



## Plain Film Radiography and Magnetic Resonance Imaging in Degenerative Disease of Spine: A Comparative Study

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### Abstract

Degenerative disease of spine is a definition that includes a wide spectrum of degenerative abnormalities. Degeneration involves bony structure, ligaments, facet joints and intervertebral disc. During life the spine undergoes continuous changes as a response to physiologic axial load, these age related changes are similar to pathologic degenerative changes and are common asymptomatic finding in adults and elderly persons. Imaging allows complete evaluation of static and dynamic factors related to degenerative disease of spine and is useful in diagnosing the different aspects of spine degeneration. The present cross sectional study is intended to compare and correlate the finding of plain film radiography with that of MRI in degenerative diseases of spine to enable early diagnosis. A total of 60 patients complained of back pain and/or patients with neurologic complaints such as tingling sensations, numbness weakness referred pain in limbs were included in the study. The current study found that percentage of the male patients was 58.33% and of female was 41.7% showing a slight male preponderance for degenerative spine disease. The mean age of incidence in our study was 43.65 years. The youngest and the oldest patients were 24 years and 79 years respectively. The most of the patients were in 40-50 years age group (25%). Lower back pain was the most common feature (70%) followed by radiating pain (55%), followed by tingling and numbness (26.6%) and cervical pain (25%). 13 patients out of 30 (43%) patients above 50 years of age had generalized involvement on plain film as compared to 24 out of 30 (80%) patients on MRI. On plain film, osteophytes were seen in 66% patients and on MRI in 55% patients. Lumbar spine was the commonest region of involvement on both imaging followed by cervical region. Commonest level of spinal canal stenosis was L4/L5 on both plain film and MRI seen in 15 and 24 patients respectively. Plain film showed facet joint arthrosis in 45% patients and on MRI it was seen in 63% patients with commonest level being L4/L5 on both the imaging techniques. Prevalence of neural foraminal obliteration and spinal canal stenosis were significantly higher on MRI as compared to plain film. Plain film is the basic modality which can be used as a baseline imaging. In a symptomatic patient who has failed non operative conservative treatment and has normal X-ray findings, an MRI can be a very useful tool for further evaluation.

**Keywords:** Spine, Disc bulge, Degenerative disease, Facet joint, Intervertebral disc, Canal stenosis, MRI.

### Introduction

Degenerative disease of spine is a definition that includes a wide spectrum of degenerative

abnormalities. Degeneration involves bony structure (spondylolisthesis, spondylolysis), ligaments (hypertrophy of spinal ligaments), facet

joints (facet hypertrophy, synovial cyst) and intervertebral disc (bulging and herniation). During life the spine undergoes continuous changes as a response to physiologic axial load these age related changes are similar to pathologic degenerative changes and are common asymptomatic finding in adults and elderly persons. A mild degree of degenerative changes is paraphysiologic and should be considered pathologic only if abnormalities determine symptoms. Imaging allows complete evaluation of static and dynamic factors related to degenerative disease of spine and is useful in diagnosing the different aspects of spine degeneration<sup>1</sup>.

Plain radiography helps in assessment of the contribution of osteophytes, spinal alignment and degenerative spondylolisthesis, facet joint arthrosis to canal stenosis. MRI is a noninvasive and radiation-free procedure that provides excellent imaging of the spinal cord and subarachnoid space and is a sensitive method for determining involvement of these by extradural pathology. MRI allows multiplanar imaging, excellent imaging of the neural elements, and increased accuracy in diagnosing intrinsic cord disease. It may detect pathology in the asymptomatic patient, or the pathology may be unrelated to the symptoms. Some spondylotic changes (small lateral osteophytes, midbody calcific densities) may be overlooked by MRI<sup>3,4</sup>.

Normally lordotic curvature is noted at two segments of the vertebral column, namely cervical and lumbar, that is they are aligned in a curve that has its convexity anteriorly and concavity posteriorly. Loss of lordosis can occur due to cervical and lower back pain. To stabilize the spine the body reacts to the pain with spasm of paraspinal muscles. Scoliosis is a lateral curvature of spine. Degenerative lumbar scoliosis typically develops after 50 years of age. It is usually associated with degenerative disc disease, facet joint arthrosis and hypertrophy of ligamentum flavum, leading to claudication and back pain<sup>10,14</sup>.

The height of intervertebral discs was evaluated on lateral x-ray spine and sagittal MRI scans. Disc

height reduction was considered to be a loss of height relative to the cephalad normal disc. Decreased in disc height is usually association with disc degeneration which in turn association with disc bulge, disc herniation and loss of hyperintense signals on T2WI. On T1WI images the disc is homogeneously hypointense to muscle, while on T2WI images disc appears bright because of its water content. The nucleus pulposus which is more hydrated than annulus fibrosus, is more hyperintense than the surrounding annulus fibrosus. With age the nucleus pulposus and annulus fibrosus losses its water content (upto 70%) and disc therefore decrease in normal hyperintense signal on T2WI.<sup>24</sup>

Modic changes are signal intensity changes of vertebral bone marrow adjacent to the endplates of degenerated intervertebral discs on magnetic resonance images (MRI). Modic et al<sup>52</sup> first classified MCs into three types based on MRI findings and histological correlations. Modic type I changes (low SI on T1W images and high SI on T2W images) are associated with vascularized granulation tissue within subchondral bone, and indicate an ongoing active degenerative process. Modic type II changes (high SI on T1W and T2W images) reflect fatty replacement of adjacent marrow, and type III changes (low SI on T1W and T2W images) are believed to be associated with subchondral bone sclerosis on plain radiographs. In recent years, Modic changes have been extensively used to identify the causes of non-specific low back pain (LBP), and in particular, Modic type I change has been reported to be associated with LBP. Schmorl's nodes are destructive lesions at endplates which are believed to be due to the herniation of the nucleus pulposus through the cartilaginous endplate into the body of a vertebra.

On T1WI the disc is homogeneously isointense to muscle, while on T2WI disc appears bright because of its water content. The incidence of intervertebral disc degeneration increases with age. A bulging disc encroaches on the spinal canal and neural foramina. The combination of sagittal

and axial T1 and T2WI provide excellent visualization of the relationships of the disc to the spinal canal and neural foramina. This abnormality of disc can be classified as disc bulge or disc herniation. Disc herniation can be further classified into protrusion, extrusion, sequestration. The hallmark of a herniated disc is a focal contour abnormality along the posterior disc margin with a soft tissue mass displacing the epidural fat, nerve root and the thecal sac. On T1WI the herniation appears isointense or slightly hyperintense relative to intervertebral portion of disc. On T2WI the herniated portion is more hypointense than the degenerating intervertebral disc. This may be due to the increased water content infiltrating the disc.

### Materials and Methods

The present study was a cross sectional study conducted in the department of Department of Radiodiagnosis in collaboration with the Department of Orthopedics, G.S.V.M. Medical College, Kanpur. The duration of study was 2 years from December 2012 to September 2014. A total 60 cases have been enrolled in this study as per inclusion criteria (Patients complaining of back pain and patients with neurologic complaints such as tingling sensations, numbness weakness referred pain in limbs). Patients with history of trauma with neurological presentation, with infective and inflammatory spondylitis, with primary or secondary neoplastic involvement of spine, myeloproliferative disorders, with bony dysplasias, connective tissue disorders, metabolic/endocrine related disorders, Paget's disease etc, with history of implants or other ferromagnetic external devices not compatible with MRI, Pregnant patients and Claustrophobic patients were not included in the study. The patients were included from outpatient and inpatient section. A complete medical history and physical examination was done. Prior to each investigation consent was taken from all patients.

### Patients Preparation for X-Ray Examination

Patients were given a hospital gown so that any metallic object can be avoided. The patients were

asked to lie down on x-ray table and image was taken in supine and lateral position. Radiographs were taken on conventional films with scale and on a PRORAD 3N Digital Radiography unit (Prognosys Medical Systems, Bangalore, India) at appropriate kV and mAs setting.

### Patient Preparation for MRI Investigation

MRI procedure was explained to him/her. Patients were given a hospital gown so that any metallic object can be avoided. MR imaging was done in supine positing and in quiet respiration. The patient was instructed not to move during the investigation. MRI was done on a 1.5 T scanner (Magnetom Symphony Maestro class, Siemens, Germany) in the premises of G.S.V.M. Medical college-LLR Hospital, Kanpur.

The following image sequences were used to assess the spine: AXIAL- T1W, T2W, SAGITTAL-T1W, T2W and CORONAL STIR. Image were viewed and analyzed on the Siemens SYNGO workstation provided by the manufacturer and all measurements were made therein using the proprietary tools provided in the software.

### Results

We performed this prospective study on sixty patients with the Patients who fulfill the inclusion criteria from the outpatient department and from admissions in wards were enrolled in the study. Each of them underwent plain radiography and MR imaging. The findings were correlated with the clinical symptoms and age of the patient at presentation. The mean age of incidence in our study was 43.65 years. The youngest patient was 24 years old and oldest was of 79 years. The most of the patients were in 40-50 years age group (25%). Out of a total of 60 patients, 35 (58.33%) were male and 25(41.7%) were female showing a slight male preponderance for degenerative spine disease. Lower back pain was the most common feature (70%) followed by radiating pain (55%), followed by tingling and numbness (26.6%) and cervical pain (25%). 40% patients presented with only cervical or low back pain with no other

associated symptom. Mid thoracic pain was present in 16.6% patients, all of them were also had complaint of low back pain. A small number of patients (5%) presented with muscle wasting of upper limbs as a consequence of compressive myelopathy.

Out of 60 patients studied a total of 188 vertebrae were affected on plain film and 294 vertebrae on MRI. The average number of vertebrae involved per patient was 3.1 on plain film and 4.9 on MRI. 13 patients out of 30 (43%) patients above 50 years of age had generalized (more than region) involvement on plain film which was significantly low as compared to 24 out of 30 (80%) patients on MRI (p value 0.007). This percentage was 100% in patients of 70-80 year age group on both imaging. 15 patients showed loss of lumbar lordosis and 8 patients showed loss of cervical lordosis. 2 of these patients had loss of both cervical and lumbar lordosis.

The presence of osteophytes, end plate sclerosis and decreased intervertebral disc height were three most common findings on plain film seen in 66%, 55% and 53% patients. On plain film osteophytes seen in 66% patients and 55% patients on MRI. Lumbar spine was the commonest region of involvement on both imaging followed by cervical region. Out of 33 patients with endplate sclerosis, 10 patients had Modic changes. Schmorl's nodes were present in 20% patients on plain film and 36% on MRI commonest site being dorsolumbar region. Most common findings seen in dorsal spine were reduced disc height and schmorl's nodes. Endplate degenerative changes (Modic changes) were present in 36% of patients out of which Type II endplate degenerative changes was commonest change seen in 15 out of 22 (68%) patients.

Commonest level of spinal canal stenosis was L4/L5 on both plain film and MRI seen in 15 and 24 patients respectively. In cervical spine C5/C6 level was most commonly involved with 5 patients on plain film and 9 on MRI. Intervertebral disc signal intensity reduction was seen most commonly at L4/L5 and C5/C6 levels in 24

patients at both levels, followed by L5/S1 and C6/C7 levels seen in 20 patients at both levels. Diffuse disc bulge was the commonest morphological type of disc degeneration with 24 patients affected most commonly at L4/L5 level. The prevalence of disc bulge increases with age with maximum 29% seen in 60-70 years age group. No disc bulge seen in thoracic spine. Protrusion was seen as the commonest type of disc herniation found in 13 cases most commonly affecting L5/S1 level followed by L4/L5. In cervical spine C5/C6 and C6/C7 levels were equally involved. Disc extrusion was seen in only 2 patients in lower lumbar region. No patient had disc sequestration.

Facet joint arthrosis was most commonly seen at lower lumbar levels commonest level being L4/L5 on both imaging. Plain film showed facet joint arthrosis in 45% patients and on MRI it was seen in 63% patients (p value 0.06). Prevalence of neural foraminal obliteration and spinal canal stenosis were significantly higher on MRI as compared to plain film. Commonest levels of involvement in cervical and lumbar regions were C5/C6 and L4/L5 on both imaging. Ligamentum flavum was normal in 44 patients and showed hypertrophy in 16 (26.6%) patients.

### Discussion

A total of 60 patients were evaluated by plain radiography and further evaluation done using MR imaging, Mean age of the patient was 51.63 years with a range of 24 years to 79 years. Out of the total 60 patients studied 35 (58.3%) were males and 25 (41.7%) were females. Thus there was male preponderance in the present study. Similar observation was made by Vroomen et al<sup>20</sup> where the mean age was 46±11.2 years, of whom 53% were males and 48% were females. A comparable mean age of 42 years and 42.8 years was also shown by Pople et al<sup>15</sup> and Carragee and Kim<sup>17</sup> respectively with male preponderance.

Lower back pain is the most common presenting symptom, seen in 37% of patients. In addition to low back pain from degenerative disc disease,

there may be shoulder or leg pain, numbness and tingling and muscle atrophy. In the present study the most common symptom of presentation was low back pain found in 42(70%) patients and cervical pain in 15(25%) patients. Referred pain found in 33 patients. Tingling /numbness and muscle wasting was found in 16 and 3 patients respectively. Only 10 patients had pain in thoracic region. The above findings were consistent with study of Damkot et al<sup>1</sup> who also found in their study that low back pain was the commonest in 66% of patients.

In the present study, out of 60 patients 8 patients showed loss of cervical lordosis, 15 (25%) showed loss of lumbar lordosis and 3 showed scoliosis in lumbar region. The findings of present study were consistent with the study done by Lebkowski WJ et al<sup>27</sup> who also found diminished lumbar lordosis only in 58(31%) patients. V.L. Murrie et al<sup>23</sup> found out that men with low back pain tend to have less prominent lumbar lordosis, but not in very significant number of cases and thus regarded as reduced lumbar lordosis is a very weak sign of low back pain.

Vertebral osteophytes are recognized as bony outgrowths on the margins of the vertebral body. With advancing age, osteophytes become more common with altered stress of anterior longitudinal ligament. On plain film they are evaluated on AP and lateral film and on MRI they are evaluated on sagittal T1 WI. In the present study 66% and 55% of patients showed osteophytes on plain film and MRI respectively. Maximum 42% and 39% had osteophytes in 60-70 years age group on plain film and MRI. It is seen in 46.6% and 41.6% patients with low back pain and in 43.3% and 36.6% patients with radiculopathy on plain film and MRI. This is comparable to study of J W Frymoyer et al<sup>4</sup> who also found strong association of osteophytes with lower back pain and lower limb symptoms.

In present study the reduction in disc height was present in 53% of patients on plain film and 61% on MRI, most commonly observed at C6/7 and L4/5 levels (both 37.8%) followed by L5/S1 in

27% of patients. This shows MRI to be a better modality for assessment of intervertebral disc height as compared to plain film radiography. The findings are consistent with the study done by Kjaer et al<sup>28</sup> who found diminished intervertebral disc height in 50% patients most common at L4/5 (39%) followed by L5/S1 level in 15% of cases. Per Kjaer et al<sup>28</sup> evaluated patients with low back pain and found that the finding of loss of disc height showed a significantly positive association with all low back pain variables.

Disc degeneration was the most frequent finding observed in 51 (85%) patients in this study. The prevalence was observed to increase with age. The prevalence of disc degeneration to young individuals (20 to 39 years) could probably be explained as a result of genetic predisposition though. Other factors like repeated traumatic injuries and physical loading history can play a role in causing disc degeneration. Disc degeneration was more frequent among males 32 (62.7%) as compared to females 19 (37.3%) though the variation observed was not statistically significant. This is similar to the findings reported by Takatalo et al<sup>35</sup>. Studies shows proportion of degenerated discs (reduction in disc signal intensity) progressively increases the lower the spine level and most common spinal levels were L4/L5 and L5/S1<sup>25, 36</sup>. Most common level involved in study was L4-S1 seen in 53% patients. The prevalence of Modic changes 36.7%, was higher compared to 23% found by Kuisma et al<sup>34</sup>, and lower than prevalence of 43% found by Jensen et al<sup>12</sup>. Type II Modic changes were more common than type I with prevalence of 25% and 10% respectively (p-value: 0.022), this is similar to what was found by Kuisma et al<sup>34</sup>. In this study, it was observed that Modic changes progressively increased the lower the spine level, and the most common location were L4/L5 and L5/S1 (20% patients). This observation is consistent with previous studies by Kuisma et al<sup>34</sup> and Tayone et al<sup>16</sup>.

In present study we found schmorl's nodes in 20% of patients on plain film, out of which 50% were

seen in dorsolumbar region. On MRI 36% patients were found to have schmorl's nodes with highest 54% number in dorsolumbar region (D10-L2). Kjaer et al<sup>28</sup> found that the schmorl's nodes were present in 29.8% of cases most common at L4-S1 vertebral levels in lumbar spine.

Endplate sclerosis is a common occurrence in degenerative spine. It is reactive sclerosis of vertebral end plates in response to the wear and tear of intervertebral joint and is therefore commonly seen with decreased intervertebral disc height. In present study, end plate sclerosis was seen in 33(55%) patients. 60% males and 48% females had end plate sclerosis. Kuisma et al<sup>35</sup> evaluated the presence of endplate sclerosis in different types of modic changes. They found end plate sclerosis exists in all types of modic changes and not only type III changes as previously assumed. In present study out of 33 patients showing endplate sclerosis, 7 had type II modic changes, 3 had type I modic changes and 1 had type III modic changes.

In the present study, the commonest morphological type of disc degeneration is in the form of diffuse disc bulge seen in 41 patients, most commonly affected level was L4/L5 (40%) which was consistent with the findings of Maureen C. Jensen et al<sup>14</sup>. Jarvik et al<sup>19</sup>, also found that (64%) patients had one or more bulging discs. They found that there was a consistent increase in prevalence from the L1-L2 to the L5-S1 disc. They also found that the commonest site for disc bulge was at L4-L5 level seen in 70 cases (47%) which was consistent with the finding in present study. In the present study, protrusion was seen as the commonest type of disc herniation seen in 13 cases, commonest level involved being L5/S1 (13 cases) which is different from the study done by Beattie et al who found extrusion as most common type of disc herniation in 10.8% of patients commonly affecting lower lumbar segments<sup>18</sup>. In our study, disc extrusion was the second most common type of disc herniation found in 2 patients at L3-L4 and L4-L5 level.

The facet joint may become enlarged as part of the body's response to degeneration of the spine, i.e. to try to provide additional stability to counteract the instability from degenerative spine disease. Facet joints are in almost constant motion with the spine and quite commonly simply wear out or become degenerated in many patients. When faced joints degenerate the cartilage become thin or disappear and there may be a reaction of the bone of the joint underneath producing overgrowth of bone spurs and an enlargement of the joints. In the present study facet joint degeneration was seen in 45 % of patients on plain film and 63% on MRI. Most common levels involved were L4/L5, L5/S1 followed by C5/C6 on both imaging. The above findings were consistent with the studies done by Jarvik et al<sup>55</sup>, who also found facet joint degeneration most commonly at L4-L5 level followed by L5-S1. This was also consistent with Kjaer et al<sup>28</sup> who found that facet joint degeneration was seen commonly at L4-L5 and L5-S1 levels in 36.2% of cases.

In the present study, the ligamentum flavum was normal in 44 patients, and showed hypertrophy in 16 cases. The finding was compared with the study done by Peter S.P. et al<sup>7</sup> who also found that isolated thickening of ligamentum flavum was rare, but was common in association with degeneration of the facet joints or shortening of the lamina due to degenerative changes. They concluded that under these conditions the ligamentum flavum may encroach significantly on neural foramen or spinal canal. Jong Beom Park et al<sup>29</sup> also found that the ligamentum flavum was significantly thicker in patients with spinal stenosis.

On plain film foraminal stenosis was diagnosed by encroachment of posterior osteophytes and degenerated facet joint to the neural foramina. On MRI foraminal stenosis was evaluated and diagnosed when hyperintense appearing epidural fat was obliterated by disc material of intermediate signal intensity or by osseous material of low signal intensity on axial T2WI. In

the present study neural foraminal stenosis was seen in 16 (26%) patients on plain film and in 34 (56%) patients. Commonest level involved being L4-L5 on both imaging. MRI was superior to plain film radiography to assess neural foraminal stenosis as it can assess discal and ligament degenerative changes and bony changes as well (p value 0.03)

The diameter of the normal lumbar spinal canal varies from 15 to 27mm. Lumbar stenosis results from a spinal canal diameter of less than 12mm in some patients; a diameter of 10mm is definitely stenotic. Spinal stenosis was assessed on lateral x-ray spine and mid sagittal section on T2WI. The hyperintense thecal sac can be seen effaced anteriorly by the bulging disc and posteriorly by ligamentum flavum and hypertrophied faced joints. In the present study, spinal canal stenosis was found in 31(51%) patients on plain film most commonly at L4/L5 level in 15 patients followed by L5/S1 in 8 patients. Most commonly involved level in cervical region was C5/6 level seen in 5 patients. On MRI 43 (71%) patients had spinal stenosis, commonest level involved was L4/L5 in 24 patients followed by L5/S1 in 14 patients. Similar to plain film commonest level involved in cervical spine was C5/C6 with number of patients 9. The findings are consistent with the study done by Kjaer et al<sup>28</sup> who also found that spinal stenosis was most frequent at L4-L5-S1 levels. MRI show higher percentage of patients with spinal stenosis as it can assess disc bulge and herniation, ligamentum flavum hypertrophy in addition to osteophytic changes and facet joint hypertrophy (p value 0.03).

### Conclusion

Imaging features which can be assessed on both plain film and MRI, were better evaluated on MRI due to excellent soft tissue details and different imaging plains to study a single feature, exception to this observation was presence of osteophytes (not significant statistically). Plain film is the basic modality which can be used as a baseline imaging. In a symptomatic patient who has failed

non-operative conservative treatment and has normal X-ray findings, an MRI can be a very useful tool for further evaluation. Overall, the advantages of MRI significantly outweigh its deficiencies, and thus it has become the standard diagnostic study for spondylotic disease. It has been demonstrated to be an accurate imaging modality.

**Conflict of Interest:** There are no financial, or other, relations that could lead to a conflict of interest.

**Ethical Approval:** This research was cleared by Ethical committee of G.S.V.M Medical College, Kanpur.

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