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Review Article

Magnetic Resonance Imaging Patterns of the Lumbosacral Spine in Low Back Pain at LASUTH, Lagos: A Narrative Review of Findings and Clinical Implications

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Abstract

Background: Low back pain (LBP) is one of the leading causes of disability worldwide and represents a major public health burden. Magnetic resonance imaging (MRI) is the imaging modality of choice for evaluating spinal pathology because of its superior soft tissue resolution. However, there is limited local data describing the spectrum of MRI findings among patients with chronic low back pain in Nigeria.

Objective: This review narrated the spectrum of lumbosacral MRI findings in patients presenting with non-traumatic low back pain at Lagos State University Teaching Hospital (LASUTH).

Methods: This hospital-based cross-sectional study evaluated lumbosacral MRI examinations of patients with chronic non-traumatic low back pain. MRI findings including disc degeneration, disc herniation, spinal canal stenosis, foraminal stenosis, ligamentum flavum hypertrophy, facet arthropathy, Modic changes, and nerve root compression were documented.

Results: Degenerative spinal changes constituted the predominant MRI abnormalities. Disc degeneration, disc herniation, foraminal stenosis, spinal canal stenosis, ligamentum flavum hypertrophy, and facet arthropathy were the commonest findings. Disc degeneration and exiting nerve root compression demonstrated significant associations with severe pain. Increasing age and longer symptom duration were associated with a higher prevalence of degenerative MRI findings, whereas most abnormalities showed no significant association with body mass index. MRI demonstrated has a diagnostic sensitivity (98%) in identifying the underlying causes of low back pain.

Conclusion: Degenerative lumbar spine disease is the predominant cause of chronic low back pain among patients undergoing MRI at LASUTH. MRI remains an indispensable diagnostic tool for identifying clinically significant spinal abnormalities and should be considered early in elderly patients and those with persistent or severe symptoms to facilitate appropriate management and improve patient outcomes

Keywords: Aetiology, Radiodiagnosis, Low back pain, MRI,

Introduction

Low back pain (LBP) is defined as pain, stiffness, or discomfort localized between the lower border of the twelfth thoracic vertebra and the gluteal folds, with or without radiation to the lower limbs (Abuya et al., 2023; Irurhe et al., 2012). It is one of the most common musculoskeletal disorders worldwide and represents a leading cause of disability, work absenteeism, and reduced quality of life. Approximately 60–80% of individuals experience at least one episode of LBP during their lifetime, with recurrence occurring in up to 90% of affected individuals (Adeyinka & Omidiji, 2011; Chiarotto & Koes, 2022).

The burden of LBP continues to increase globally owing to population ageing, sedentary lifestyles, obesity, occupational hazards, and physical inactivity (Karran et al., 2020). In Africa, lifetime prevalence ranges from 28% to 74%, comparable to Western populations, while studies in Nigeria have reported prevalence rates between 38% and 73.5% (Adeyinka & Omidiji, 2011). In rural settings, heavy manual labour, farming, water carrying, poor ergonomic practices, poverty, and limited healthcare access further increase susceptibility to chronic low back pain (Igwesi-Chidobe et al., 2019).

Low back pain is broadly classified into specific and non-specific types. Specific LBP results from identifiable pathological conditions such as infections, tumours, fractures, inflammatory diseases, congenital abnormalities, and degenerative disorders, whereas non-specific LBP, accounting for approximately 80–90% of cases, lacks a clearly identifiable anatomical cause and is believed to result from a complex interaction of biological, psychological, and social factors (Yang et al., 2017; Chiarotto & Koes, 2022). Etiologically, LBP may also be categorized into mechanical, non-mechanical, and visceral causes. Mechanical disorders account for nearly 90% of presentations and include degenerative disc disease, lumbar spondylosis, disc herniation, spinal stenosis, spondylolisthesis, and facet joint arthropathy (Chou et al., 2011).

Despite careful clinical history and physical examination, the underlying cause of LBP remains unidentified in a significant proportion of patients. Consequently, imaging plays an important role in identifying structural abnormalities, excluding serious pathology, and guiding treatment decisions.

Radiological evaluation of LBP has evolved considerably over the past century. Plain radiography was the earliest imaging modality but remains limited to assessment of osseous structures. Myelography, introduced in the early twentieth century, improved visualization of the spinal canal but was invasive and has largely been replaced. Computed tomography (CT) subsequently provided detailed cross-sectional imaging of bony structures; however, magnetic resonance imaging (MRI) has become the gold standard for evaluating spinal disorders because of its superior soft tissue contrast, multiplanar capability, and absence of ionizing radiation (Brinjikji et al., 2015).

MRI provides detailed visualization of intervertebral discs, vertebral bodies, spinal canal, nerve roots, ligaments, spinal cord, and surrounding soft tissues. It is highly sensitive for detecting disc degeneration, disc herniation, spinal canal stenosis, foraminal stenosis, ligamentum flavum hypertrophy, Modic endplate changes, infections, inflammatory conditions, and spinal tumours (Hazra et al., 2017; Hwang et al., 2016). Unlike CT and conventional radiography, MRI directly demonstrates neural compression and soft tissue abnormalities responsible for pain.

Although MRI is highly sensitive, imaging findings should always be interpreted alongside clinical presentation because degenerative abnormalities may also occur in asymptomatic individuals. Current international guidelines therefore recommend MRI primarily for patients with red-flag symptoms, neurological deficits, suspected infection or malignancy, or persistent symptoms despite conservative management (Sharma et al., 2020).

The lumbar spine consists of five lumbar vertebrae (L1–L5), the sacrum, intervertebral discs, facet joints, ligaments, muscles, spinal cord, cauda equina, and nerve roots. The vertebral bodies bear body weight, while the intervertebral discs absorb compressive forces and permit spinal mobility. Degeneration of any of these structures may produce pain through mechanical instability, inflammatory mediators, or nerve root compression.

Intervertebral disc degeneration is the most frequent pathological finding associated with chronic LBP. Degenerative changes include dehydration of the nucleus pulposus, annular fissuring, reduced disc height, disc bulging, disc protrusion, extrusion, and sequestration. Progressive degeneration may also lead to facet joint arthropathy, ligamentum flavum hypertrophy, spinal canal stenosis, and neural foraminal narrowing (An et al., 2004). Inflammatory changes involving vertebral endplates (Modic changes) and vertebral endplate defects such as Schmorl's nodes are additional MRI features associated with degenerative spinal disease.

MRI grading of disc degeneration commonly employs the Pfirrmann classification, which categorizes degeneration into five grades based on disc structure, signal intensity, disc height, and distinction between nucleus pulposus and annulus fibrosus. Increasing Pfirrmann grades correlate with progressive disc degeneration and are widely used in both clinical practice and research.

The Lagos State University Teaching Hospital (LASUTH) houses a modern 1.5 Tesla MRI scanner, providing comprehensive evaluation of patients presenting with chronic low back pain. However, despite increasing MRI utilization in Nigeria, there remains limited local data describing the spectrum and frequency of MRI abnormalities in patients with non-traumatic LBP.

This study therefore seeks to document the spectrum of lumbosacral MRI findings among patients presenting with chronic non-traumatic low back pain at LASUTH, determine the frequency of individual abnormalities, identify the common causes of LBP in the local population, and contribute evidence that may improve diagnosis, clinical management, and healthcare planning.

Burden of Low back pain

Low back pain is among the leading causes of disability worldwide and contributes substantially to healthcare expenditure, reduced productivity, and socioeconomic burden. Globally, 70–85% of adults will experience LBP during their lifetime, while recurrent episodes occur in nearly 90% of affected individuals (National Institute of Neurological Disorders and Stroke, 2023).

Pain may originate from muscles, ligaments, intervertebral discs, vertebral bodies, facet joints, nerve roots, or surrounding vascular structures. Specific causes include fractures, spinal infections, tumours, inflammatory disorders, and disc herniation, whereas non-specific LBP constitutes approximately 80–90% of all presentations (Chang et al., 2006).

Clinical assessment remains the cornerstone of diagnosis. Nevertheless, MRI becomes indispensable in patients with persistent symptoms, neurological deficits, or suspected serious spinal pathology. MRI accurately depicts soft tissue abnormalities, neural compression, disc disease, spinal stenosis, and inflammatory changes, thereby facilitating timely diagnosis and appropriate treatment (Modic et al., 1988).

Low back pain is a significant cause of morbidity in our setting, resulting in a significant amount of missed workdays per year (Gawri et al., 2013; Karran et al., 2020).

The lifetime probability of an adult having low back pain is as high as 30% to 79.2% worldwide. In a systematic review, the lifetime prevalence of low back pain in Africa was between 28% to 74% and were almost at par to the rates in Western societies and stands as the second most common cause of adult disability (Hazra et al., 2017). Previous studies in Nigeria have reported a wide range of prevalence of low back pain of 38% to

73.5% (Adeyinka & Omidiji, 2011). The actual cause of low back pain seams to differ along urban to rural region. In the USA lumbar strain accounted for about 70% while in a rural area in south western Nigeria lumbar spondylosis is the most prevalent cause in about 80% of cases (Omidiji, 2010). However, it will be more pragmatic to compare these regions in the same locality and race in order to note the deductions and make possible generalization, which is one of the reasons for this research.

Unfortunately, the basis of low back pain is not always apparent, with 80% of low back pain cases lacking a specific diagnosis. However, imaging abnormalities are a critical component of diagnosing low back pain (Suparyanto & Rosad, 2020). MRI is a useful imaging modality due to its non-use of ionizing radiation, high soft tissue resolution and ability to generate multi-planar images without any known biohazard effects (Standring, 2016).

The study seeks to address the limited studies regarding the spectrum of MRI findings in patient with low back pain within the local context. It aims to enhance radiological data on this condition in Nigeria, with the goal of improving diagnostic accuracy and management outcomes, potentially reducing morbidity and mortality.

This study aims to review the lumbosacral spine MRI images of patients experiencing non-traumatic low back pain at Lagos State University Teaching Hospital (LASUTH), documenting the spectrum of findings.

MRI Anatomy of the Lumbar Spine

The lumbar spine comprises five lumbar vertebrae connected by intervertebral discs, facet joints, ligaments, and paraspinal muscles. The vertebral bodies contain fatty and hematopoietic marrow that demonstrate characteristic MRI signal intensities. Intervertebral discs consist of the nucleus pulposus, annulus fibrosus, and cartilaginous endplates. Healthy discs demonstrate high T2 signal intensity due to abundant water content, whereas degeneration results in progressive signal loss and reduction in disc height.

The spinal canal contains the distal spinal cord, conus medullaris, cauda equina, and exiting nerve roots. The ligamentum flavum, posterior longitudinal ligament, and facet joints contribute to spinal stability but may undergo hypertrophy during degeneration, producing spinal canal or foraminal stenosis. Familiarity with normal MRI anatomy is essential for accurate identification of pathological changes.

The lumbosacral spine receives innervation from various nerves, encompassing the spinal cord, cauda equina, and sciatic nerve (Waxenbaum et al., 2022). The spinal cord concludes its course at the first lumbar vertebra, while the cauda equina, a cluster of spinal nerves, extends further into the sacrum and coccyx regions. The sciatic nerve, the body's largest nerve, emerges from the sacral plexus, formed by nerve roots L4 to S4 (Drake et al., 2015) (Figure 1).

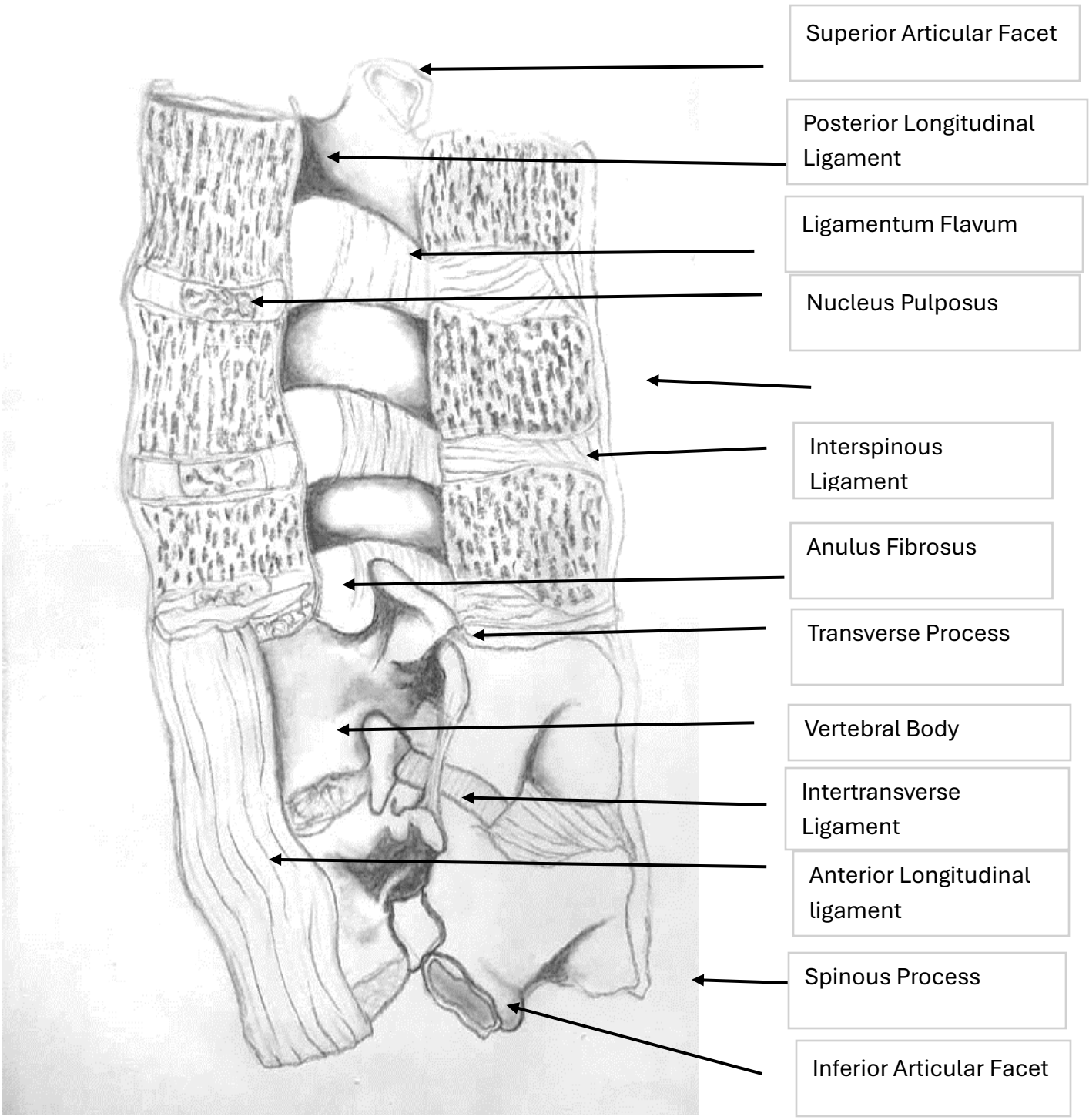

Figure 1: A graphic schematic diagram of the sagittal cross-section of the lumbar spine.

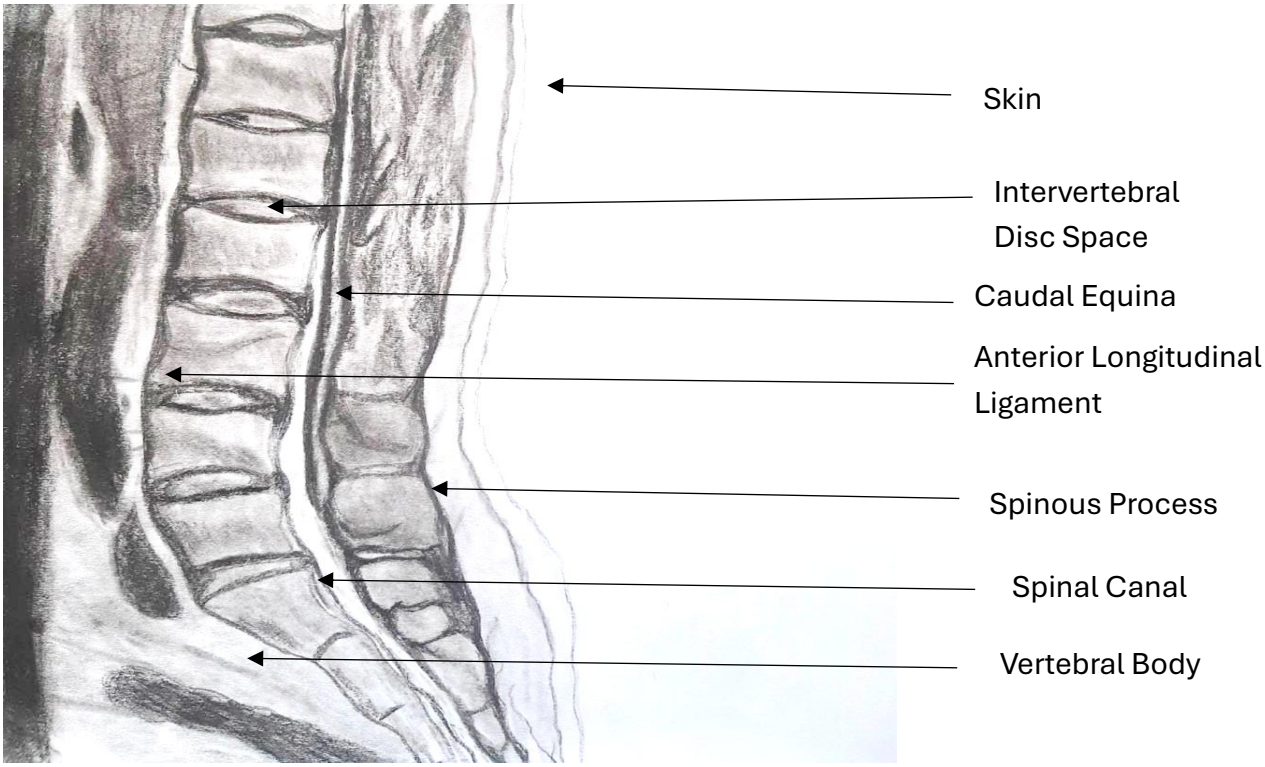

Figure 2: A graphic schematic sagittal cross- section diagram of the lumbar spine

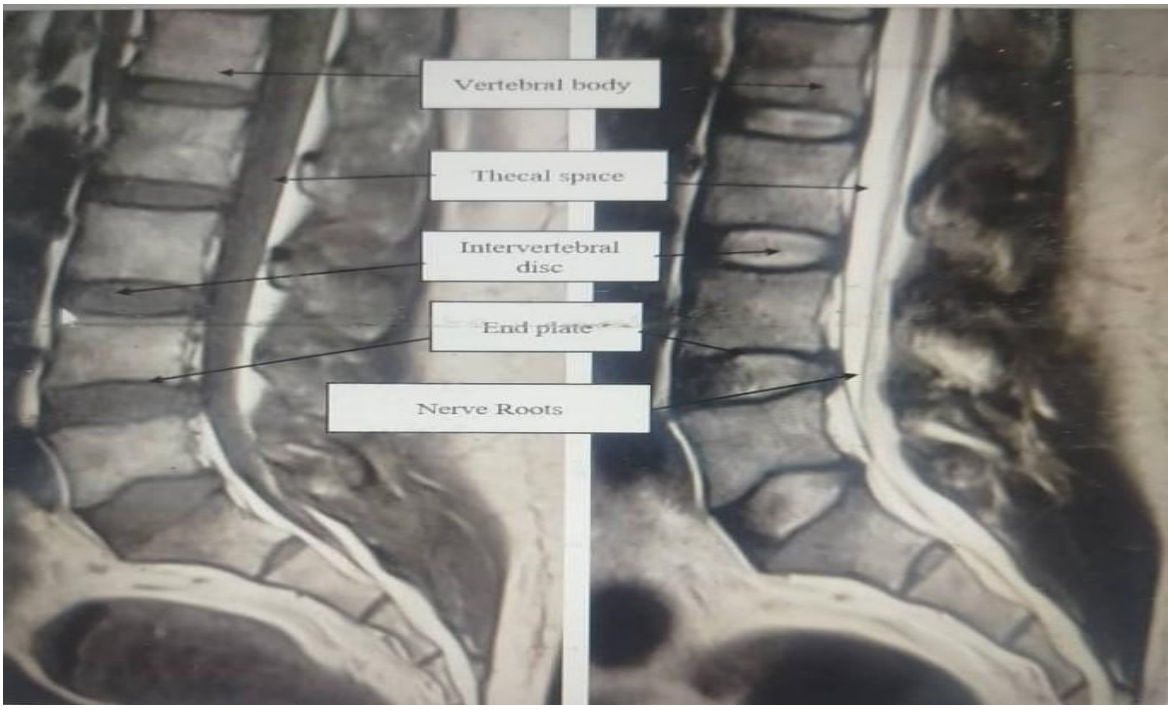

Figure 3: A T2- and T1- weighted magnetic resonance image showing the sagittal cross – sectional view of the lumbar spine.

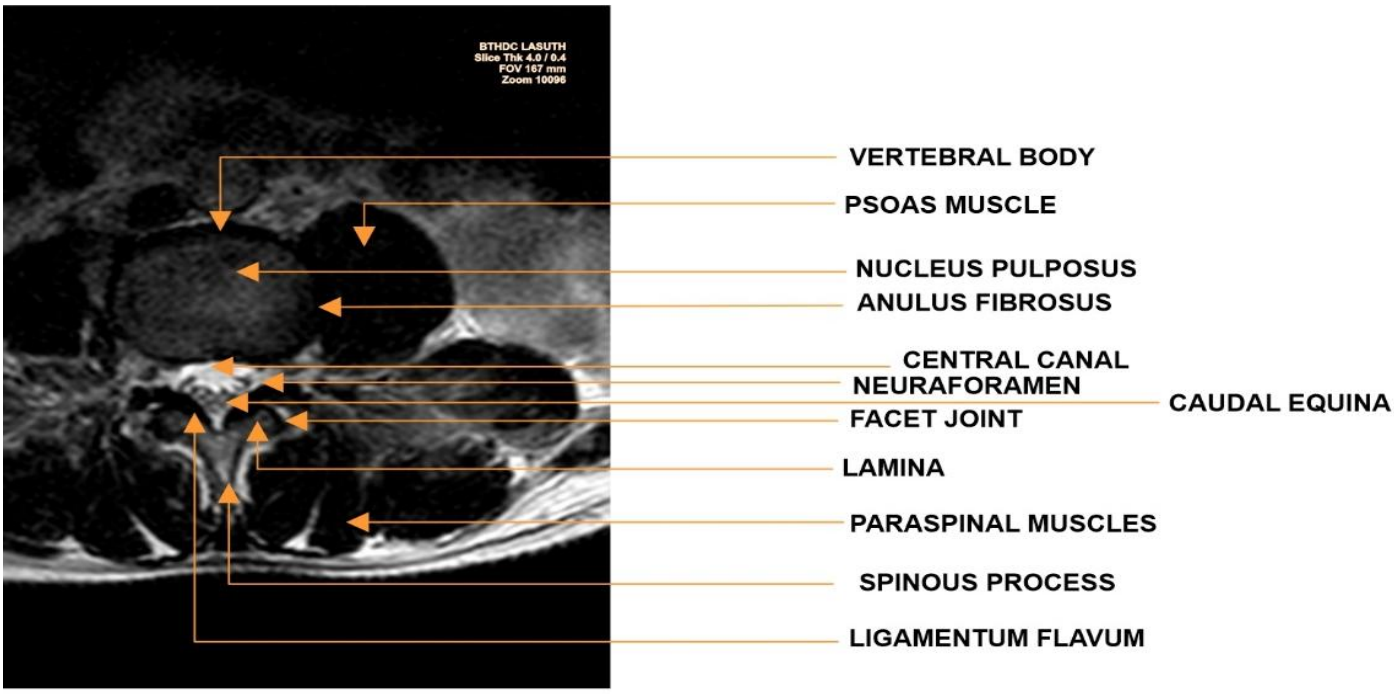

Figure 4: A T2-weighted magnetic resonance image showing the axial cross – sectional view of the lumbar spine

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Aetiologies of Low back pain

Low back pain arises from diverse pathological processes including degenerative, traumatic, inflammatory, infective, congenital, neoplastic, and metabolic disorders. Mechanical causes remain the most common and include degenerative disc disease, lumbar spondylosis, facet arthropathy, spinal stenosis, spondylolisthesis, and muscle strain. Genetic predisposition, obesity, aging, poor posture, repetitive lifting, smoking, and occupational stress increase susceptibility to degenerative spinal disease.

Intervertebral disc degeneration results from progressive biochemical and structural alterations involving loss of proteoglycans, dehydration, annular fissuring, matrix degradation, cytokine release, and reduced disc height. These changes produce mechanical instability and neural compression that contribute to pain.

Degenerative Disease of the Spine

Degenerative abnormalities represent the commonest MRI findings in chronic LBP. Disc degeneration progresses from dehydration of the nucleus pulposus to disc bulging, protrusion, extrusion, sequestration, and eventual disc collapse. MRI grading is commonly performed using the Pfirrmann classification, which categorizes degeneration into five grades according to disc signal intensity, morphology, and height.

Vertebral endplate abnormalities, known as Modic changes, are important MRI markers of degeneration. Type I changes indicate active inflammatory marrow oedema, Type II reflects fatty marrow replacement, while Type III represents subchondral sclerosis. Type I changes demonstrate the strongest association with painful LBP.

Schmorl's nodes represent herniation of disc material through vertebral endplates. Although frequently encountered on MRI, they are often incidental findings and are less strongly associated with chronic pain than Modic changes. Additional degenerative MRI findings include facet joint arthropathy, ligamentum flavum hypertrophy, spinal canal stenosis, neural foraminal narrowing, nerve root compression, and spondylolisthesis. MRI remains the preferred imaging modality because it simultaneously evaluates bone, discs, ligaments, neural structures, and surrounding soft tissues.

Diskogenic Stenosis

The intervertebral discs (IVDs) is made up of three major components namely, the Annulus Fibrosus (AF), central nucleus Pulposus (NP), and the end plate (Jensen, Karppinen, et al., 2008; Laustsen & Bech-Azeddine, 2016; Jensen, Leboeuf-Yde, et al., 2012). In healthy intervertebral disc, the nucleus Pulposus has a high glycosaminoglycan and water content which provides resistance to compression, whereas the Annulus Fibrosus contains collagen-rich concentric lamellar sheets. At the disco-vertebral junction (DVJ), the 1mm thick cartilaginous endplate (CEP) is present which serves to attach the intervertebral disc to the vertebral body and facilitates the movement of solutes into and out of the IVD through nearby capillaries within the bony vertebral endplate (Hwang et al., 2016). The consensus among researchers was that a variety of multifactorial physiological and pathological circumstances, including apoptosis, cellular senescence, mechanical stress, rises in degradative enzymes, and elevated levels of inflammatory substances, can cause IVD degeneration (Yu et al., 2012). Pain symptoms from Diskogenic stenosis are usually from nociceptors in the cartilaginous endplates, in the outer Annulus Fibrosus as well as in the periosteum of the vertebral bodies (Ruiz-España et al., 2015). The most prevalent proteoglycan in the intervertebral disc, aggrecan, is lost by fragmentation, which lowers the disc height. This neurological consequence results in back discomfort (Urrutia et al., 2016; Sher et al., 2019). Intervertebral disc degeneration occurs naturally as people age, much like wrinkles on the skin. Degenerative disc disease is a painful disorder that is similar to the disc aging more quickly.

End-plate changes

The initial signs of intervertebral disc degeneration manifest as changes in the vertebral end plates. In a healthy state, vertebral end plates exhibit uniform thickness, a lack of protrusion into the vertebrae, and a homogenous appearance resembling hyaline cartilage (Kelempisioti et al., 2011). The end plate experiences an increase in both microscopic and visible damage as degeneration progresses. In addition, there is a spike in subchondral bone sclerosis, which is similar to cartilage degeneration.

Anterior intervertebral disc degeneration has also been linked to changes in the morphology of the end plate and subchondral bone, such as fractures or sclerosis (Amin et al., 2017) (due to factors like nucleus decompression). All things considered, the end plate is a vital part of the intervertebral disc since it is closely linked with intervertebral disc degeneration and episodes of low back pain.

Modic et al. (1988) and de Roos et al. (1987) independently observed distinct appearances of the bone marrow near damaged endplates in patients with low back pain (LBP) when examined with MRI (Udby et al., 2022) known as Modic changes. They identified three types of endplate lesions (types 1, 2 and 3). Type 1 Modic changes (MC1) showed diffuse high signal on T2-weighted images and low signal on T1-weighted images, suggesting fibrovascular replacement of the hematological marrow and active inflammation. Type 2 Modic changes (MC2) showed fatty replacement of the marrow, appearing as diffuse hyperintensity on T1-weighted images and isointense to slightly hyperintense on conventional T2-weighted scans. Type 3 Modic changes (MC3) showed hypointensity on both T1- and T2-weighted images, indicating sclerotic subchondral bone (Fields et al., 2019).

Low back pain has been linked to anomalies in the Modic-type subchondral signal seen on MRI in the bone marrow next to degenerative discs. But compared to Modic type 2 (M2) changes, Modic type 1 (M1) changes show a higher correlation with pain (Jensen, Karppinen, et al., 2008). Furthermore, M2 changes often develop from M1 changes. The prevalence of M2 changes tends to increase with age. Modic changes have therefore been suggested as typical age-related observations (Jensen, Leboeuf-Yde, et al., 2012).

Schmorl's node

Grant Schmorl's nodes are endplate abnormalities, but they are different from Modic endplate changes in that they are subchondral pathological entities with a different origin, natural history, significance for back pain and distribution within the endplate architecture. Schmorl's nodes are rarely clinically significant in adults with low back pain and usually develop in the adolescent spine. Unlike Modic changes, Schmorl's nodes are typically centrally distributed rather than anterior/eccentric. The latter may be attributed to abnormal biomechanical loading on the endplate, similar to the MRI changes observed in late-stage hip or knee osteoarthritis. Therefore, caution should be exercise not to place too much emphasis on Schmorl's nodes, as they are likely pre-existing radiological findings (Bussières et al., 2021).

Disc Changes

MRI is regarded as the gold-standard imaging modality for soft-tissue structure assessment (Fields et al., 2014). It makes it possible to examine the dimensions, form, and anatomical relationship between the vascular, neuronal and spinal components. The best applications for MRI are spondylolisthesis, hypertrophy or calcification of the posterior longitudinal ligament and ligamentum flavum, concomitant compressive alterations of the nerve roots and the thecal sac, and other intervertebral disc pathologies (Brinjikji et al., 2015; Berg et al., 2013).

Utilizing MRI, the Pfirrmann grading system serves as a subjective rating tool for the morphological and semi-quantitative assessment of intervertebral disc degeneration. This MR imaging method, recognized for its noninvasiveness, simplicity, and convenience, facilitates the evaluation process. However, its efficacy is limited in capturing substantial disc degeneration changes (Watanabe et al., 2021).

A five-level grading system is used in the Pfirrmann classification to determine the degree of disc degeneration. This evaluation is based on MRI scans and includes parameters including disc height, signal strength, nucleus and annulus separation, and disc structure homogeneity. The data obtained from these assessments is then divided into five grades. Grade I have a normal disc height, a distinct nucleus-an annulus separation, and a consistent, bright signal intensity. On the other hand, grade V denotes a decreased signal intensity, a difficulty to discern the nucleus from the annulus, and a collapsed disc space (Pfirrmann et al., 2001).

Conclusion

This review contributes robust local evidence to the growing body of African research on the radiological patterns of CLBP. Disc degeneration, herniation/bulge, and neural impingement remain the dominant MRI findings, consistent with both Nigerian and broader African data.

The strong association between these findings and pain severity reinforces their clinical importance. However, the variability in presentation despite similar imaging findings highlights the necessity of a multidisciplinary approach combining imaging, clinical evaluation, and functional assessment. With the sensitivity of 98% in the detection of low back pain aetiology, early lumbosacral MRI is essential for proper assessment of patients with low back pain especially in elderly candidates in order to improve the effectiveness of care, reduce morbidity and improve the quality of life.

Table 1. Pfirrmann Classification of Disc Degeneration

Grade	Structure	Distinction of Nucleus and Annulus	Signal Intensity	Height of Intervertebral Disc
I	Homogeneous bright white	Clear	Hyperintense, isointense to CSF	Normal
II	Inhomogeneous with or without horizontal band	Clear	Hyperintense, isointense to CSF	Normal
III	Inhomogeneous grey	Unclear	Intermediate	Normal to slightly decreased
IV	Inhomogeneous grey to black	Lost	Intermediate to hypointense	Normal to moderately decreased
V	Inhomogeneous black	Lost	Hypointense	Collapsed disc space

References

Abuya, J. M., Orege, J. A., & Elias, G. D. O. (2023). Common magnetic resonance imaging (MRI) patterns in patients with low back pain in Eldoret, Kenya. *Journal of Scientific and Innovative Research, 2*(2), 204–209.

Adeyinka, A., & Omidiji, O. (2011). Magnetic resonance imaging diagnoses in the lumbar spine of adults with low back pain in South-West, Nigeria. *West African Journal of Radiology, 18*(1), 12–19.

An, H. S., Anderson, P. A., Haughton, V. M., Iatridis, J. C., Kang, J. D., Lotz, J. C., Natarajan, R. N., Oegema, T. R., Pope, M. H., Sherman, J. E., Urban, J. P., & Weinstein, J. N. (2004). Disc degeneration: Summary. *Spine, 29*(23), 2677–2678. https://doi.org/10.1097/01.brs.0000146458.26778.f4

Brinjikji, W., Diehn, F. E., Jarvik, J. G., Carr, C. M., Kallmes, D. F., Murad, M. H., & Luetmer, P. H. (2015). MRI findings of disc degeneration are more prevalent in adults with low back pain than in asymptomatic controls: A systematic review and meta-analysis. *American Journal of Neuroradiology, 36*(12), 2394–2399. https://doi.org/10.3174/ajnr.A4498

Chang, U., Lee, M. C., & Kim, D. H. (2006). *Surgical anatomy and techniques to the spine*. W.B. Saunders.

Chiarotto, A., & Koes, B. W. (2022). Nonspecific low back pain. *New England Journal of Medicine, 386*(18), 1732–1740. https://doi.org/10.1056/NEJMcp2032396

Chou, D., Samartzis, D., Bellabarba, C., Patel, A., Luk, K. D., Kisser, J. M., & Skelly, A. C. (2011). Degenerative magnetic resonance imaging changes in patients with chronic low back pain: A systematic review. *Spine, 36*(21 Suppl), S43–S53. https://doi.org/10.1097/BRS.0b013e31822ef703

Hazra, I., Singh, R., & Ahmad, S. (2017). Spectrum of magnetic resonance imaging findings in patients of low back pain at a tertiary care institute of West Bengal. *International Journal of Medical Science and Public Health, 6*(9), 1381-1386

Hwang, D., Kim, S., Abeydeera, N. A., Statum, S., Masuda, K., Chung, C. B., & Bae, W. C. (2016). Quantitative magnetic resonance imaging of the lumbar intervertebral discs. *Quantitative Imaging in Medicine and Surgery, 6*(6), 744–755. https://doi.org/10.21037/qims.2016.12.09

Igwesi-Chidobe, C. N., Obiekwe, C., Sorinola, I. O., & Godfrey, E. L. (2019). Assessing self-reported disability in a low-literate population with chronic low back pain. *Disability and Rehabilitation, 41*(8), 948–957. https://doi.org/10.1080/09638288.2017.1419383

Irurhe, N. K., Adekola, O. O., Quadri, A. R., Menkiti, I. D., Udenze, I. C., & Awolola, N. A. (2012). The magnetic resonance imaging scan findings in adult Nigerians with low back pain. *World Journal of Medical Sciences, 7*(4), 204–209.

Karran, E. L., Grant, A. R., & Moseley, G. L. (2020). Low back pain and the social determinants of health: A systematic review and narrative synthesis. *Pain, 161*(11), 2476–2493. https://doi.org/10.1097/j.pain.0000000000001944

Modic, M. T., Steinberg, P. M., Ross, J. S., Masaryk, T. J., & Carter, J. R. (1988). Degenerative disk disease: Assessment of changes in vertebral body marrow with MR imaging. *Radiology, 166*(1), 193–199. https://doi.org/10.1148/radiology.166.1.3336678

National Institute of Neurological Disorders and Stroke. (2023). *Back pain*. U.S. Department of Health and Human Services, National Institutes of Health.

Omidiji, A. O. (2010). *Spectrum of magnetic resonance imaging findings in the lumbar spine of adults with low back pain in Lagos University Teaching Hospital, Idi-Araba, Lagos* (Fellowship dissertation). National Postgraduate Medical College of Nigeria.

Sharma, S., Traeger, A. C., Reed, B., Hamilton, M., O'Connor, D. A., Hoffmann, T. C., & Maher, C. G. (2020). Clinician and patient beliefs about diagnostic imaging for low back pain: A systematic qualitative evidence synthesis. *BMJ Open, 10*(8), e037820. https://doi.org/10.1136/bmjopen-2020-037820

Standring, S. (Ed.). (2016). *Gray's anatomy: The anatomical basis of clinical practice* (41st ed.). Elsevier.

Watanabe, K., Daimon, K., Fujiwara, H., Nishiwaki, Y., Okada, E., Nojiri, K., & Yato, Y. (2021). The long-term impact of whiplash injuries on patient symptoms and the associated degenerative changes detected using MRI: A prospective 20-year follow-up study comparing patients with whiplash-associated disorders with asymptomatic subjects. Spine, 46(11), 710–716. https://doi.org/10.1097/BRS.0000000000003889

Yang, C., Werner, B. C., Singla, A., & Abel, M. F. (2017). Low back pain in adolescents: A 1-year analysis of eventual diagnoses. *Journal of Pediatric Orthopaedics, 37*(5), 344–347. https://doi.org/10.1097/BPO.0000000000000652