that affected L5/S1 the most followed by L4/L5. However, the single case of sequestration was seen at L2/L3 level

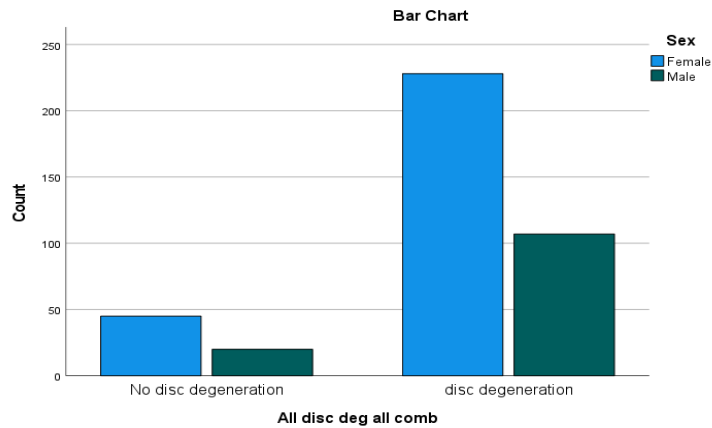


Figure 3. A bar chart showing the sex distribution of disc degeneration

Table 1. A table showing the sex distribution of variable types of disc degeneration

Disc degeneration types	Sex							
	Female			Male			Both	
	Present (in number)	Present (in % among females)	Present in % from all with type of degeneration	Present in number	Present (in % among males)	Present in % from all with type of degeneration	Present (in number total)	Present (in % from all)
Disc desiccation	210	76.9	69.3	93	73.2	30.7	303	75.8
Disc height loss	55	20.1	63.2	32	25.1	36.8	87	21.8
Disc bulging	211	77.3	67	104	81.9	33	315	78.8
Disc protrusion	16	5.9	55.2	13	10.2	44.8	29	7.2
Disc extrusion	11	4	52.4	10	7.9	47.6	21	5.3
Disc sequestration	0	0	0	1	0.8	100	1	0.3
Annular fissure	78	28.6	67.8	37	29.1	32.2	115	28.7
Disc degeneration in general	228	83.5	68.3	107	84.3	31.8	335	83.8

5.2.2 End plate degeneration changes and osteophytes

In our study, 246 (61.5%) individuals had end pate degeneration changes. Among endplate changes, Modic changes 147(36.8%) was more common than Schmorl node 48 (12%). Anterior

and posterior osteophytes were seen in 216(54%) and 42 (10.5%) patients respectively. The most common Modic change subtype was type 2 followed by type 1 and mixed type 1 and 2 in decreasing order. Among Schmorl nodes, upper endplates were more affected than lower endplates.

Endplate degeneration was found more among female than male participants, 170 (62.3%) and 76 (59.8%) respectively (Table 2). Schmorl nodes and anterior osteophytes are common among females. However, Modic changes and posterior osteophytes were more prevalent in males. Modic changes were seen in 53 (41.7%) of males and 94 (34.4%) females participants. Sex variation was not statistically significant for all subtypes other than posterior osteophytes (p-value 0.007 for posterior osteophytes)

An increase in prevalence with ageing was seen with both subtypes of endplate degenerative changes and osteophytes (p-value <0.001). 128 of 134 (95.5%) of patients aged 50 years and above had MRI findings of endplate degeneration compared to 44.4% prevalence in participants below 50. L4/L5 level was the most commonly affected level seen in 210 (52.5%) of participants followed by L3/L4 and L2/L3 levels each seen in 203 (50.5%) and 186 (46.5%) of participants respectively in decreasing order. L5/S1 and L1/L2 levels were less affected. However, for Schmorl node L2/L3 was the most common affected level.

Table 2. A table showing the sex distribution of endplate degeneration

End plate degeneration types and osteophytes		Sex						
		Female			Male			Both
		Present (in number)	Present (in % among females)	Present in % from all with type of degeneration	Present in number	Present (in % among males)	Present in % from all with type of degeneration	Present (in number total)
Modic changes		94	34.4	63.9	53	41.7	36.1	147
Schmorl nodes		34	12.5	70.8	14	11	29.2	48
Osteophytes	Anterior	149	54.6	69	67	52.8	31	216
	Posterior	21	7.7	50	21	16.5	50	42
	Total	149	54.6	69	67	52.8	31	216
Total		170	62.3	69.1	76	59.8	30.9	246

5.2.3. Posterior elements degeneration

Posterior element degeneration changes were seen in 177 (44.3%) of individuals in this study. It was found in 125 (45.8%) of female and 52 (40.9%) of male participants (p-value of 0.364). From posterior element degeneration subtype, facet joint arthropathy was seen in 151 (37.8%) of participants; and found to be similar in both females and males, seen in 103 (37.7%) and 48 (37.8%) respectively (p-value 0.990). Another posterior element, ligamentum flavum, was thickened in 103 (25.8%) participants and was noted in 85 (31.1%) females and 18 (14.2%) males; the sex difference was significant statistically (p-value <0.001). Among facet joint arthropathies mild grade was the most common while moderate grade was uncommon and severe grade was rare.

Posterior elements degenerative changes prevalence noted to increase with age (Figure 4), with prevalence of 70.9% and 30.8% in ≥ 50 years and below 50 years of age respectively (p-value < 0.001). The prevalence of facet joint arthropathy was 64.2% and 24.4% while that of ligamentum flavum thickening was 46.3% and 15.4% both in ≥ 50 years and below 50 years of age respectively (p-value < 0.001).

L4/L5 level was the most common level affected by posterior element degeneration seen in 151 (37.8%) of participants followed by L5/S1 and L3/L4 levels each affecting 117 (29.3%) and 95 (23.8%) of patients respectively in decreasing order. L2/L3 and L1/L2 levels were affected to lesser extent, seen in 50 (12.5%) and 33 (8.3%) patients respectively.

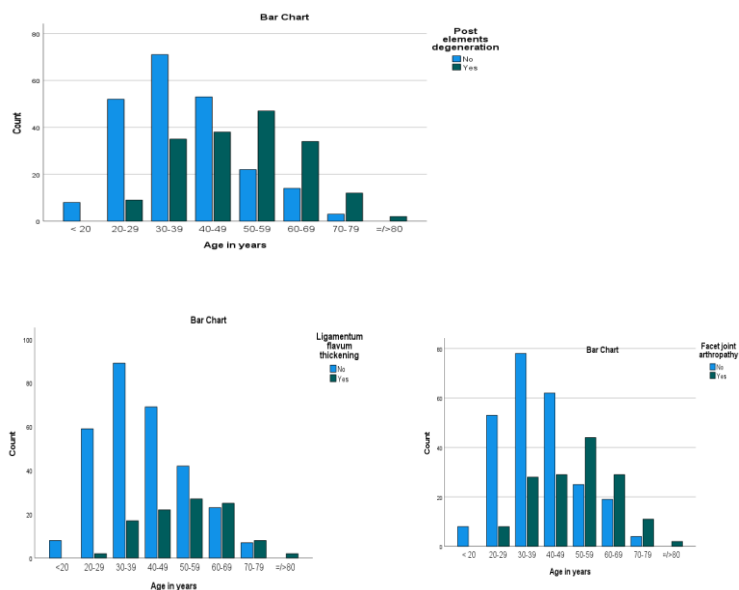


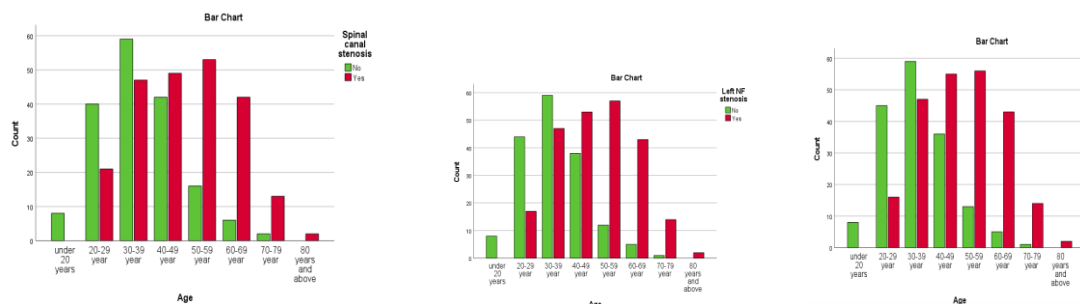
Figure 4. The bar chart showing the age distribution of posterior elements degeneration

5.2.4. Spinal canal and neural foraminal narrowing

Either of spinal canal or neural foraminal narrowing was also common in our study seen in 269 (67.3%) of individuals. It affected 186 (68.1%) of female and 83 (65.4%) of male participants. Spinal canal narrowing was seen in 227 (56.8%) of participants, more common in females 163 (59.7%) compared to males 64 (50.4%). Neural foraminal narrowing was also common as spinal canal narrowing seen in 238 (59.5%) patients and was seen in females 170 (62.3%) than males 68 (53.5%). No statistically significant sex difference was noted for both spinal canal and neural foraminal narrowing (p-values of 0.08 and 0.098 respectively). The prevalence of right and left neural stenosis was similar both found in 233 (58.3%) of patients.

In our study, both types of neural canal narrowing prevalence correlate with age (Figure 5) (p-values of < 0.001 for both). Spinal canal narrowing was seen in 82% and 44% while neural foraminal narrowing was seen in 86.6% and 45.9% of ≥ 50 years and below 50 years of age participants respectively, for both.

L4/L5 level was the most commonly affected by both spinal canal and neural foraminal narrowing, followed by L5/S1, L3/L4, L2/L3 and L1/L2 in decreasing order with prevalence as follows; 48.8%, 27.3%, 25.3%, 11.5% and 3.5% for spinal canal stenosis. Among the 2000 lumbar spine levels studied, 293 (14.65%) had mild spinal canal stenosis, while 128 (6.4%) and 44 (2.2%) had moderate and severe spinal canal stenosis respectively. 27 and 20 levels of severe neural canal stenosis were seen at L4/L5 and L3/L4 levels. 50% of participants had L4/L5 neural foraminal narrowing. From 2000 disc levels studied 471 (23.55%) and 468 (23.4%) levels had left and right side neural foraminal stenosis respectively. Most of them were mild stenosis affecting 15.7% and 15% of the disc levels on the right and left sides respectively. Severe stenosis only affected 2.7% and 2.3% of disc levels on the left and right sides, respectively.



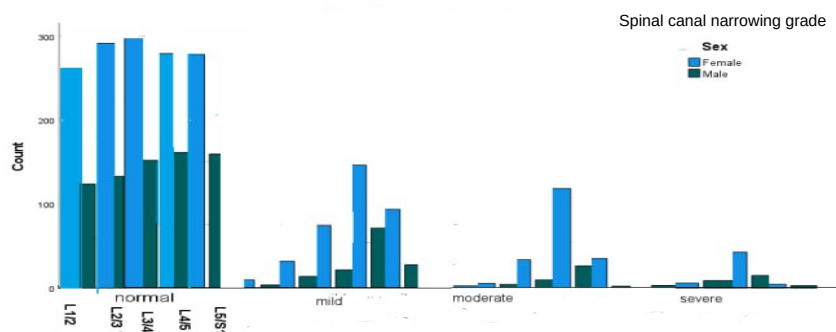


Figure 5. Bar chart showing the age and sex distribution of the spinal canal and neural foramina narrowing.

5.2.5. Spondylolisthesis

Among 400 patients studied, only 27 (6.75%) had spondylolisthesis. Among these, 19 (70.3%) had anterolisthesis, while 9 (33.3%) patients had posterolisthesis, and one patient had both. Spondylolisthesis was more common among females affecting 22 (8%) compared to males 5 (3.9%) but no statistically significant difference was noted (p-value 0.214). Anterolisthesis was seen in 19 patients, of which one was male. However, the sex difference was still not significant (p-value 0.084). Among anterolisthesis, 11 (57.9%) were Grade I, while 7 (36.8%) and 1 (5.3%) were Grade II and III respectively. No Grade IV anterolisthesis was noted. Among nine patients with posterolisthesis, 8 had Grade I and one had Grade II posterolisthesis. No Grade III and IV posterolisthesis was noted.

Spondylolisthesis and both subtypes, anterolisthesis and posterolisthesis had statistically significant age correlation (p-values of 0.002, 0.049 and 0.002 respectively). The prevalence of spondylolisthesis was 14.2% and 3% in patients ≥ 50 years and below 50 years of age respectively. 10 and 8 patients of anterolisthesis were seen at L4/L5 and L5/S1 levels respectively. Only one patient had at L3/L4 level. 6 of the nine posterolisthesis were seen at the L5/S1 level, while the two were seen at L4/L5. Only one patient had at L3/L4 and L2/L3 levels, one at each level. No spondylolisthesis was noted at L1/L2 level.

Table 3. A table showing lumbar level distribution of various types of lumbar spine degeneration

Degeneration types	Disc levels											
	L1/L2		L2/L3		L3/L4		L4/L5		L5/S1		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Disc degeneration	246	61.5	147	36.8	203	50.7	295	73.8	284	71.0	335	83.8
Disc desiccation	103	25.8	129	32.3	180	45.0	241	60.3	246	61.5	303	75.8
Disc height loss	5	1.3	18	4.5	20	5.0	46	11.5	60	15.0	87	21.8
Disc bulging	39	9.8	78	19.5	146	36.5	263	65.8	237	59.3	315	78.8
Disc protrusion	3	0.8	1	0.3	32	8	12	3.0	15	3.8	29	7.2
Disc extrusion	2	0.5	2	0.5	0	0	8	2.0	9	2.3	21	5.3
Disc sequestration	0	0	1	0.3	0	0	0	0	0	0	1	0.3
Annular fissure	4	1.0	11	2.8	31	7.8	67	16.8	47	11.8	115	28.7
Modic changes	29	7.2	45	11.3	56	14.0	67	16.8	79	19.8	147	36.8
Schmorl nodes	19	4.8	27	6.8	21	5.3	14	3.5	2	0.5	48	12.0
Anterior osteophytes	156	39.0	175	43.8	190	47.5	196	49.0	157	39.3	216	54.0
Posterior osteophytes	4	1.0	10	2.5	14	3.5	31	7.8	19	4.8	42	10.5
Facet joint arthropathy	33	8.3	50	12.5	87	21.8	129	32.3	102	25.5	151	37.8
Lig flavum thickening	3	0.8	12	3.0	37	9.3	81	20.3	48	12.0	103	25.8
Spinal canal stenosis	14	3.5	46	11.5	101	25.3	195	48.8	109	27.3	227	56.8
Left NF stenosis	7	1.8	23	5.8	91	22.8	200	50.0	144	36.0	233	58.3
Right NF stenosis	8	2.0	23	5.8	89	22.3	201	50.2	147	36.8	233	58.3
Anterolisthesis	0	0	0	0	1	0.3	10	2.6	8	2.1	19	4.9
Posterolisthesis	0	0	1	0.3	1	0.3	2	0.5	6	2.6	9	2.3

Table 4. A table showing age and sex distribution of various types of lumbar spine degeneration.

Types of spine degeneration	Sex			p-value	Age in years																		Total	p-value
	Female		Male		Less than 20 year		20-29 year		30-39 year		40-49 year		50-59 year		60-69 year		70-79 year		80 years and above					
	N	%	%		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%				
Disc degeneration	228	83.5%	107	84.3%	0.853	1	12.5%	43	70.5%	75	70.8%	82	90.1%	69	100.0%	48	100.0%	15	100.0%	2	100.0%	335	83.8%	<0.001
Disc desiccation	210	76.9%	93	73.2%	0.422	1	12.5%	35	57.4%	60	56.6%	75	82.4%	67	97.1%	48	100.0%	15	100.0%	2	100.0%	303	75.8%	<0.001
Disc height loss	55	20.1%	32	25.2%	0.254	0	0.0%	4	6.6%	14	13.2%	19	20.9%	17	24.6%	24	50.0%	7	46.7%	2	100.0%	87	21.8%	<0.001
Disc bulge	211	77.3%	104	81.9%	0.295	1	12.5%	41	67.2%	70	66.0%	75	82.4%	65	94.2%	46	95.8%	15	100.0%	2	100.0%	315	78.8%	<0.001
Disc protrusion	16	5.9%	13	10.2%	0.116	0	0.0%	6	9.8%	8	7.5%	5	5.5%	3	4.3%	5	10.4%	2	13.3%	0	0.0%	29	7.2%	0.754
Disc extrusion	11	4.0%	10	7.9%	0.109	0	0.0%	1	1.6%	7	6.6%	4	4.4%	2	2.9%	5	10.4%	1	6.7%	1	50.0%	21	5.3%	0.51
Disc sequestration	0	0.0%	1	0.8%	0.142	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	2.1%	0	0.0%	0	0.0%	1	0.3%	0.393
Annular fissure	78	28.6%	37	29.1%	0.908	0	0.0%	13	21.3%	26	24.5%	29	31.9%	23	33.3%	19	39.6%	4	26.7%	1	50.0%	115	28.7%	0.18
Endplate changes	170	62.3%	76	59.8%	0.642	0	0.0%	13	21.3%	46	43.4%	59	64.8%	65	94.2%	47	97.9%	14	93.3%	2	100.0%	246	61.5%	<0.001
Modic Changes	94	34.4%	53	41.7%	0.159	0	0.0%	5	8.2%	27	25.5%	35	38.5%	34	49.3%	35	72.9%	9	60.0%	2	100.0%	147	36.8%	<0.001
Schmorl's nodes	34	12.5%	14	11.0%	0.682	0	0.0%	4	6.6%	9	8.5%	8	8.8%	13	18.8%	11	22.9%	3	20.0%	0	0.0%	48	12.0%	<0.001
Osteophytes	149	54.6%	67	52.8%	0.733	0	0.0%	9	14.8%	37	34.9%	47	51.6%	64	92.8%	43	89.6%	14	93.3%	2	100.0%	216	54.0%	<0.001
Anterior osteophytes	149	54.6%	67	52.8%	0.733	0	0.0%	9	14.8%	37	34.9%	47	51.6%	64	92.8%	43	89.6%	14	93.3%	2	100.0%	216	54.0%	<0.001
Posterior osteophytes	21	7.7%	21	16.5%	0.007	0	0.0%	2	3.3%	3	2.8%	4	4.4%	10	14.5%	14	29.2%	8	53.3%	1	50.0%	42	10.5%	<0.001
Posterior elements	125	45.8%	52	40.9%	0.364	0	0.0%	9	14.8%	35	33.0%	38	41.8%	47	68.1%	34	70.8%	12	80.0%	2	100.0%	177	44.3%	<0.001
Facet joint arthropathy	103	37.7%	48	37.8%	0.990	0	0.0%	8	13.1%	28	26.4%	29	31.9%	44	63.8%	29	60.4%	11	73.3%	2	100.0%	151	37.8%	<0.001
Ligamentum flavum thickening	85	31.1%	18	14.2%	<0.001	0	0.0%	2	3.3%	17	16.0%	22	24.2%	27	39.1%	25	52.1%	8	53.3%	2	100.0%	103	25.8%	<0.001
Spinal canal stenosis	163	59.7%	64	50.4%	0.080	0	0.0%	21	34.4%	47	44.3%	49	53.8%	53	76.8%	42	87.5%	13	86.7%	2	100.0%	227	56.8%	<0.001
Neural foraminal stenosis (either right or left)	170	62.3%	68	53.5%	0.098	0	0.0%	17	27.9%	47	44.3%	58	63.7%	57	82.6%	43	89.6%	14	93.3%	2	100.0%	238	59.5%	<0.001
Right neural foraminal stenosis	168	61.5%	65	51.2%	0.051	0	0.0%	16	26.2%	47	44.3%	55	60.4%	56	81.2%	43	89.6%	14	93.3%	2	100.0%	233	58.3%	<0.001
Left neural foraminal stenosis	166	60.8%	67	52.8%	0.129	0	0.0%	17	27.9%	47	44.3%	53	58.2%	57	82.6%	43	89.6%	14	93.3%	2	100.0%	233	58.3%	<0.001
Spondylolisthesis	22	8.1%	5	3.9%	0.214	0	0.0%	0	0.0%	4	3.7%	4	4.4%	7	10.0%	10	20.8%	1	6.7%	1	50.0%	27	6.8%	0.002
Anterolisthesis	18	6.7%	1	0.8%	0.084	0	0.0%	0	0.0%	2	1.9%	3	3.3%	5	8.1%	8	16.6%	1	6.7%	0	0.0%	19	4.9%	0.049
Posterolisthesis	5	1.9%	4	3.1%	0.425	0	0.0%	0	0.0%	2	1.8%	1	1.1%	2	2.9%	3	6.3%	0	0.0%	1	50.0%	9	2.3%	0.002
Final diagnosis (spine degeneration)	236	86.4%	109	85.8%	0.867	2	25.0%	44	72.1%	80	75.5%	85	93.4%	69	100.0%	48	100.0%	15	100.0%	2	100.0%	345	86.3%	<0.001

6. Discussion

This study assessed the MRI patterns of lumbar spine degeneration regarding age, sex and lumbar spine disc levels in participants who presented with low back pain at Saint Paul Hospital Millennium Medical College. In this study, female participants were predominant (68.3%) which is also seen in study done in Tanzania by Jacob *et al*(32). The mean age of our participants was 43.4 ± 14 years with an age range of 13 to 86 years. This age distribution is also similar to the study done in Tikur Anbessa Hospital by Biluts H *et al* (39). The commonest age group were between 30-39 years accounting for 26.5% of participants followed by 40-49 years, accounting for 22.8% of the participants. This is also similar to the study done in Thailand by Ruangchainikom *et al* in 2021 and by Sharma *et al* in 2018 in Nepal (22,30).

Our study showed the overall prevalence of lumbar spine degeneration to be 86.3%, where disc degeneration was the most commonly found (83.8%). This is slightly lower to study done by Neelakandan *et al* in India, which showed an overall 93.21% prevalence of lumbar degenerative findings (13). This difference could be due to older population of the study done by Neelakandan *et al* which was 47 ± 16.5 years compared to our study. Studies done in Tanzania by Jacob *et al* also showed a high prevalence of disc degeneration which was 83% (32). Nather *et al* also showed that structural changes to the discs affected 88.4% of patients over 50(3) . The most common disc degeneration type in our study was disc bulging which has a higher prevalence compared to other studies (13,32). This difference may be due to difference in sample size as these studies used smaller sample size or could be due to difference in the population studied.

In our study disc protrusion and extrusion were seen in 21.3% and 7.2% of participants respectively. A study done in Nigeria by Iyidobi *et al* also showed a 26.7% prevalence of disc extrusion to sequestration spectrum (33). A study done in Nepal by Sharma *et al* in 2018 showed the prevalence of disc extrusion and sequestration at 12% and 1.9%, respectively (30). Disc desiccation, annular fissure and disc height loss were also common findings in our study. Studies done in Nepal by Sharma *et al* 2018 showed the prevalence of annular fissure at 21.3% which was lower compared to our study (30). This difference could be result of the variation in prevalence of problem as the studied populations are different. It could also be due to difference in sample size and MRI machine quality as study done in Nepal included 108 patients and 0.35T MRI was used. In addition, the exclusion criteria were also different.

Disc degeneration was slightly more common in males than females in our study. Neelakandan *et al* also showed similar results (13). Studies done in Nigeria by Ogolodom *et al* in 2022 and in

Tanzania by Jacob *et al* also showed higher male prevalence (32,37). However, there is no statistically significant difference between females and males noted both in our study and other studies (3). Unlike our study, a study done by Hangai *et al* in 2008 in Japan showed higher female prevalence that was not statistically significant (21). This difference may be the difference in age of study population, since Hangai *et al* included only above 50 years of age where this could result in higher female prevalence since females have longer life expectancy in Japan. The prevalence of disc degenerative findings was increasing with age in our study which was statistically significant. This was also similar to various studies done (3,13,32).

In this study we found that 61.5% of individuals had endplate degeneration changes. Among these, Modic changes were seen in 36.8% of participants. This prevalence was lower than the study done by population based Finnish twin cohort which showed the prevalence of 55.6% (23). However, in both studies type 2 Modic changes were the most common types followed by type 1 and mixed type 1 and 2. Neelakandan *et al* in India also indicated Type 2 Modic changes as the most common type though in this study overall prevalence was lower (7.97%) compared to our study(13). This difference in prevalence may result from different study population; study done by population based Finnish twin cohort only included male twins while study in India only done with 138 patients.

Schmorl nodes were seen in 12% of individuals in our study, which was higher in comparison to study done in China by Zhang *et al* in 2016 which involved 5288 participants (41). Similar to our study, in this study Schmorl nodes were seen commonly in upper lumbar spine. In our study, osteophytes commonly anterior osteophytes, were seen in 54% of participants, which is lower compared to the multicentric cross-sectional study done by Violante *et al* in 2019 in Italy which showed a prevalence of 76% (42). This difference could be due to the difference in the population studied and different study designs.

We found that endplate degeneration was more common in female than male participants. However, among endplate degenerative changes, Modic changes were more common among males compared to females similar to the study done by Jacob *et al* (32). Posterior osteophytes were also more common in male participants. A study done in Switzerland by Muellner *et al* also showed higher male prevalence of osteophytes (28). However, according to our study, Schmorl nodes and anterior osteophytes were more common among females. In our study, endplate degenerative changes and all its subtypes noted to increase with aging similar to other study (32). On the contrary, study done by Zhang *et al* in 2016 in China showed there was no association of

aging with Schmorl node (41). This could also possibly due to difference in demography and sample size difference. L4/L5 level was the most commonly affected by endplate degeneration affecting 210 (52.5%) of participants similar to other study (32).

Our study found that, 44.3% of participants had MRI findings of posterior element degenerative changes. Facet joint arthropathy was seen in 37.8% of participants. The study done by Eubanks *et al* in 2007 in the US also showed a higher prevalence of facet arthropathy. However, it was a cadaveric anatomic study (27). A study done by Saleem *et al* in Pakistan showed facet joint arthropathy in 55.2% of patients, commonly at the L4/L5 level (20). This variation can be due to difference in study population as Saleem *et al* included only patients already diagnosed with lumbar disc degeneration that can lead to higher prevalence of the facet joint arthropathy. We found the prevalence of facet joint arthropathy to be similar in both females and males which was also similar in study done in Switzerland by Muellner *et al* in 2022 (28).

We found ligamentum flavum thickening in 25.8% of patients. Saleem *et al* in Pakistan found higher ligamentum flavum thickening prevalence than our study, which was seen in 38% of patients commonly at the L4/L5 level (20). However, a study done in Nepal by Sharma *et al* in 2018 showed the prevalence to be lower at 16.7% (30). This variation can be due to difference in study population and MRI quality as Saleem *et al* included only patients already diagnosed with lumbar disc degeneration while Sharma *et al* used 0.3 Tesla MRI machine which might had led to suboptimal evaluation of ligamentum flava.

The L4/L5 level was the most common level affected by posterior element degeneration affecting, 37.8% of participants followed by L5/S1 and L3/L4 levels similar to other studies (15,20,27). The prevalence of posterior element degenerative changes was noted to increase with age similar to other studies (27,29).

In our study, spinal canal stenosis was seen in 56.8% of participants. Studies done in Nepal by Sharma *et al* 2018 and in India by Neelakandan *et al* showed 49.1% and 50% prevalence respectively (13,30). This difference may be due to sample size difference. In addition, Sharma *et al* used spinal canal diameter measurement unlike our study. In our study, spinal canal narrowing was found to be more common in females (59.7%) compared to males (50.4%), similar to the study done in India, though the difference was not statistically significant (13). However, a study done in Tanzania, by Jacob *et al* showed slight male predominance, though it was not statistically significant (32). This discrepancy may be due to the sample size difference or real difference in the prevalence of the problem.

We have found neural foraminal stenosis in 59.5% of patients, which was lower compared to the study done in Tanzania, which showed a prevalence as high as 77% (32). Studies done in Nepal, by Sharma *et al* 2018 also showed a higher prevalence of 76.9% (30). This difference could be due to variation in age as study participants in both studies had higher mean age indicating older participants compared to our study. In our study, it was more common in females than males. However, the sex difference was not statistically significant. Neelakandan *et al* however showed male predominance (13). A study done in Tanzania also showed statistically insignificant male predominance (32). This difference could be due variation in population studied and sample sizes.

Both the spinal canal and neural foraminal narrowing were noted to increase with age in our study. Various studies also support similar findings (13,32). In our study, L4/L5 level was the most commonly affected level by spinal canal stenosis followed by L5/S1 and L3/L4 levels similar to the study done in Tanzania by Jacob *et al* (32). However, a study done by Neelakandan *et al* indicated L5/S1 as the most commonly affected level (13). L4/L5 was the most affected by neural foraminal stenosis, noted in 50% of our participants, followed by L5/S1, L3/L4, L2/L3 and L1/L1 in decreasing order. This is contrary to a study by Neelakandan *et al*, which showed L5/S1 as the most affected level with the prevalence decreasing toward cranial lumbar spine levels (13). This difference could be due to cyclical nature of lumbar spine degeneration; if one level is affected adjacent levels will also be affected due to changing of biomechanical load as the prevalence of L4/L5 was followed by L5/S1 in our study while L5/S1 was followed by L4/L5 in study done by Neelakandan *et al*.

Among 400 patients we studied, 27 (6.75%) patients had spondylolisthesis. Among these, 19 patients had anterolisthesis, while nine had posterolisthesis and one had both. A study done in Egypt by Osman *et al* in 2017 showed the prevalence of spondylolisthesis to be 10.8%, higher compared to our study (35). However, Uduma *et al* 2011 showed a low prevalence of spondylolisthesis in patients with low back pain in a study done in Cameroon, lower compared to our study (34). This variation may be due to difference in sample sizes, as Osman *et al* and Uduma *et al* used sample size of 40 and 48 respectively. Saleem *et al* in Pakistan showed the prevalence of spondylolisthesis to be 9.2% of patients, of which 6.1% was at L5/S1 level (20). This higher prevalence could be due to inclusion of only patients already diagnosed with lumbar disc degeneration by Saleem *et al*. However, another study showed L4/5 as the commonest degenerative spondylolisthesis site (33). In our study, 10 and 8 patients of anterolisthesis were

seen at L4/L5 and L5/S1 levels respectively; and 6 of the nine posterolisthesis were seen at L5/S1 level.

In our study, spondylolisthesis was more common among females, but no statistically significant sex difference was noted. Spondylolisthesis, including both anterolisthesis and posterolisthesis, had significant age correlation similar to that done by Denard PJ *et al* in the US (31).

7. Limitation and strength of the study

Limitations

- Data was collected from lumbar spine MRI reports of different radiologists with different levels of experience in the area which may lead to interobserver variation.
- Only patients for the last three months were included due to the unavailability of MRI images taken a few months or years back from the PACS system.
- Associated factors for lumbar spine degeneration were not assessed since the study was retrospective, and secondary data was used where those data were not found.

Strengths

- A larger sample size and multiple variables that had not been studied previously in our country were included.
- It is primary research in the studied area.

8. Conclusion

MRI findings of lumbar spine degeneration were very common among patients with low back pain with a prevalence of 86.3%. Among these intervertebral discs degeneration was the most common finding. It was followed by spinal canal stenosis, neural foraminal stenosis, anterior osteophytic growth, facet joint arthropathies, Modic changes and ligamentum flavum thickening in decreasing order. Schmorl nodes, posterior osteophytes and spondylolisthesis affected only a small proportion of participants.

Intervertebral disc degeneration, Modic changes, posterior osteophytes and posterolisthesis had male predominance while other types were seen more in female participants. Facet joint degeneration had a similar prevalence in both females and males. No statistically significant sex difference in the prevalence of most lumbar spine degeneration types was seen. All types of lumbar spine degeneration prevalence increase with age. L4/L5 and L5/S1 lumbar spine levels were the most commonly affected by degenerative changes.

9. Recommendations

▪ For policy makers

- Support for research in the area for further investigation to advance understanding of the condition and improve diagnostic and treatment strategies.

▪ For researchers

- Multi-centered and population-based studies with longer study period are recommended to make conclusion on general population
- Prospective study is also recommended to study factors associated with lumbar spine degeneration

▪ For the radiology department

- Standard reporting template should be developed by the department that will reduce interobserver variation by reporting radiologists
- MRI axial images should be taken in contiguous manner to better characterize disc degeneration and neural foraminal narrowing.

10. References

1. Simon J, McAuliffe M, Shamim F, Vuong N, Tahaei A. Discogenic low back pain. Vol. 25, Physical Medicine and Rehabilitation Clinics of North America. W.B. Saunders; 2014. p. 305–17.
2. Kushchayev S V., Glushko T, Jarraya M, Schuleri KH, Preul MC, Brooks ML, et al. ABCs of the degenerative spine. Vol. 9, Insights into Imaging. Springer Verlag; 2018. p. 253–74.
3. Näther P, Kersten JF, Kaden I, Irga K, Nienhaus A. Distribution patterns of degeneration of the lumbar spine in a cohort of 200 patients with an indication for Lumbar MRI. *Int J Environ Res Public Health*. 2022 Mar 1;19(6).
4. Emch TM, Modic MT. Imaging of lumbar degenerative disk disease: History and current state. Vol. 40, *Skeletal Radiology*. 2011. p. 1175–89.
5. James-Belin E, Ostertag A, Couzi E, Petrover D, Yelnik A, Orcel P, et al. Economic impact of work disability due to chronic low back pain from the patient perspective. *Rev Epidemiol Sante Publique*. 2023 Aug 1;71(4):101858.
6. Yang H, Hurwitz EL, Li J, de Luca K, Tavares P, Green B, et al. Bidirectional comorbid associations between back pain and major depression in US adults. *International Journal of Environmental Research and Public Health*. 2023 Feb 27;20(5):4217.
7. Wong CK, Mak RY, Kwok TS, Tsang JS, Leung MY, Funabashi M, et al. Prevalence, incidence, and factors associated with non-specific chronic low back pain in community-dwelling older adults aged 60 years and older: A systematic review and meta-analysis. Vol. 23, *Journal of Pain*. Elsevier B.V.; 2022. p. 509–34.
8. Louw QA, Morris LD, Grimmer-Somers K. The prevalence of low back pain in Africa: a systematic review. *BMC Musculoskeletal Disorders*. 2007 Nov 1;8(1).
9. Jegnie M, Afework M. Prevalence of self-reported work-related lower back pain and its associated factors in Ethiopia: A systematic review and meta-analysis. Gualano MR, editor. *Journal of Environmental and Public Health*. 2021 Sep 23;2021:1–19.
10. Shobeiri E, Khalatbari MR, Taheri MS, Tofighirad N, Moharamzad Y. Magnetic resonance imaging characteristics of patients with low back pain and those with sciatica. *Singapore Medical Journal*. 2009 Jan 1, 50(1):87–93.
11. Barrey CY, Le Huec JC. Chronic low back pain: Relevance of a new classification based on the injury pattern. Vol. 105, *Orthopaedics and Traumatology: Surgery and Research*. Elsevier Masson SAS; 2019. p. 339–46.

12. Watanabe T, Otani K, Sekiguchi M, Konno SI. Disc degeneration and low back pain. A cross-sectional community study. *Fukushima Journal of Medical Science*. 2022 Aug 18;68(2):97–107
13. Neelakandan A, Daniel A, Pitchai PA, Arulraj E. Evaluation of patterns of lumbar spine degeneration among patients based on radiological analysis. *EAS Journal of Radiology and Imaging Technology*. 2021; Available from: <https://www.easpublisher.com>
14. De Schepper EIT, Damen J, Van Meurs JBJ, Ginai AZ, Popham M, Hofman A, et al. The association between lumbar disc degeneration and low back pain the influence of age, gender and individual radiographic features. *Spine*, vol. 35, no. 5, Mar. 2010, pp. 531–536.
15. Suthar P, Patel R, Mehta C, Patel N. MRI evaluation of lumbar disc degenerative disease. *Journal of Clinical and Diagnostic Research*. 2015 Apr 1;9(4):TC04–9.
16. Urrutia J, Besa P, Campos M, Cikutovic P, Cabezon M, Molina M, et al. The Pfirrmann classification of lumbar intervertebral disc degeneration: an independent inter- and intra-observer agreement assessment. *European Spine Journal*. 2016 Sep 1;25(9):2728–33.
17. Parizel PM, Van Hoyweghen AJL, Bali A, Van Goethem J, Van Den Hauwe L. The degenerative spine: pattern recognition and guidelines to image interpretation. In: *Handbook of Clinical Neurology*. Elsevier B.V.; 2016. p. 787–808.
18. Modic MT, Ross JS. Lumbar degenerative disk disease. Vol. 245, *Radiology*. 2007. p. 43–61.
19. Manchikanti L, Pampati V, Rivera J, Fellows B, Beyer C, Damron K. role of facet joints in chronic low back pain in the elderly: A Controlled Comparative Prevalence Study. *Pain Practice*. 2001 Dec;1(4):332–7.
20. Saleem S, Aslam HM, Rehmani MAK, Raees A, Alvi AA, Ashraf J. Lumbar disc degenerative disease: Disc degeneration symptoms and magnetic resonance image findings. *Asian Spine J*. 2013 Dec;7(4):322–34.
21. Hangai M, Kaneoka K, Kuno S, Hinotsu S, Sakane M, Mamizuka N, et al. Factors associated with lumbar intervertebral disc degeneration in the elderly. *Spine Journal*. 2008 Sep;8(5):732–40.
22. Ruangchainikom M, Daubs MD, Suzuki A, Xiong C, Hayashi T, Scott TP, et al. Patterns of lumbar disc degeneration: Magnetic Resonance Imaging analysis in symptomatic subjects. *Asian Spine J*. 2021;15(6):799–807.
23. Wang Y, Videman T, Battié MC. Modic changes: Prevalence, distribution patterns, and association with age in white men. *Spine Journal*. 2012 May;12(5):411–6.

24. Mok FPS, Samartzis D, Karppinen J, Fong DYT, Luk KDK, Cheung KMC. Modic changes of the lumbar spine: Prevalence, risk factors, and association with disc degeneration and low back pain in a large-scale population-based cohort. *Spine Journal*. 2016 Jan 1;16(1):32–41.
25. Kanna RM, Shetty AP, Rajasekaran S. Patterns of lumbar disc degeneration are different in degenerative disc disease and disc prolapse Magnetic Resonance Imaging analysis of 224 patients. *Spine Journal*. 2014 Feb 1;14(2):300–7.
26. Sonne-Holm S, Jacobsen S, Røvsing H, Monrad H. The epidemiology of Schmorl's nodes and their correlation to radiographic degeneration. *European Spine Journal*. 2013;22(8):1907–12.
27. Eubanks JD, Lee MJ, Cassinelli E, Ahn NU. Prevalence of lumbar facet arthrosis and its relationship to age, sex, and race an anatomic study of cadaveric specimens; *Spine*. 2007 Sep;32(19):2058–62.
28. Muellner M, Kreutzinger V, Becker L, Diekhoff T, Pumberger M, Schömig F, et al. Unexpected sex differences in the relationship of sacroiliac joint and lumbar spine degeneration. *Diagnostics*. 2022 Feb 1;12(2).
29. Kolte VS, Khambatta S, Ambiyev MV. Thickness of the ligamentum flavum: Correlation with age and its asymmetry Magnetic Resonance Imaging study. *Asian Spine J*. 2015;9(2):245–53.
30. Sharma R, Tiwari A, Dwivedi R. Pattern of lumbar MRI changes in patients with chronic low back pain in a tertiary care center. *Journal of Lumbini Medical College*. 2018 Dec 29;6(2).
31. Denard PJ, Holton KF, Miller J, Fink HA, Kado DM, Yoo JU, et al. Lumbar spondylolisthesis among elderly men: Prevalence, correlates and progression. *Spine (Phila Pa 1976)*. 2010 May;35(10):1072–8.
32. Jacobs M, Akoko LO, Kazema RR. Lumbar disc degenerative disease: Magnetic Resonance Imaging findings in patients with low back pain in Dares Salem. *East and Central African Journal of Surgery*. 2015;20:122–31.
33. Iyidobi EC, Obande BO, Ekwunife RT. Pattern of MRI findings in patients with low back pain at National Orthopaedic Hospital, Enugu Nigeria. *Journal of Biosciences and Medicines*. 2018;06(04):85–94.
34. Uduma FU, Ongolo P, Assam G, Fokam P, Motah M. Evaluation of pattern of Magnetic Resonance Images of lumbo-sacral spine in Cameroon-A Pioneer Study. Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journal of Medical Research, 2011 Mar 15;11(2):31–41.

35. Osman NM, Fawzy FM, Lateef HM. MRI evaluation of lumbar disc degenerative disease. *The Egyptian Journal of Hospital Medicine*. 2017 Jul;68(2):1202–7.
36. Ongeti KW, Ogeng'o J, Gakuu LN, Saidi H, Pulei A. Prolapsed intervertebral disc in an African population: Kenyan Experience. *East African Orthopaedic Journal*. 2012;6(1):12–5.
37. Ogolodom MP, Ugwuanyi DC, Onwuka MC, Egbeyemi OO, Chiaghanamm NO, Omita E, et al. Magnetic Resonance Imaging findings in patients with low back pains and its associations with demographic variables and body mass index in Onitsha Nigeria. *European Scientific Journal*, ESJ. 2022 Jul 31;18(24):21.
38. Gebrewold Y, Tesfaye B. Does lumbar MRI predict degree of disability in patients with degenerative disc disease? A prospective cross-sectional study at University of Gondar Comprehensive Specialized Hospital, North West Ethiopia, 2020. *BMC Med Imaging*. 2022 Dec 1;22(1).
39. Hagos Biluts, Tadios Munie, Mersha Abebe. Review of lumbar disc diseases at Tikur Anbessa Hospital. *Ethiop Med J*. 2012 Jan;1:57-65.
40. Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: Version 2.0 Recommendations of the combined task forces of the North American Spine Society, the American Society of Spine Radiology and the American Society of Neuroradiology. Vol. 14, *Spine Journal*. Elsevier Inc.; 2014. p. 2525–45.
41. Zhang J, Zhao F, Wang FL, Yang YF, Zhang C, Cao Y, et al. Identification of lumbar disc disease hallmarks: a large cross-sectional study. *Springer plus*. 2016 Dec 1;5(1).
42. Violante FS, Zompatori M, Lovreglio P, Apostoli P, Marinelli F, Bonfiglioli R. Is age more than manual material handling associated with lumbar vertebral body and disc changes? A cross-sectional multicentre MRI study. *BMJ Open*. 2019 Sep 1;9(9).
43. Pfirrmann CWA, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic Resonance classification of lumbar intervertebral disc degeneration. *Spine*. 2001 Sep;26(17):1873–8

11. Annex

Data collection template (tables 2 and 3) on MRI patterns of lumbar spine degeneration in patients presented with low back pain at Saint Paul's Hospital Millennium Medical College from April to June 2024

Table 5. Data collection template on MRI patterns: disc degeneration and end plate lesions of lumbar spine degeneration

	S No.										
	Patient MRN:										
	Sociodemographic data: Age: ____ yr Sex: Female Male:										
Lumbar spine level	Disc degeneration							Osteophytes		End plate lesions	
	Disc desiccation grade	Disc height loss	Disc bulge	Disc protrusion	Disc extrusion	Disc sequestration	Annular fissure	Anterior Vertebral body Osteophytes	Posterior Vertebral body Osteophytes	Modic change types	Schmorl nodes
	(1-5)	Yes (1), No (0)	No (0), diffuse bulge, (1), asymmetric bulge (2)	Yes (1), No (0)	Yes (1), No (0)	Yes (1), No (0)	Yes (1), No (0)	No (0), yes (1)	No (0), yes (1)	Absent (0), type 1 (1), type 2(2), type 3 (3), mixed 1 and 2 (4), mixed 2 and 3(5), mixed 1 and 3(6), mixed all (7)	Absent (0), upper endplate (1), lower endplate (2), both(3)
	L1/2										
	L2/3										
	L3/4										
	L4/5										
	L5/S1										

Table 6. Data collection template on MRI patterns: facet joint arthropathy, ligamentum flavum thickening, spinal canal stenosis, neural foraminal stenosis and spondylolisthesis) of lumbar spine degeneration

S No.									
Patient MRN:									
Sociodemographic data:			Age: ____ year		Sex: Female Male				
Lumbar spine level	Facet joint arthropathy grade	Ligamentum flavum thickening	Canal stenosis (and grading)			Spondylolisthesis grade		Final diagnosis	Remark
	Normal (0), mild (1), moderate (2), severe (3)		Yes (1), No (0)	Spinal canal	Left neural foramina	Right neural foramina	Anterolisthesis		
			Normal (0), mild (1), moderate (2), severe (3)	Normal (0), mild (1), moderate (2), severe (3)	Normal (0), mild (1), moderate (2), severe (3)	(1-4)	(1-4)		
L1/2									
L2/3									
L3/4									
L4/5									
L5/S1									

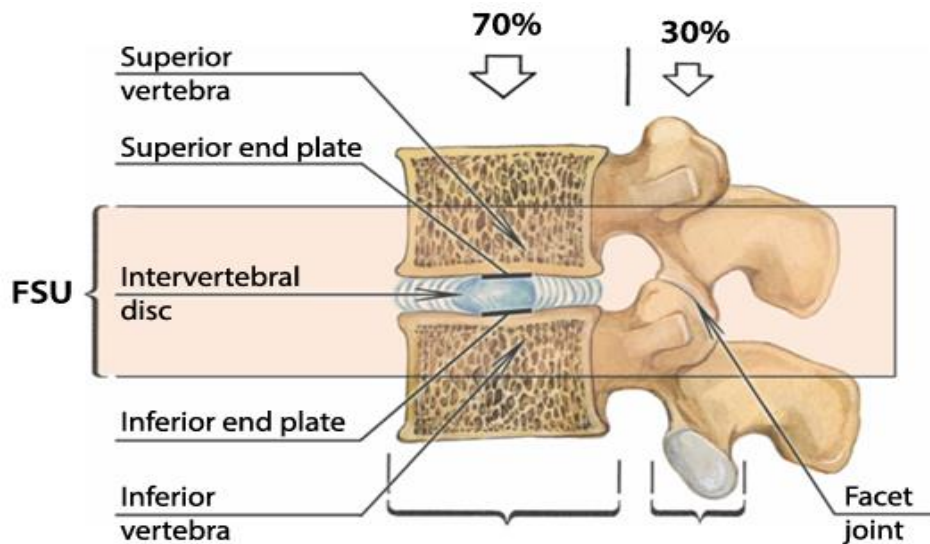


Figure 6. Functional spinal unit (FSU). It represents the smallest motion segment of the spine and exhibits biomechanical characteristics similar to those of the entire spine. Around 70 % of axial compression is transmitted by the vertebral body and the intervertebral discs, with the remaining 30% is distributed through the facet joints (2)

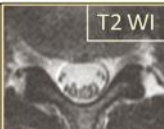
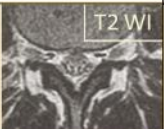
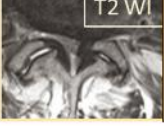
Grade		Central canal		Lateral recess		Foraminal
Grade 0 Normal						
Grade 1 Mild	Anterior CSF space is mildly obliterated, nerves in cauda equina can be clearly separated from each other.		Narrowing of the lateral recess without root flattening or compression.		Mild foraminal stenosis (<50%).	
Grade 2 Moderate	Cauda equina aggregation.		Narrowing of the lateral recess with root flattening and some preservation of the space lateral to the root in the lateral recess.		Moderate foraminal stenosis (>50%).	
Grade 3 Severe	Entire cauda equina as a bundle.		Severe root compression with severe narrowing and complete obliteration of CSF space surrounding or lateral to the nerve root.		Severe foraminal stenosis (nerve root collapse).	

Figure 7. A grading of severity of central canal, lateral recess and foraminal stenosis on the lumbar spine (2)

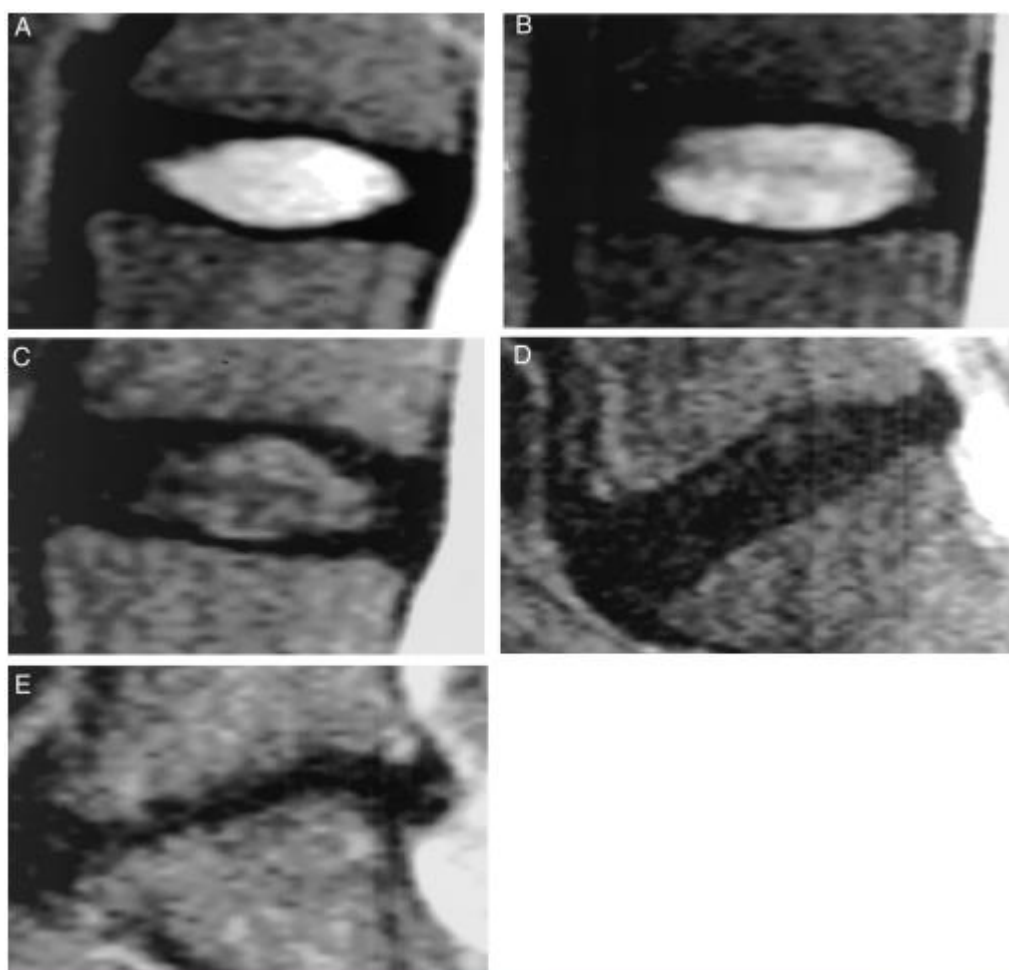


Figure 8.(A–E)- Pfirman grading system for lumbar disc desiccation. Grading is performed on T2-weighted midsagittal images (43).

Grade I (A): The structure of the disc is homogeneous with normal disc height and bright signal intensity.

Grade II (B): The disc is inhomogeneous, with a hyperintense white signal. The distinction between nucleus and annulus is clear, and the disc height is normal, with or without horizontal gray bands.

Grade III (C): The disc is inhomogeneous, with intermediate gray signal intensity. The distinction between nucleus and annulus is unclear, and the disc height is normal or slightly decreased.

Grade IV (D): The disc is inhomogeneous, with hypointense dark gray signal intensity. The distinction between nucleus and annulus is lost, and the disc height is normal or moderately decreased.

Grade V (E): The disc is inhomogeneous, with a hypointense black signal intensity. The distinction between nucleus and annulus is lost, and the disc space is collapsed.

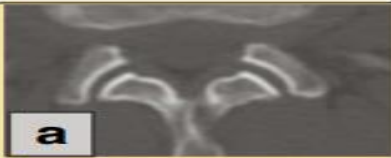
Grade	Facet joint osteoarthritis	
<u>Grade 0</u> Normal		 a
<u>Grade 1</u> Mild	Mild narrowing and joint irregularity.	 b
<u>Grade 2</u> Moderate	Moderate narrowing and joint irregularity, sclerosis, and osteophyte formation.	 c
<u>Grade 3</u> Severe	Severe narrowing and almost total loss of joint space, sclerosis, and osteophyte formation	 d

Figure 9. A radiological grading of facet joint arthropathy (2)



Figure 10. Types of Modic changes; Modic I (b and c), Modic II (e and f) and Modic III (h and i) (2)

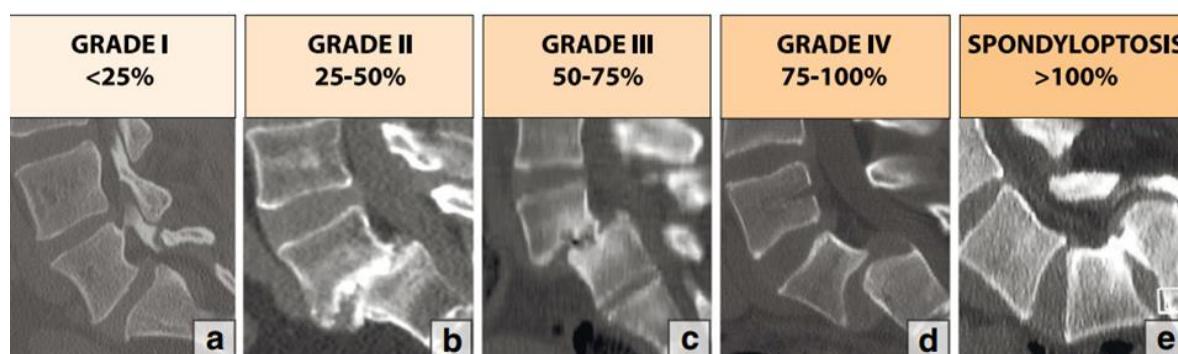


Figure 11. Meyerding classification of spondylolisthesis(2)

Assurance of Principal Investigator

I the undersigned agree to accept all responsibilities for the scientific and ethical conduct of the research project. I will provide timely progress report to my advisors and seek the necessary advice and approval from my primary advisors in the course of the research. I will communicate timely to my advisors and all stakeholders involved in the study including any source of funding for this research.

Name of the student: Rabisra Waktola (MD, Radiology Resident)

Signature: _____

Date: _____

Approval of the Clinical Advisor

Name of the primary advisor: Dr. Hilaludin Mohammed (Assistant Professor of Radiology)

Signature: _____

Date: _____

Approval of the Public health Advisor

Name of the primary advisor: - Mr. Belayneh Lulseged (MPH, Assistant Professor)

Signature: _____

Date: _____