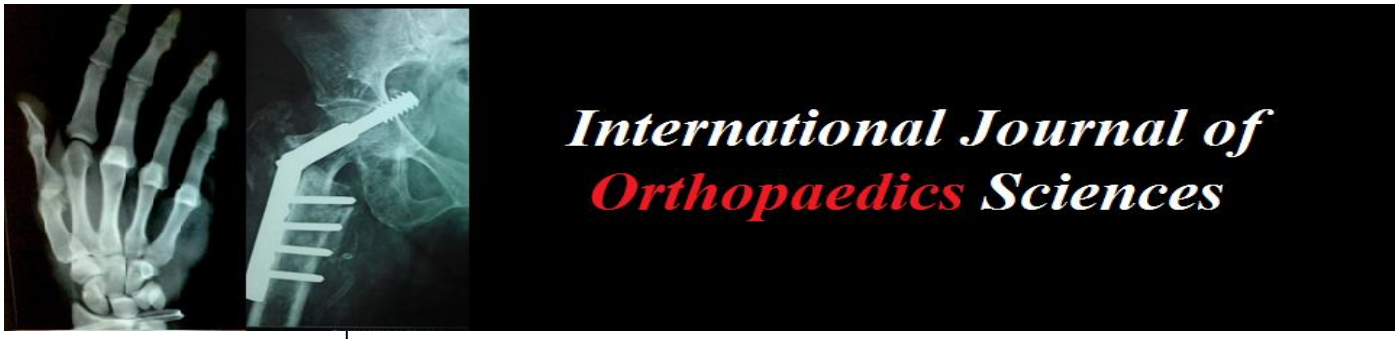

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Magnetic resonance imaging spectrum of degenerative disease of the lumbosacral spine: A single institution retrospective cross-sectional observational study

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Abstract
Background: Degenerative Disease of the Lumbosacral spine is a leading cause of back ache and radiculopathy with significant medical and socioeconomic importance. Its pathogenesis represents a biomechanically related continuum of temporally evolving alterations which are identifiable on various imaging modalities. Due to its excellent soft tissue contrast, multiplanar capabilities and non-ionizing nature MRI is indispensable for detailed morphological evaluation of all components of the Functional Spinal Unit (FSU). It facilitates optimal assessment of the burden of disease thereby guiding prognostication as well as subsequent therapy and rehabilitation.
Materials and methods: This study is a retrospective cross-sectional observational study whereby MRI findings ascribed to Degenerative Disease of the Lumbosacral Spine were analysed in 100 patients fulfilling the inclusion and exclusion criteria.
Results: The mean age of the study participants was 51 years ± 14 years with Male: Female ratio of 1.9:1. The L4-L5 intervertebral disc was the most frequently as well as most severely involved level irrespective of age and gender of the study subjects. Disc degeneration was the commonest manifestation seen (100%) followed by nerve root compression (74%), spinal canal stenosis (67%), disc herniation (64%), facetal arthropathy (41%), bulging discs (38%), ligamentum flavum hypertrophy (34%) and Modic endplate degenerative changes (31%) in decreasing order of frequency.
Conclusion: MRI is the modality of choice for evaluation of Degenerative Disease of the Lumbosacral Spine and allows most precise assessment of central spinal canal stenosis. It is hence recommended as mandatory in the radiological work up of all patients with the chief complaint of low back pain irrespective of the presence or absence of radiculopathy and / or neurological deficit.

Keywords: Lumbosacral spine, MRI, Disc degeneration, facetal arthropathy, ligamentum flavum hypertrophy, central spinal canal stenosis

Introduction
Degenerative Disease of the Lumbosacral Spine is the commonest cause of low back pain worldwide irrespective of age & gender and hence a common referral to the radiologist [1, 2]. In such cases, conventional spine radiography has often been the initial radiological investigation followed by NCCT evaluation. However, these often underestimate the quantum of disease both in terms of extent and severity. MRI by virtue of its non-ionizing character, unparalleled soft tissue contrast and excellent multiplanar capabilities scores over and above both these conventional modalities [3]. It particularly enables direct visualization of the soft tissue components of the spinal column and hence pinpoints the precise relationship between the herniating disc and the regional nervous structures (nerve roots and spinal cord) as well as intervertebral foramina [2]. Thereby it facilitates an in-depth review of both the static as well as the dynamic causative agents for Spinal Degenerative Disease. Additional benefits include a holistic view of the entire vertebral column on the whole spine screening sequence which further contributes to the diagnostic yield [2, 3].

Material and methods
Study Design: The present study was carried out in the Department of Radiodiagnosis of Government Medical College and Rajindra Hospital, Patiala (Punjab). It is a retrospective cross-sectional observational study of two months duration.

All patients referred with the chief complaint of low back pain & with findings ascribed exclusively to Degenerative Disease of the Spine on subsequent MRI were included in the study. A total of 100 such patients fulfilling the inclusion and exclusion criteria were enrolled in the present study.

Inclusion Criteria: Patients with history of low back pain with or without radiculopathy or neurological symptoms and with imaging features of Degenerative Disease of the Lumbosacral Spine as the sole pathology on the subsequent Dedicated MRI examination.

Exclusion Criteria: Patients with history as detailed above but with concurrent history/manifestations of prior spine surgery, spinal fractures, metabolic bone disease, spinal infectious pathologies, malignancy, Ankylosing Spondylitis or Fluorosis.

Procedure: A non – contrast Multiplanar and Multi-sequence Evaluation was done on a 1.5 T SIEMENS MAGNETOM Aera Platform in non-weight bearing position using an 18-channel body coil. The region of interest included Dorsal vertebra 12 (D12) to S1 sacral segment using predetermined parameters. The images were acquired as conventional T1 TSE and T2 TSE weighted in axial and sagittal planes, T1 STIR in sagittal and coronal planes as well as T2 TIRM COR sequences. Additional series were also carried out to generate a Whole Spine Sagittal Screening Image. All cases were independently reviewed by an experienced radiologist.

Statistical Analysis

Data entry and analysis was done on Microsoft Office Excel version 2019 and Epi Info (CDC Atlanta version 7.2.4.0). Most of the data was expressed in percentages while difference was statistically analysed using the chi square test wherever applicable.

Results

The study included 100 patients with age range from 20 to 78 years (mean: 50.97~51 years ±14 years) with majority being male (66%) while females comprised only a third of the study population (34%).

Table 1: Description of Age of subjects

	Subjects	Total	Mean	Var	Std Dev	Min	25%	Median	75%	Max	Mode
Age	100	5097	50.97	196.9587	14.0342	20	43	52	58.5	78	53

The overall prevalence of spinal degenerative findings in descending order of frequency was disc degeneration (commonest manifestation seen in N=100; 100%) followed by nerve root compression (74%), spinal canal stenosis (67%), disc herniation (64%), facetal arthropathy (41%), bulging discs (38%) and ligamentum flavum hypertrophy (34%). Modic type endplate degenerative changes (31%) were the least common finding of this spectrum.

Table 2: Age-wise Distribution of Imaging Spectrum of Degenerative Disease of the Lumbosacral Spine

Age Group→	20-39years n=21		40-59years n=56		60-79years n=23		Total n=100		p value of Chi-square tests
Degenerative Finding Spectrum ↓	Number of patients	%	Number of patients	%	Number of patients	%	Number of patients	%	
Disc Degeneration	21	100	56	100	23	100	100	100	1
Modic Changes	2	9.5	18	32.1	11	47.8	31	31	0.0223*
Disc Bulge	9	42.9	21	37.5	8	34.8	38	38	0.8533
Disc Herniation	10	47.6	34	60.7	20	87.0	64	64	0.0186*
Central Spinal Canal Stenosis	10	47.6	37	66.1	20	87.0	67	67	0.0209*
Nerve Root Compression	12	57.1	41	73.2	21	91.3	74	74	0.0351*
Facetal Arthropathy	0	0	18	32.1	23	100	41	41	<0.0001*
Ligamentum Flavum Hypertrophy	0	0	11	19.6	23	100	34	34	<0.0001*
							* Statistically Significant		

The overall prevalence as well as severity of Spinal Degenerative Disease was directly proportional to advancing age with advanced degenerative changes seen in all patients above 60 years of age and was statistically significant. Bulging discs were an exception with a higher prevalence in the relatively younger age group but this difference was not statistically significant.

The overall prevalence as well as more severe manifestations of Spinal Degenerative Disease were more frequently observed among males but this difference was not statistically significant.

Table 3: Gender - wise Distribution of Imaging Spectrum of Degenerative Disease of the Lumbosacral Spine

Gender→	Males n=66		Females n=34		Total n=100		p value of Chi-square tests
Degenerative Disease Spectrum ↓	Number of patients	%	Number of patients	%	Number of patients	%	
Disc degeneration	66	100	34	100	100	100	1
Modic Changes	23	34.85	8	23.53	31	31	0.246
Disc bulge	24	36.36	14	41.18	38	38	0.639
Disc herniation	45	68.18	19	55.88	64	64	0.225
Canal stenosis	45	68.18	22	64.71	67	67	0.727
Nerve root compression	53	80.30	22	64.71	75	75	0.088
Facetal Arthropathy	31	46.97	10	29.41	41	41	0.090
Ligamentum Flavum Hypertrophy	25	37.88	9	26.47	34	34	0.254

Disc degeneration was the most frequent finding (N=100; 100%) with L4-L5 Disc being the single most commonly affected level (72%). Multilevel involvement was more frequent in the older subjects. The occurrence of these changes in the younger patients was likely due to repetitive microtrauma ascribed to bad posture and physical loading. This was in consonance with similar studies carried out in the past [4, 5].

Disc herniations were seen in majority of patients (64%) with males having higher prevalence than females but was statistically not significant. Also, pertinent to note is the fact that (though not statistically significant) while disc bulges were more frequently encountered in the younger subjects (in 20-39 years group); the herniations were more frequently encountered in the older individuals. Overall, the vast majority of the herniations (95%) were protrusions while a minority (5%) were extrusions. Among these the posterocentral & paracentral were the most common zones (combined 91%) while exclusively foraminal and extra-foraminal were far less common (7% & 2% respectively).

Central Spinal Canal Stenosis of varying degrees (Borenstein *et al.* grading) [6] was invariably associated in all cases with posterocentral and paracentral herniations as well as in those with significant posterior disc bulges.

Nerve root compression correlated directly with more severe disc herniations/protrusions as well as prominent posterior bulging discs; with additional worsening effect due to coexistent facetal arthropathy and ligamentum flavum hypertrophy at the respective discal level wherever present. Traversing nerve roots were more frequently compressed due to posterocentral and paracentral herniations while exiting nerve root compression was associated more with foraminal & extra-foraminal zone herniations. Exiting nerve root compression correlated well with all cases referred with radiculopathy/ sciatica.

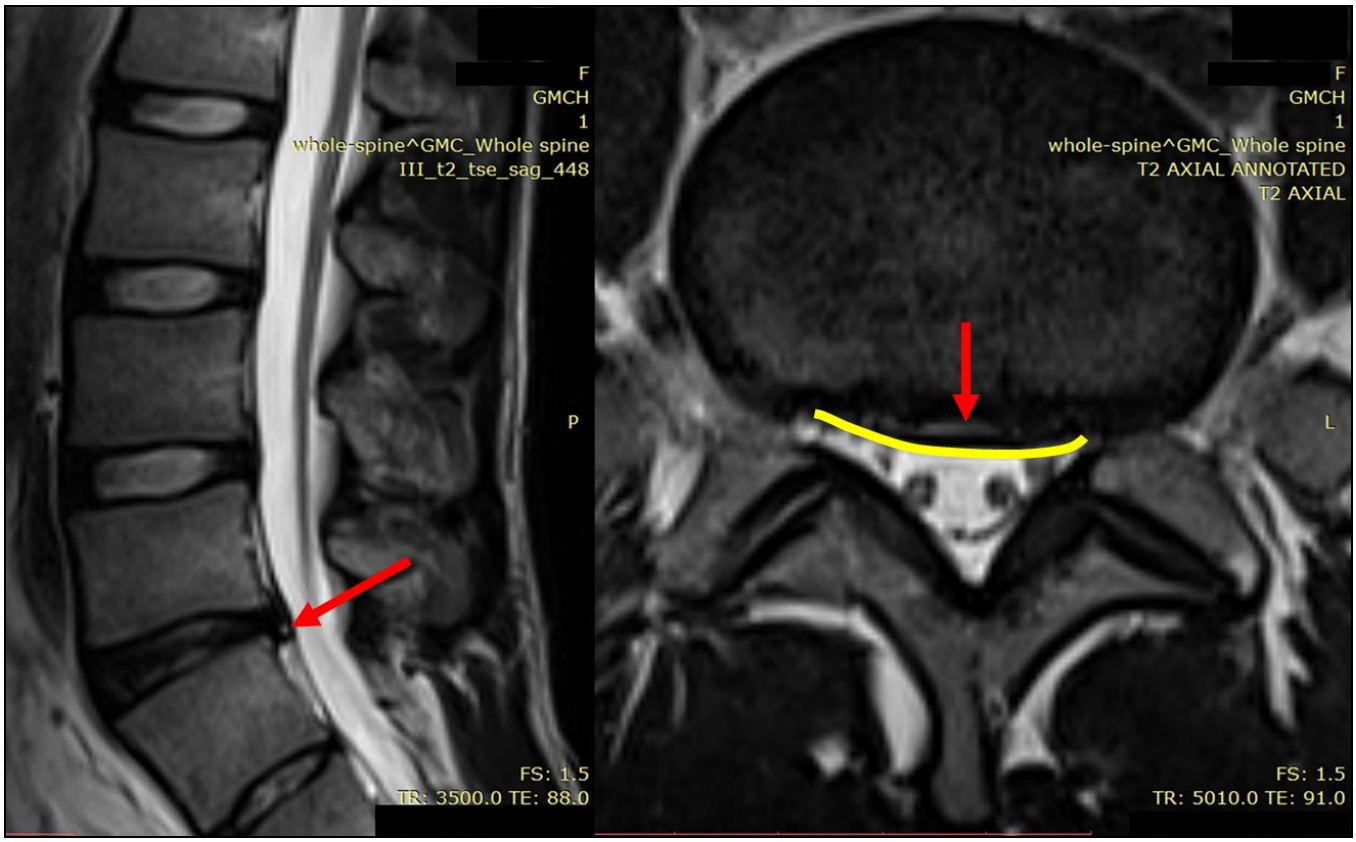
The presence as well as severity of Facetal Arthropathy as well as Ligamentum Flavum Hypertrophy exhibited direct correlation with advancing age (both seen to varying degrees in 100% patients more than 60 years of age) with L4-L5 intervertebral level being the single most commonly involved level irrespective of age and sex of the study subject.

Discussion: The MRI findings were analysed in all 100 patients with features of Degenerative Disease of the Lumbosacral Spine alone without any comorbidities in accordance with the inclusion and exclusion criteria. All the acquired views and sequences were analysed and observations compiled methodically into age & sex-based as well as frequency-based categories.

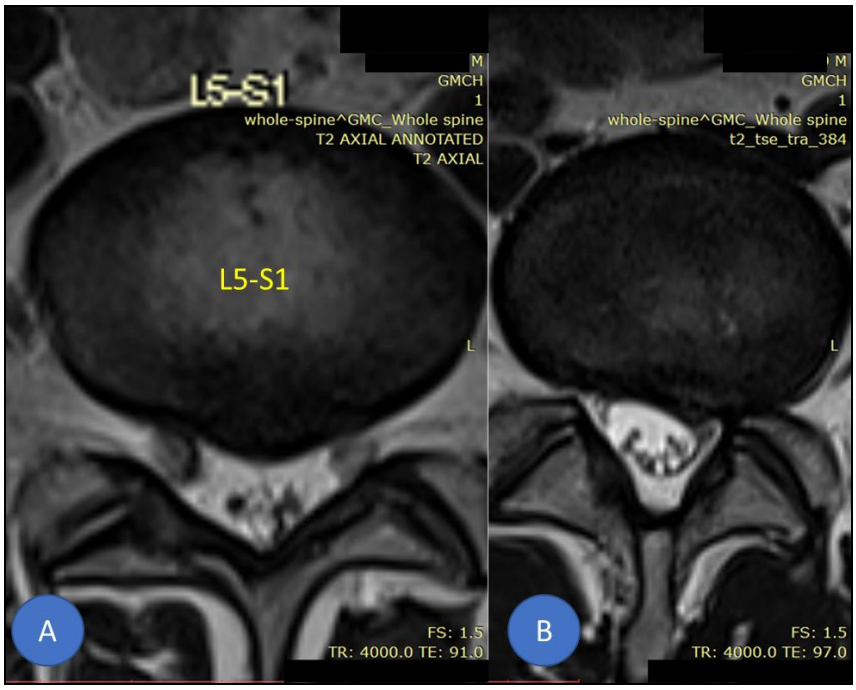
The most frequent as well as severe changes were consistently observed at the L4-L5 level irrespective of age and sex of the study participant. This was explainable due to this level of the Lumbar Spine being more prone to weight bearing and resultant repetitive microtrauma related changes similar to previously done studies by Ong *et al.* [5].

Disc Degeneration of varying degrees was the commonest MRI correlate [4, 5, 7-10] in all these cases across all categories seen at single/ few/ multiple vertebral levels in all cases. However, the disc bulges were seen to be more frequent among the younger subjects while herniations were more frequently encountered in the elderly.

The Discal Herniations were categorised as per the Combined North American Task Force Society Recommendations (11) and the vast majority of these were protrusions with extrusions seen in the minority of individuals. Two among these exhibited Sequestrated discs with migration (one each with the cranial and caudal respectively).



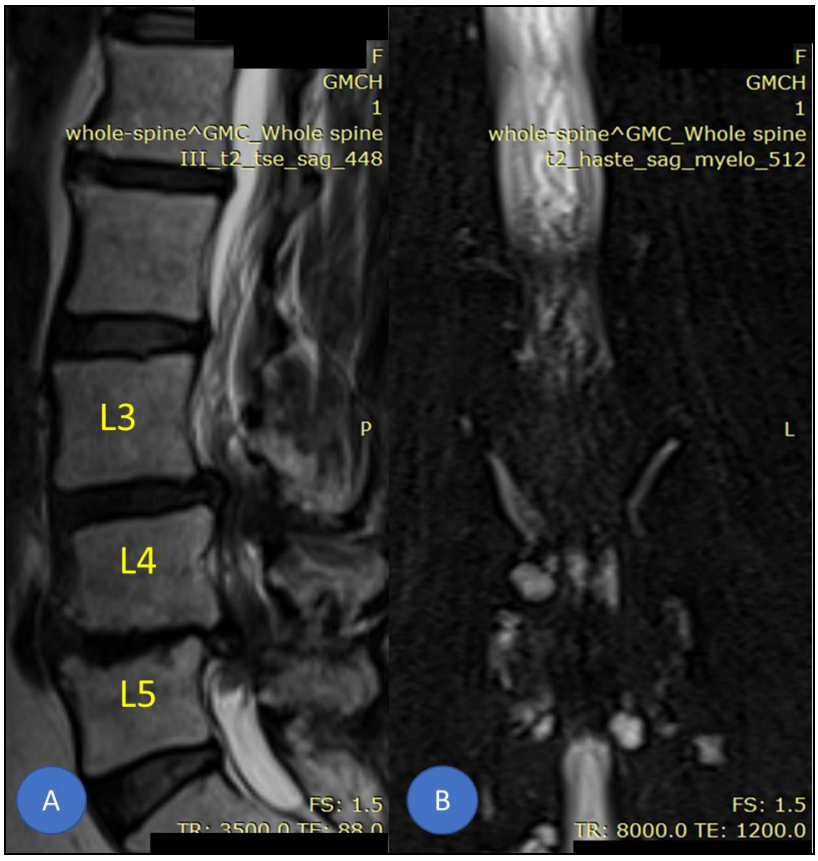
Case 1: 29 years F: T2 TSE SAG & AXIAL Lumbosacral Spine: L5-S1 disc: Single level involvement with broad-based posterocentral herniation (yellow curve), midline annular fissure (red arrows) with compression of thecal sac & bilateral traversing nerve roots



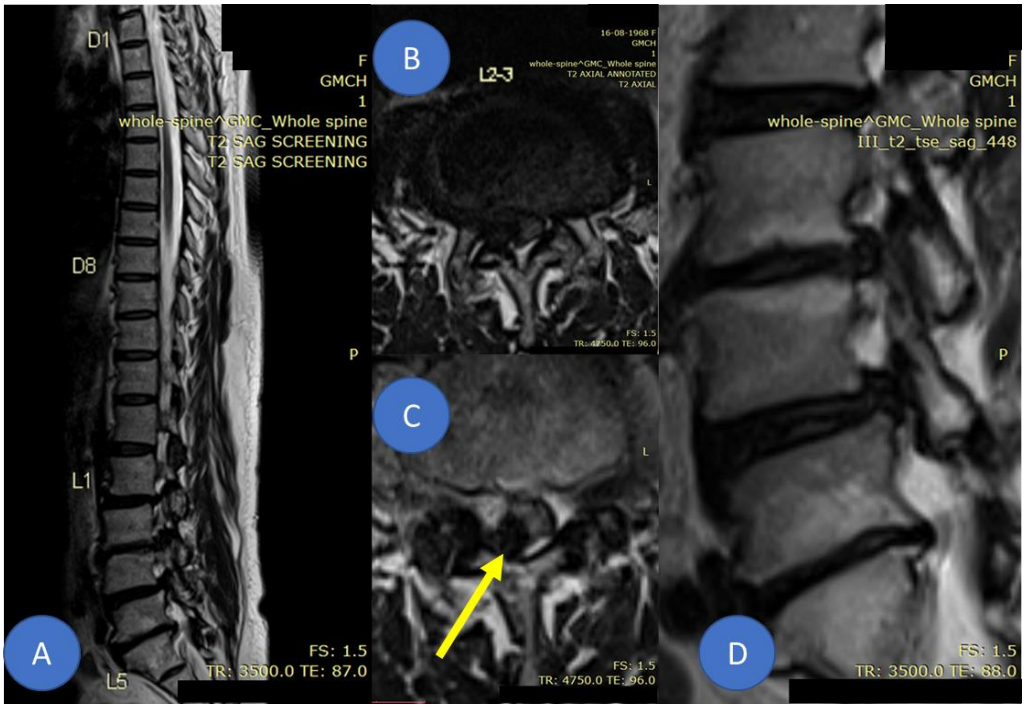
Case 2 & 3: A: 40years F: T2 TSE AXIAL L5-S1 Disc: Degenerated Disc with Broad-based Posterocentral Herniation causing compression of thecal sac & impingement of right traversing nerve root
B: 36years M: T2 TSE AXIAL: Left Paracentral Herniation causing compression of Thecal Sac & left traversing nerve root

Spinal Central Canal Stenosis of varying degrees was uniformly seen in all cases with discal herniations of the posterocentral and paracentral zones as well as in those with significant posterior disc bulges with no significant sex-related variation in the study group as a whole. This was in agreement with similar observations noted in the study by Shobeiri *et al.* [12]

Nerve Root Compression was invariably observed in those with the clinical profile of Sciatica with its prevalence independent of the sex but directly proportional to the age of the scanned subject. L4-L5 level was the most frequently affected level in contrast to the L5-S1 level encountered in the study by Shobeiri *et al.* [12]

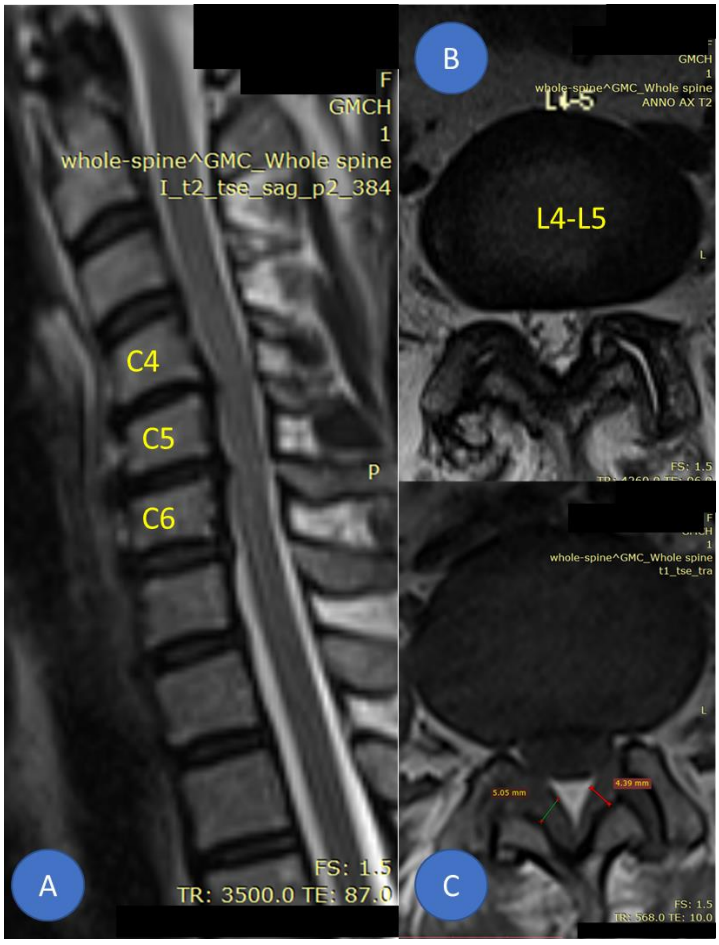


Case 4: 43years F: A: T2 TSE SAG LS Spine: Grade 1 Retrolisthesis L4 over L5; L4-L5 reduced disc height; L3-L4 & L4-L5 posterior disc herniations causing marked compression / near complete obliteration of Thecal sac; B: Myelogram Images: Near complete cut off of Thecal Sac corresponding to herniating discs



Case 5: 55years F: A: T2 TSE SAG LS Spine : Lumbosacral Transitional Vertebra (Sacralization of L5) (as labelled) with Multilevel Advanced Spinal Degenerative Disease; B:L2-L3 : Diffuse asymmetric circumferential disc bulge with marked compression of Thecal Sac & Bilateral Traversing & Exiting Nerve roots; C: Large extruded disc fragment with superior migration on right side; D: Modic Type II endplate degenerative changes

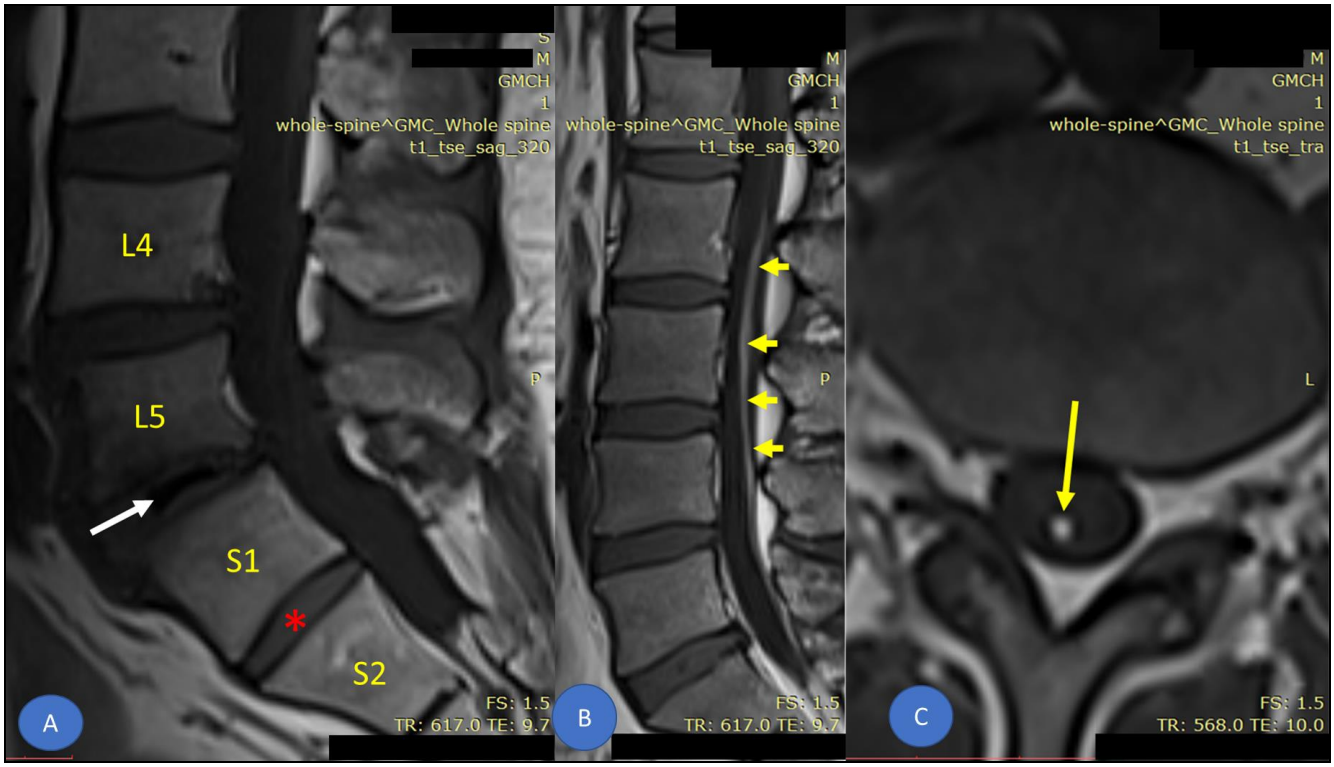
Ligamentum Flavum Hypertrophy [13] as well as Facetal Arthropathy [14] were increasingly encountered in the older individuals with resultant aggravation of the pre-existing discogenic central spinal canal stenosis; similar to previous such studies.



Case 6: 58 year F: A: T2 TSE SAG Screening Whole Spine: Multilevel Disc-osteophyte complexes causing marked cervical central canal stenosis with altered cord signal intensity consistent with Compressive Myelopathy; B: T2 TSE AXIAL L4-L5 Disc level: Bilateral Facetal Arthropathy; C: T1 TSE AXIAL: Bilateral Ligamentum Flavum Hypertrophy

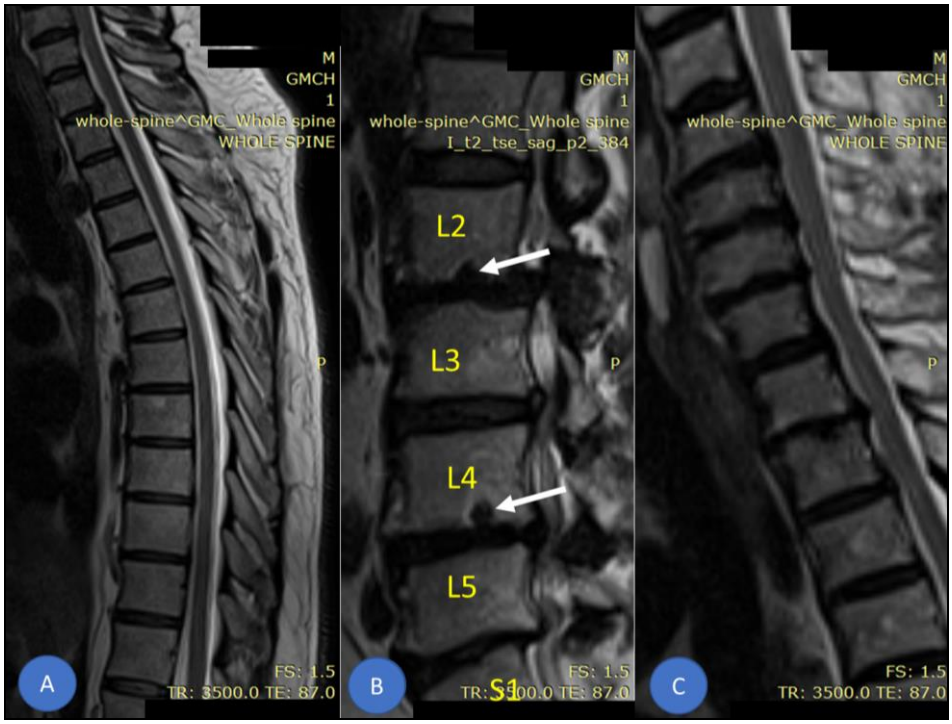
Modic Type End Plate Degenerative changes were the least frequently encountered finding but exhibited a definite age proportional trend similar to findings by Kuisma *et al.* [15] This was likely ascribed to physiological ageing related changes in the older study subjects. Also, to be noted is the observation that Type II changes were more frequently seen in close agreement with the study by Kuisma *et al.* [15]

The additional Whole Spine Sagittal Screening image enabled detection of coexistent Cervical Spine Degenerative Disease (in 92% cases with two of these with MRI features of Compressive Myelopathy Cervical Cord) as well as Dorsal Spine Degenerative disease (in 25% cases). There was also the additional benefit of detection and confirmation of Congenital Spinal Anomalies (N=12; 12%) viz. Lumbosacral Transitional Vertebra (5 cases) and Congenital Block Vertebra (2 cases), Persistent Ventriculus Terminalis (1 case) and Filar Lipoma (3 cases).



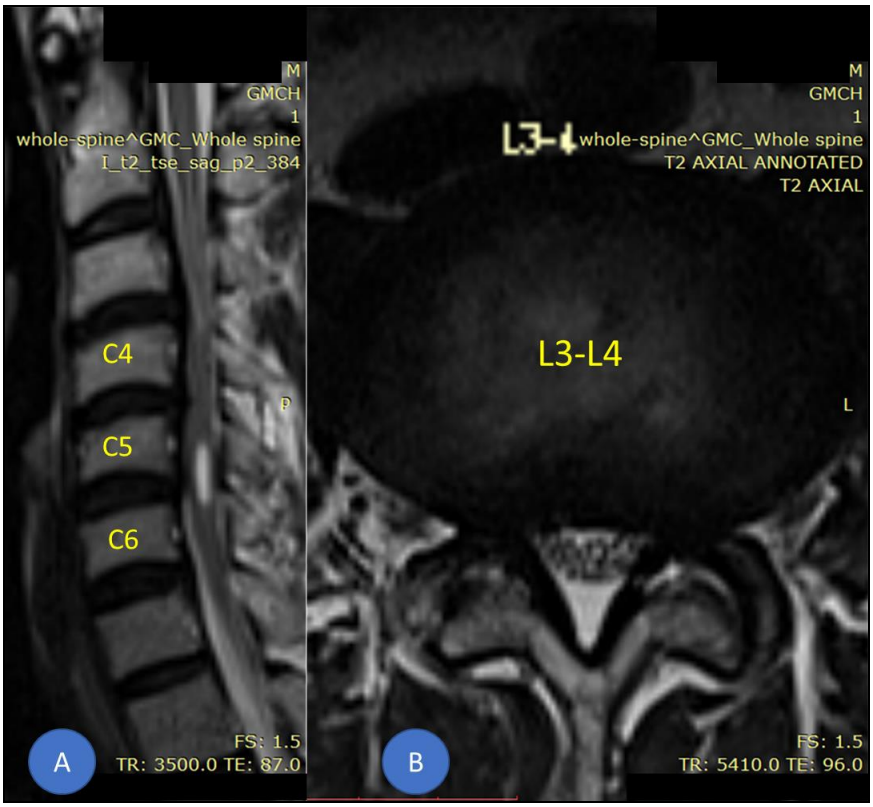
Case 7: A: 63years M: T1 TSE SAG Lumbosacral Spine: Lumbarization of L1 with well-formed S1-S2 disc (*); Vacuum Disc Phenomenon L5-S1 disc (white arrow)

Case 8: 41years M: B: T1 TSE SAG: Long segment Filar Lipoma; C: T1 TSE AXIAL: Filar Lipoma



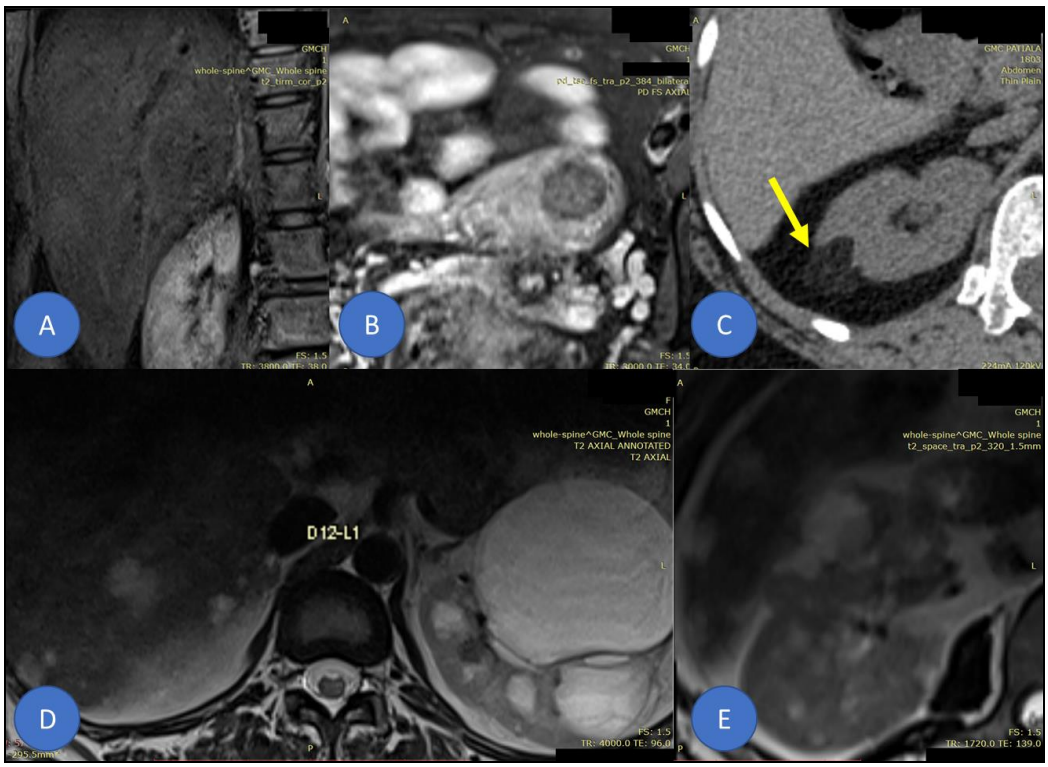
Case 9: A: 53years M: T2 TSE WHOLE SPINE SAG: Multilevel degenerative discs Dorsal spine but no frank herniation

Case 10: 72 years M: B: T2 TSE SAG: Pre-existing congenital bony spinal canal stenosis aggravated by multi-level spinal degenerative disease (Schmorl's nodes and Retrolisthesis L5 over S1; C: Posteriorly herniating degenerated dorsal discs causing thecal sac compression

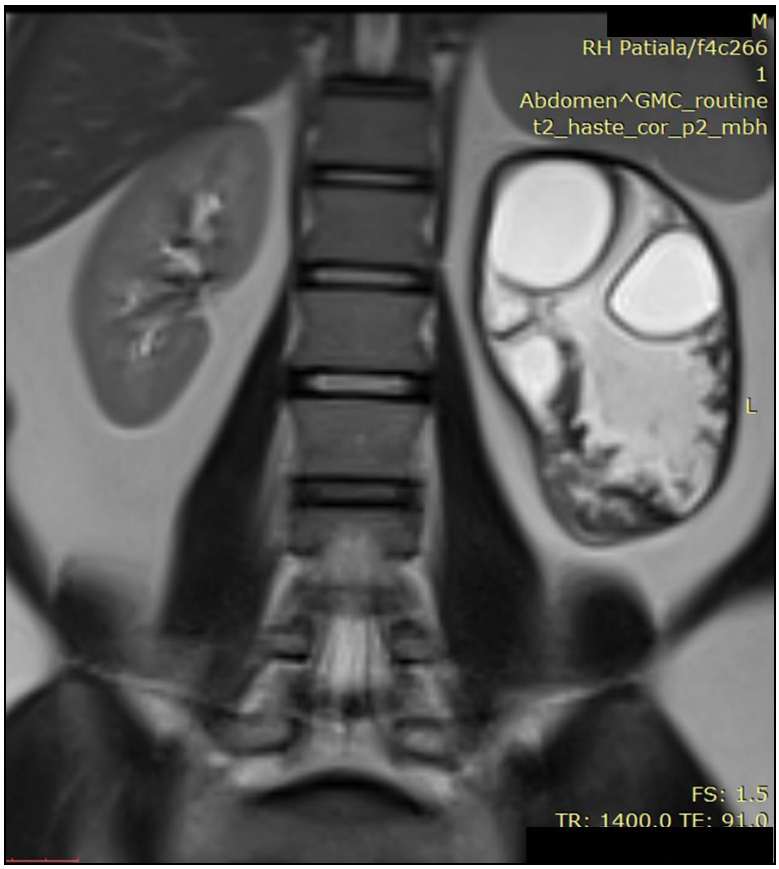


Case 11: 48 years M :A: T2 TSE SAG Screening Whole Spine : Multilevel Disc-osteophyte complexes causing marked Cervical central canal stenosis Most marked C4-C5 & C5-C6 intervertebral disc levels with resultant Compressive Myelopathy leading to Syrinx formation; B: T2 TSE AXIAL L3-L4 disc Level : Marked diffuse symmetric circumferential disc bulge causing severe bilateral foraminal compromise & compression of thecal sac & bilateral traversing nerve roots

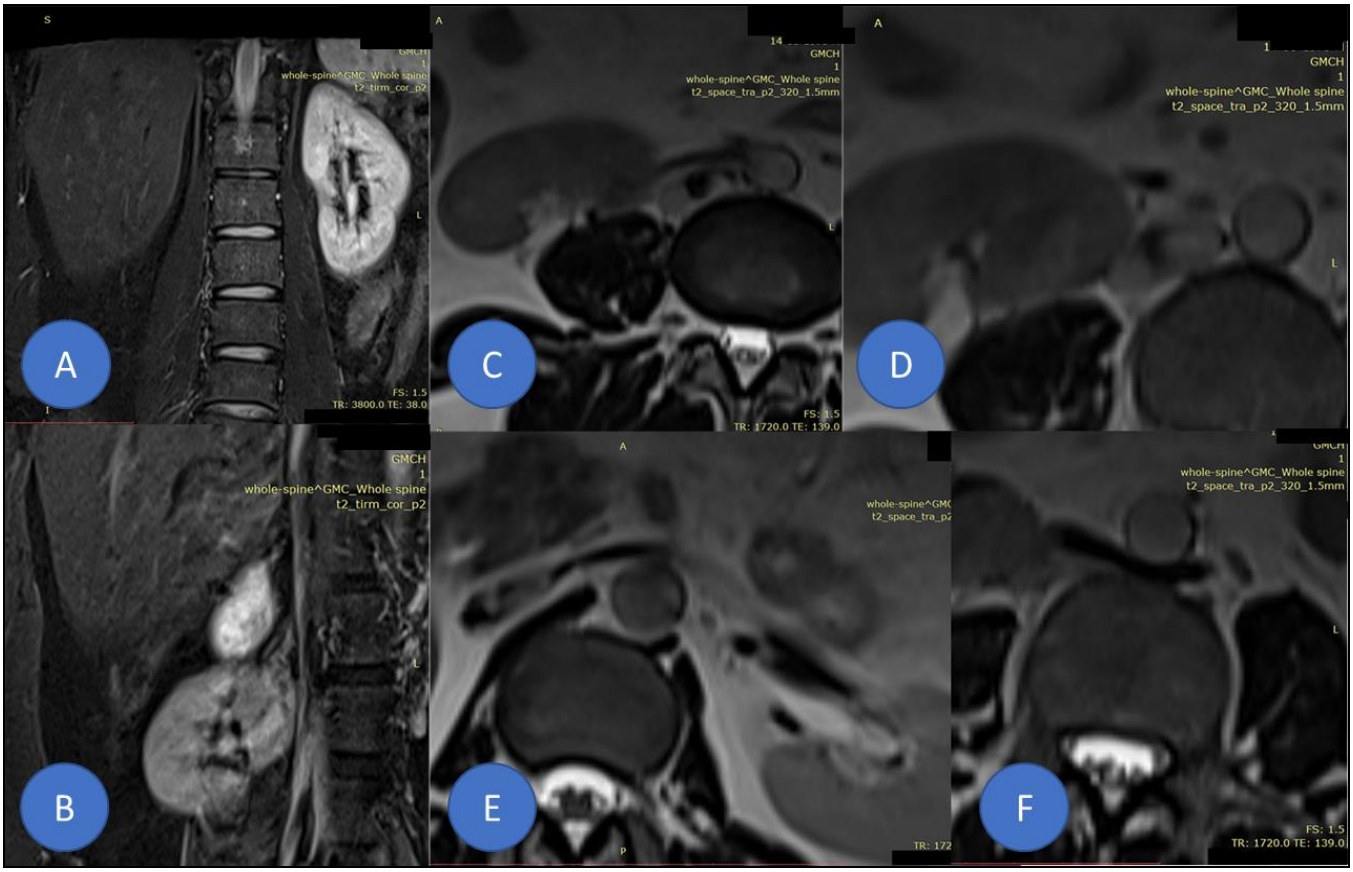
This study also had an unforeseen spinoff by way of enabling the detection of hitherto unsuspected and undiagnosed ancillary extra-spinal conditions (N=11; 11%) viz. Renal (5 patients in all; one case each with Right Renal Caudal Ectopia with Aberrant Vascular Anatomy, Unilateral Renal Hydatid Disease, Unilateral Angiomyolipoma, Autosomal Dominant Polycystic Kidney Disease and Giant Exophytic Renal Cortical Cyst) ; Adrenal (one case with unilateral lipomatous mass), Uterine (4 cases; one with Diffuse Uterine Adenomyosis and three with Fibroids) as well as Hepatomegaly (1 case)



Incidentally detected Non-Spinal Conditions: A: Hepatomegaly; B: Uterine intramural Fibroid; C: Correlative NCCT Axial section: Renal Angiomyolipoma: D&E: Bilateral Autosomal Dominant Polycystic Kidney Disease: Bilateral Renal & Hepatic cysts



Incidentally detected Non-Spinal Condition: Left Renal Hydatid Disease



Incidentally detected Non-Spinal Conditions: Renal positional anomaly with aberrant vascular anatomy: Orthotopic Left Kidney (A); Right Renal Caudal Ectopia (B); Right Kidney with dual arterial supply (1 & 2) from Abdominal Aorta (C&D); Left Kidney with Dual Venous Drainage into Inferior Vena Cava (caudal is retroaortic) (E&F)

Conclusion: MRI has a key role in the accurate and comprehensive evaluation of Degenerative Disease of the Lumbosacral Spine. Its ability to assess the Functional Spinal Unit inclusive of the normal anatomy, discal composition &

architecture and central spinal canal stenosis all justify and approve of its indispensable role in the radiological workup of such cases. It is hence highly recommended to be carried out in all MRI compatible and safe scenarios in patients with low back pain irrespective of the presence or absence of radiculopathy and /or neurological symptoms.

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