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Unexplained back pain and sciatica: the added value of upright dynamic MRI of the lumbar spine in cases of clinical/radiological mismatch

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Abstract

Background: Degenerative disease of the lumbar spine is one of the most prevalent pathologies worldwide, and MRI is the gold standard imaging modality that helps to assess soft tissue and bony abnormalities and elicit causes of neural compression. It is not uncommon in the daily practice to have patients presenting with neurological symptoms during standing or walking while MRI fails to detect lesion that explains their clinical picture. The aim of this study was to detect changes that appear on dynamic weight-bearing MRI of the lumbar spine that was hidden on conventional supine MRI and to correlate them with the clinical situation.

Methodology: Ninety patients with back pain were enrolled in the study, they did conventional and dynamic MRI of the lumbar spine. We compared findings in both modalities as regard alignment, ligamentum flavum buckling, foraminal narrowing and neural compression.

Results: Dynamic MRI showed neural compression in 87% of patients in comparison to supine MRI, ligamentum flavum buckling was reported in 80%, neural foraminal narrowing was seen in 24%, exaggeration of the lumbar lordosis in 10% and exaggeration of the already existing disc protrusion was documented in 60% of the included patients.

Conclusions: Upright dynamic MRI has added to supine MRI in problem solving cases with clinical radiological mismatch. The results indicated changes in the spine alignment, neural compression and spinal canal stenosis. Since the examination is non-invasive, it could be used in the preoperative planning of patients with degenerative lumbar spine disease.

Keywords: Upright, Dynamic, MRI, Lumbar, Spine, Degenerative

Background

The lifetime prevalence of low back pain may be up to 80% in the industrialized countries and is one of the main causes of sick leave and disability pension with huge personal and socioeconomic consequences. Low back pain

causes more disability than any other condition, and a global point prevalence has been calculated at 9.4% [1–3].

Imaging of the spine poses particular challenges, both to the radiologist and to the clinician. The dynamic nature of the spine and its mobility across multiple segments is difficult to depict with any single imaging modality [4–6].

Supine MRI remains the technique of choice for detecting degenerative spine disease associated with acute and chronic pain. However, conventional MRI performed in the supine position sometimes is unable to answer the clinical question creating clinical/radiological mismatch

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when the imaging findings fail to explain patient's symptoms [7].

Spine surgeons have been frustrated from the discordance of the imaging findings in some patients especially in those with dynamic mechanical low back pain, in addition to inaccuracy in preoperative planning regarding the level to be operated and how many levels. Moreover; preoperative imaging documentation of compression was needed for medico-legal proof of surgical indication [8].

The concept of functional imaging in radiology is becoming more popular as it helps us to better understand the pathophysiology of the disease, applying it to the spine; which is a dynamic structure subjected to the effect of gravity, means it is more physiological to scan the patient in upright weight-bearing position and in flexion and extension, thus revealing abnormalities that are missed by traditional MRI studies, in which it is performed in supine position [7].

The aim of the work

The aim of this study was to detect changes that appear on dynamic weight-bearing MRI of the lumbar spine in term of neuronal compression, that was hidden on conventional supine MRI and to correlate them with the clinical situation.

Methods

The study was conducted from January 2016 to September 2018, in a specialized spine facility and was approved by the local ethical committee. Ninety subjects with chronic back pain were retrospectively enrolled in this study, including 64 males (71.1%) and 26 females (28.9%). Mean age was 56.5 years (range: 42–71 years). All subjects were diagnosed with degenerative lumbar spine disease via conventional X-ray, and conventional MRI, however the radiological findings failed to correlate with the clinical picture (Table 1). Recruited patients were referred from spine surgery clinic because the images failed to detect a lesion explaining their symptomatology provided that the referring physician suspected spine etiology of their complaint. Exclusion criteria were suspected central brain pathology, spine infection and

malignancies. The study is retrospective; so no prior consent was taken from the patients.

The examination was conducted using 0.5T, U shaped superconductive cryogen-free MR system MROpen @ Paramed. Italy, which allows scanning the patient in upright and dynamic positions (Fig. 1). Patients did the scan in standing position while holding a bar to ensure support and eliminate movements.

Sagittal lumbar T1- (TR: 680, TE: 17, NEX: 3, ETL: 3) weighted fast spin echo imaging (T1FSEWI), sagittal lumbar T2- (4000, 140-160, 2, 13-15) weighted fast spin echo imaging (T2FSEWI), axial lumbar T2WI were performed in all lumbar studies using a phased array dedicated receiving coil. In all cases upright neutral, upright flexion, and upright extension imaging was performed. Degree of flexion and extension is done according to patient's maximum tolerance.

Patients passed the examination with no complaint. The examination time was approximately 40 min, including 20 min in the neutral position and 20 min in doing the dynamic images.

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The images from conventional and dynamic MRI were interpreted by one experienced radiologist (17 years' experience) and one experienced orthopaedic spine surgeon (25 years' experience) for changes in lumbar curvature, lumbar spine height, disc space height, disc bulge, epidural fat shape, dural sac dimension, ligamentum flavum thickening, lateral recess and neural foraminal narrowing. Changes in the diameter of the thecal sac were assessed subjectively based on indentation by the disc lesion and obliteration of the epidural fat as well as

Table 1 Clinical symptomatology of the included patients

Clinical presentation	Number of patients	Percentage of patients
Low back pain	90	100%
Radicular pain	69	77%
Interment claudication	25	28%
Lower limb weakness	16	18%



Fig. 1 Upright MRI machine, 0.45 T U shaped superconductive MR system which allows scanning the patient in upright and dynamic positions

objectively by manually measuring the AP (anteroposterior) dimension of the spinal canal in axial plane using 13 mm as a cut off value for canal stenosis.

Degenerative spinal disease including focal intervertebral disc herniation, spinal stenosis involving the central spinal canal and spinal neural foramina, and hyper-mobile spinal instability were compared in neutral and dynamic images.

Results

We compared the radiological findings in conventional and dynamic MRI and correlated the data acquired by the later with the clinical information.

Starting with conventional MRI, it shows abnormal alignment in the form of scoliosis in 2 patients (2%), Foramen narrowing in 3 patients (3%), disc protrusion in 54 patients (60%), ligamentum flavum buckling in 9 patients (10%), spinal canal stenosis in 3 patients (3%).

Dynamic MRI showed changes in the vertebral alignment in 18 patients (20%) in the form of exaggeration of the normal physiological lordosis in 9 patients (10%) and increase in scoliosis angle in 9 patients (10%). The change in lumbar lordotic curve resulted in decrease in height of the lumbar vertebrae by approximately 3 mm.

Axial loading resulted in prominence of the already existing disc lesion in 54 patients (60%). The previously present disc lesions in supine scans became more protruding in upright images, and induced more neuronal effects that matched with patient symptoms. These findings were not seen in supine images and accordingly, the patients' symptoms were not explained by routine MR images (Fig. 2).

Upright weight-bearing position evoked disc protrusion in initially non-protruded disc in 9 patients (10%).

The ligamentum flavum became more prominent in dynamic extension images in 72 patients (80%). This induced narrowing of the spinal canal AP dimension also with obliteration of the anterior epidural fat planes and encroachment on the thecal sac. Secondary spinal canal stenosis with thecal sac compression was detected in dynamic extension images in 78 patients (87%) (Fig. 3).

Narrowing of the neural foraminal dimension could be elicited in dynamic images in 22 patients (24%).

No evidence of synovial cyst or dural herniation could be elicited in any patient.

11 patients (12%) showed no changes in dynamic upright MRI images.

Comparison between the findings in conventional and dynamic MRI are listed in Table 2. This table shows the number of patients showing changes in spine alignment, disc protrusion, and ligamentum flavum buckling, spinal canal and foraminal stenosis both in conventional and in

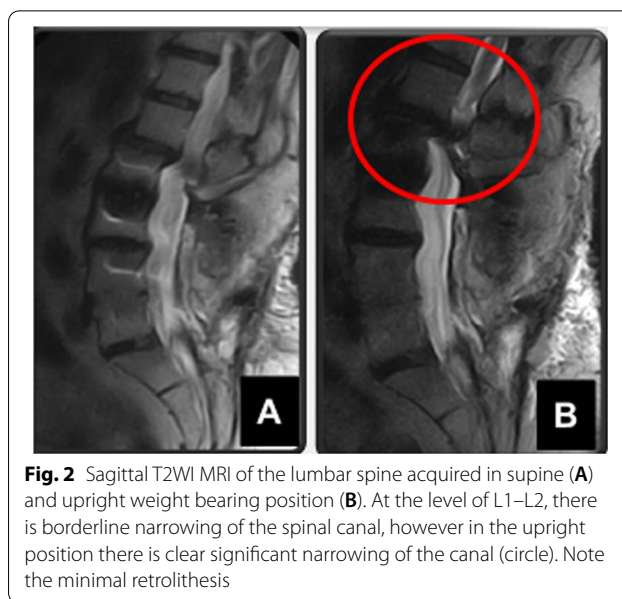


Fig. 2 Sagittal T2WI MRI of the lumbar spine acquired in supine (A) and upright weight bearing position (B). At the level of L1–L2, there is borderline narrowing of the spinal canal, however in the upright position there is clear significant narrowing of the canal (circle). Note the minimal retrolisthesis

dynamic MRI. Dynamic MRI showed more changes and correlated well with the clinical and surgical findings.

Table 3 compares the sensitivity, specificity and accuracy of conventional and dynamic MRI regarding spine alignment, disc protrusion, ligamentum flavum buckling, spinal canal and foraminal stenosis. Dynamic MRI showed more sensitivity, specificity and accuracy in comparison to conventional MRI.

Overall sensitivity of dynamic MRI was 96% compared to intraoperative data, specificity of 100% and accuracy of 97%.

Discussion

In patients with degenerative disease of the spine, proper diagnosis is the key to optimum preoperative planning and hence postoperative outcome.

Conventional MRI of the lumbar spine is the gold standard examination in patients with degenerative disease, however; it is performed in supine position, with knees and hips bent and with elimination of the gravity effects. Pathological conditions underlying clinical symptoms, often prompted by standing or sitting, are therefore not seen. This can result in negative findings, even in the presence of symptoms, or an underestimation of pathological conditions [8, 9].

Our study aimed to assess the changes occurring in dynamic MRI while the patients were scanned in weight bearing position in comparison to the findings in supine MRI and to correlate the findings with the clinical data. These changes include changes in the alignment of the lumbar curve, decreased disc height, progression of the disc protrusion and neural compression, ligamentum

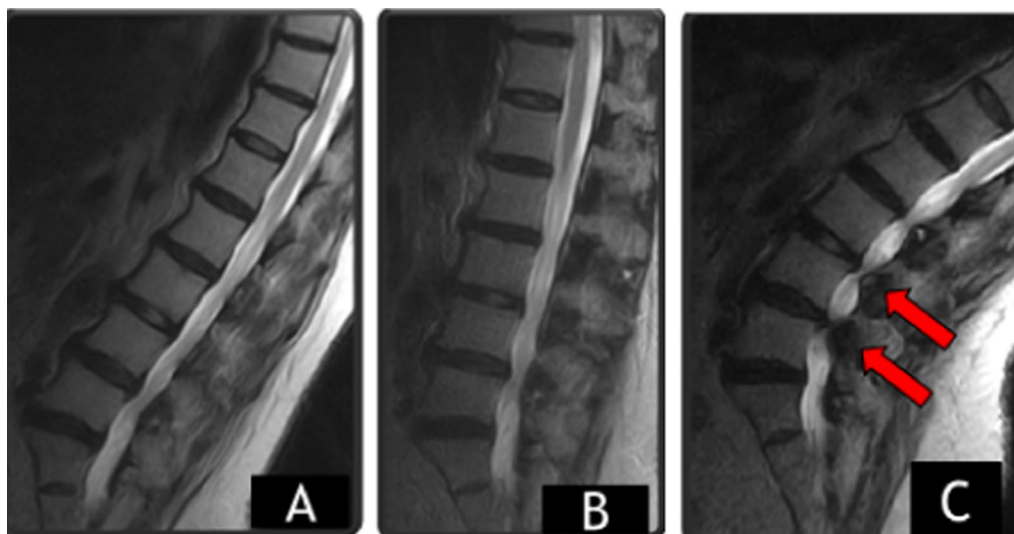


Fig. 3 Sagittal T2WI MRI of the lumbar spine acquired in neutral (A), flexion (B) and extension (C) positions while the patient is sitting. Although there is no significant thecal sac compression in the first two images, in extension, there is significant buckling of the ligamentum flavum at the levels of L3–L4 and L4–L5 (arrows). Associated disc protrusions with subsequent canal stenosis

Table 2 Comparison of changes in conventional, anddynamic MRI together with the clinical and surgical findings, including numberof patients and their percentages

	Spine alignment Scoliosis No./percent	Disc protrusion No./percent	Ligamentum flavum buckling No./percent	Spinal canal stenosis No./percent	Foraminal stenosis No./percent
Conventional MRI	2/2%	54/ 60%	9/10%	3/3%	3/3%
Dynamic MRI	9/10%	84/93%	72/80%	78/87%	22/24%
Clinical/surgical outcome	9/10%	86/96%	72/80%	80/89%	30/33%

Table 3 Comparison of sensitivity, specificity and accuracy of Conventional and dynamic MRI regarding spine alignment, disc protrusion, ligamentum flavum buckling, spinal canal and foraminal stenosis

	Spine alignment Scoliosis		Disc protrusion		Ligamentum flavum buckling		Spinal canal stenosis		Foraminal stenosis	
	Con. MRI	Dyn MRI	Con. MRI	Dyn MRI	Con. MRI	Dyn MRI	Con. MRI	Dyn MRI	Con. MRI	Dyn MRI
Sensitivity	74%	100%	85%	98%	70%	100%	85%	97.5%	54%	73%
Specificity	79%	100%	96%	100%	70%	100%	87%	100%	63%	100%
Accuracy	78%	100%	85%	98%	70%	100%	85%	98%	54%	91%

Cov, conventional MRI; Dyn, dynamic MRI

flavum buckling and spinal canal stenosis along with neural foraminal narrowing.

The main findings of the present study are the buckling of the ligamentum flavum (from 4 mm to more than 9 mm) in dynamic extension position inducing narrowing of the spinal canal, in addition to the narrowing induced by the disc protrusion which also increased in extension,

in comparison to Kubosch et al. [10], where the main finding was narrowing of the neuroforaminal diameter during the change from a lying to standing position with extension.

The spinal canal, dural sac and neuroforaminal size decreases in individuals both with and without low back pain [11]. These changes may partly be explained by an

increased thickness in the ligamenta flava [11], and an increased posterior disc curvature [12].

We reported increase in size of the posterior disc herniation in extension in agreement with Weishaupt et al. [13].

Tarantino et al [14], reported that the lumbar lordosis angle increases in the standing scanning position compared to the conventional supine position or the neutral seated position. This was in agreement with our findings.

The severity of spinal stenosis increases in the upright standing position [15] and with the extension of the lumbar spine in the upright position [14]. This is in accordance with the symptomatology, which includes radiculopathy, back pain and muscular fatigue predominating in the standing position or during walking [16, 17].

These classic symptoms may partly be explained by an increased thickness of the ligamentum flava found in the upright and extended position as a result of the increased lordosis [8].

In our study, clinical radiological correlation revealed that 78 of the surveyed patients (87%) showed radiological findings in dynamic upright MRI to explain their clinical picture, upon follow up with the spine surgeon, surgery with thecal sac decompression on the suggested levels was done for 61 patients and they showed postoperative clinical improvement.

Our study still has some limitations, including lack of inclusion of postoperative images and the need to scan of more population with long term follow up period.

Conclusion

We conclude from this study that, functional imaging tools; like dynamic upright MRI of the lumbar spine, allows better visualization of hidden pathologies in supine MRI and gives spine surgeon a helpful tool in order to understand and explain patients symptomatology. It provides documented proof of neural compression and hence facilitates accurate preoperative planning regarding the procedure and the target level, and accordingly better postoperative outcome.

Abbreviations

MRI: Magnetic resonance imaging; AP: Anteroposterior.

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Authors' contributions

IH: Reviewing literature and Data collection and analysis, perform statistical analysis, revise the manuscript and interpret MRI. DK: Suggesting the idea, reviewing literature and write the manuscript and final editing. Both authors have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Neurospinal Hospital, UAE with approval number 24. The study was retrospect, so no verbal or written consent was taken from the patients.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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