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ORIGINAL ARTICLE

Lumbar spine MRI axial loading in patients with degenerative spine pathologies: Its impact on the Radiological findings and treatment decision

Heba Ibrahim Ali [a,*], **Alaa Saleh** [b]

[a] *Ain Shams University, Radiology Department, Ramsis Street, Cairo, Egypt*
[b] *Alexandria University, Radiology Department, Egypt*

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KEYWORDS

Axial loading;
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Abstract *Purpose:* The aim of the study was to assess the Radiological changes occurring after axial loading of the lumbar spine during MRI in patients whose conventional MRI did not explain their clinical symptoms and to evaluate the impact of these changes on the treatment decision.
Materials and methods: 20 patients (11 males and 9 females) with neurological symptoms are included in this study. Their symptoms included low back pain, sciatica and neurogenic claudication. Conventional MRI findings alone were not sufficient to explain their clinical complaint.
Results: Axial loaded MRI of the lumbar spine revealed changes in the vertebral alignment in 45% of patients, prominence of the already existing disk lesion in 60% of patients, newly seen disk protrusion in 10% of patients and prominent ligamentum flavum in 80% with subsequent spinal canal stenosis and thecal sac indentation.
Conclusion: Patients with clinical symptoms not explained by conventional MRI can benefit from Axial loading MRI which can add more information and also can change the treatment decision plan.

1. Introduction

We commonly encounter patients with low back pain, and these patients with acute low back pain often experience increased symptoms during standing or sitting as compared to lying supine (1). It is well known from clinical work that a number of patients with significant symptoms do not have corresponding imaging abnormalities, even with the most sophisticated techniques (2).

MRI is the most accepted imaging modality in assessment of the lumbar spine pathologies in patients with low back pain, sciatica and neurogenic claudication.

Since symptoms are usually induced or exaggerated by standing or walking, so imaging in the most symptomatic

* Corresponding author at: Cairo, 38 Omar Zaafan Street, Nasr City, Egypt.
E-mail addresses: Hebaali_m@hotmail.com (H.I. Ali), alaaaldinsaleh@gmail.com (A. Saleh).
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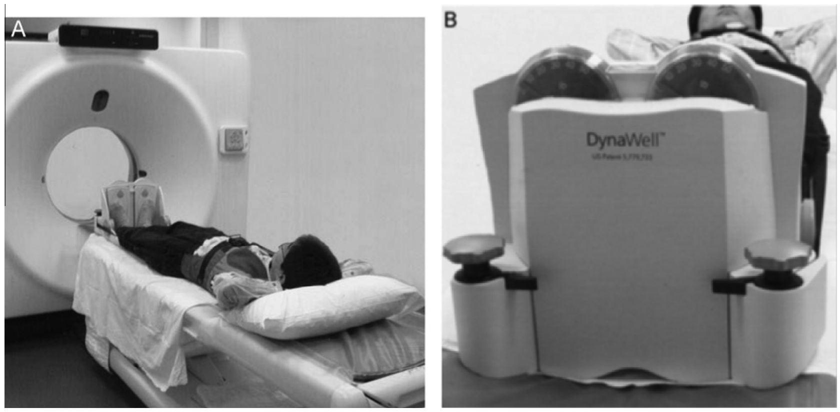

Fig. 1 Patient in position during axial compression. (A and B) Device consists of nonmagnetic harness/jacket with straps connected to a footplate. By tightening or loosening the adjustment knobs on the compression part, the load can be regulated and equally distributed to both the legs. The applied load can be measured by using scales on the footplate (2).

position may yield more diagnostic information than imaging in psoas relaxed neutral position.

Ideally, imaging in standing position would be optimal with the normal gravitational pressure exerted on the spine. This is impractical, however, since it would require the patient to stand motionless for about 30 min.

To simulate upright position, clinicians and researchers have developed a device (DynaWell L-spine; DynaWell Int. AB, Billdal, Sweden) (Fig. 1) that loads axially to the spine in the supine position (3–7).

This device consists of a harness/jacket with straps connected to a footplate. By tightening the straps, an axial load can be applied to the patient's spine during imaging (2).

Our hypothesis is that the intervertebral disk height and accordingly the disk circumference changes with axial loading, which may account for symptom alteration, also the degree of neural compression, lateral recess narrowing and ligamentum flavum thickening will change during axial loading of the lumbar spine.

Table 1 Age and gender distribution with changes occurring after axial loading of the lumbar spine.

Patients	Gender	Age	Changes after axial loading	
1	Male	38	Decreased height of	Ligamentum
2	Male	34	the disk space	flavum thickening
3	Male	29		
4	Male	47		
5	Female	52		
6	Male	54		
7	Female	49		
8	Male	38		
9	Female	21		
10	Male	56		
11	Female	58		
12	Male	40		
13	Female	48		
14	Female	38		
15	Male	52	Exaggerated lordosis	
16	Male	51		
17	Male	47	Exaggerated lordosis	
18	Female	53		
19	Female	43	Increase in scoliosis	
20	Female	41		

2. Patients and methods

2.1. Patients

Twenty patients were enrolled into the study, including 11 males and 9 females, aged 21–58, with a mean age of 39.5. Fourteen patients had low back pain, ten had sciatica and five had neurogenic claudication. The selection of the patients was based on their conventional MR imaging which failed to explain their clinical symptoms and in such cases the neurosurgeon was not convinced by the results and was not confident about the surgical decision plan. The study included patients who had single level of disk pathology to make sure that the symptoms are related to this particular level affection.

2.2. MR Technique

The examination was conducted using 0.32T system using a surface coil, and scanning was done in supine position with slight hip flexion with pillow under the knee.

The scan included two parts, in the first part, routine MR imaging consisted of sagittal T2 weighted (3190/128/3) [TR/TE/number of excitation] and sagittal T1 weighted (790/17/3) turbo spin echo sequences, axial T2 and T1 weighted, coronal and axial gradient 3D thin cuts. Slice thickness is 4 mm with intersection gap 1.4 mm.

After the routine MR imaging, the second part of the examination; the axial loading was applied using the commercially available device (DynaWell L-Spine; DynaWell Int. AB, Billdal, Sweden) (Fig. 1), and the device is United States Food and Drug Administration approved (3–7).

The device includes a nonmagnetic Jacket with straps connected to a footplate with compression mechanism. The Jacket was applied before start of routine MR imaging, then during axial loading the side straps are tightened to apply pressure on the trunk against the footplate, the applied load is approximately 60% of the patient weight, and this load is equally distributed on both legs, for example; patient weight 100 kg and

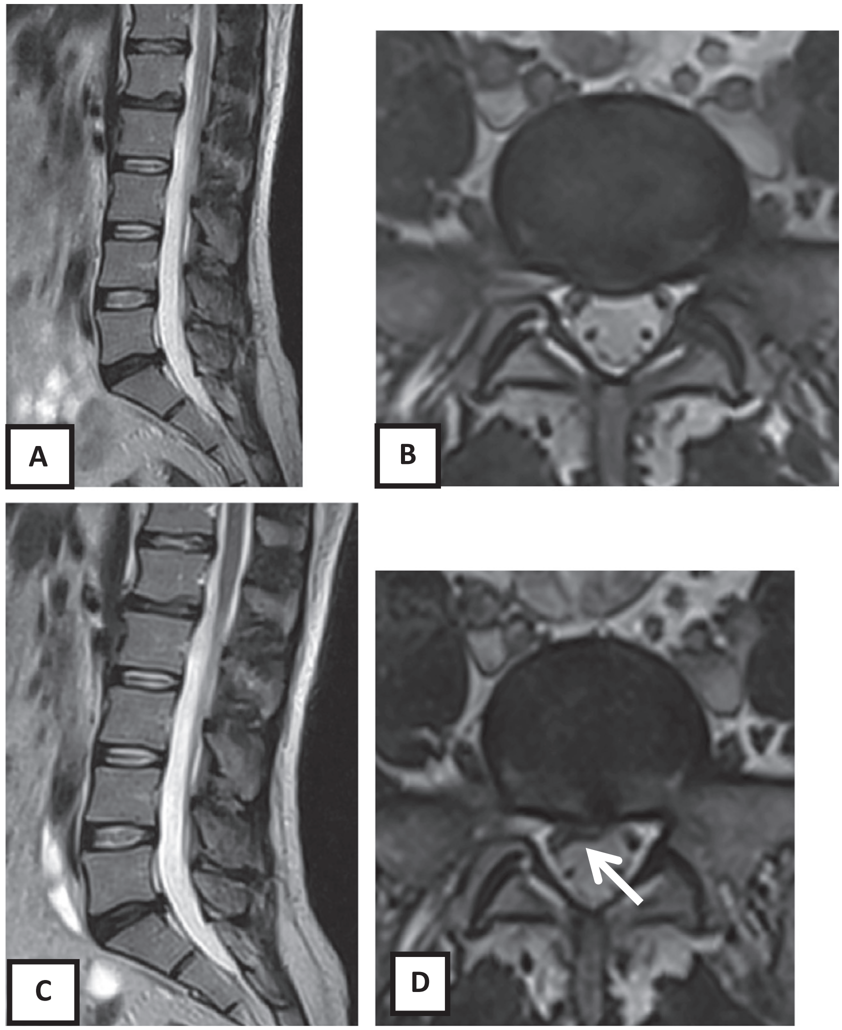

Fig. 2 MRI of the lumbar spine pre axial loading Sagittal T2WI (A) and axial (B), Axial loaded Sagittal T2WI (C) and Axial (D), in a patient with right sciatica; the preloaded images revealed central disk protrusion indenting the thecal sac while in loaded axial image, there is clear compromise of the right sided S1 nerve root (arrow) by the disk which appears more inclined to the right after axial loading.

30 kg of load was applied to each leg, taking into consideration patient tolerability. The load was applied for 5 min followed by acquiring sagittal and axial T2-weighted images.

Patients tolerated the study; no additional pain medication was given.

2.3. Images interpretation

The images from routine and axial loading were interpreted by two experienced Neuroradiologists for changes in total lumbar curvature, lumbar spine height measured from the superior vertebral end plate of L1 down to superior vertebral end plate of S1, disk space height, disk bulge, epidural fat shape, Dural sac dimension, ligamentum flavum thickening, lateral recess and neural foraminal narrowing.

3. Results: (Table 1)

This study was approved by the ethics committee of our institution. All patients enrolled in the study passed the examination with no complaint. The examination time was approximately 40 min.

A total of 20 patients who had symptoms related to lumbar neurological compromise were enrolled in the study, including 11 (55%) males and 9 (45%) females, aged 21–58, with a mean age of 39.5.

Changes in the vertebral alignment were observed in 5 patients (25%) in the form of exaggeration of the normal physiological lordosis in 3 patients (15%) and increase in scoliosis angle in 2 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 disk lesion in 12 patients (60%), the previously present disk lesions became more protruding that induced more neuronal effects that matched with patient symptoms, these findings were not seen in preloading images and accordingly, the patients' symptoms were not explained by routine MR images (Figs. 2 and 3).

Axial loading evoked disk protrusion in initially non-protruded disk in 2 patients (10%).

Fig. 3 MRI of the lumbar spine pre and postaxial loading demonstrating the change in total lumbar spine height. Sagittal T2WI pre axial loading (A) and postaxial loading (B).

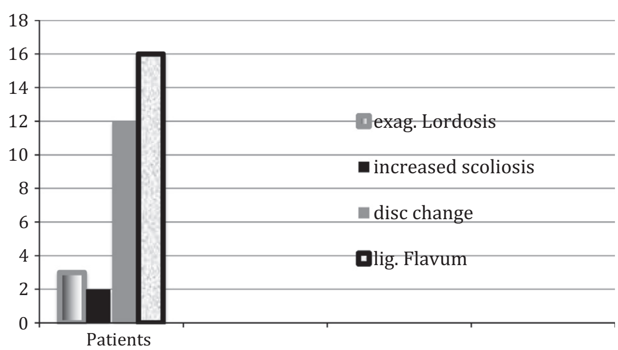

Chart 1 Changes elicited after axial loading of the lumbar spine.

The ligamentum flavum became more prominent after axial loading in 16 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 (Chart 1).

No significant changes elicited in the neural foraminal dimension could be elicited after axial loading.

Changes in the diameter of the thecal sac were assessed subjectively based on indentation by the disk lesion and obliteration of the epidural fat.

No evidence of synovial cyst or dural herniation could be elicited after axial loading.

4. Discussion

It has been postulated that the worsening of patients' symptoms in standing or walking positions is due to narrowing of the spinal canal and crowding of the nerve roots (2).

Standard MR scanning in supine, Psoas muscle relaxation position hinders scanning the spine in the most symptomatic position unlike in Conventional myelography, where patients are scanned in upright position (2).

Several authors have reported that axial loading influences spinal dynamics and morphologic changes during MRI (8–11). The common reason for this accentuation of spinal stenosis is thickening of the ligamentum flavum, accentuation of a bulging disk, and thickening of the dorsal fat pad, which result in deformation of the dural sac (2). According to Hansson et al. (12), the finding that ligamentum flavum contributed to between 50% and 85% of the load induced narrowing of the spinal canal made it the most significant and "dynamic structure" determining most of the load induced changes of the available space within the spinal canal. Consequently, load induced symptoms due to cauda equina encroachment seemed more likely to be caused by bulging of the ligamentum flavum than protrusion of the disk.

Willén and Danielson (13) reported "additional valuable imaging information" for 29% of the symptomatic patients, which is in agreement with Hiwatashi et al. (2).

Danielson et al. (14) studied the effect of the axial loading on the lumbar spine in suspected lumbar spinal stenosis. They reported that axial loading significantly decreased size of the dural sac.

In 76% patients with suspected spinal stenosis, a significant difference in the size of the dural sac was found. In axial loaded MRI, a more pronounced indentation of the dorsal fat pad, thickening of the ligamentum flavum, or a more pronounced disk protrusion is found (15).

Danielson et al. (14) showed that treatment decisions had been changed in 10 out of 20 patients who had a narrowing of the spinal canal detected with axial loaded MRI. Also, treatment decisions of 5 patients changed from conservative management to surgery.

Choi et al. (15) performed decompression of multi-levels, which were found to be compressed using axial loaded MRI and this resulted in satisfactory outcome.

The reason for doing this study was, to determine whether axial loading could add more information to explain patient symptomatology and accordingly if this would affect treatment decision, axial loading MRI revealed positive findings that could not be elicited by conventional MRI and changed the management plan in 80% of patients included in our study.

The limitations of this study are including limited numbers of patients included in the study and lack of quantitative assessment of dural sac surface area.

The disadvantage of axial loading technique is that it is longer than routine MRI by 5–10 min and it induces some pain during the procedure.

5. Conclusion

Axial loading MRI can add more information about vertebral alignment, intervertebral disk height, thecal sac indentation and ligamentum flavum buckling; this information can explain patients' symptomatology and accordingly can significantly change the treatment decision plan.

Conflict of interest

None declared.

References

(1) Popovich Jr JM, Sum JC, Poppert EM, Colletti PM, Kulig K. Axial loading of the lumbar spine in persons with acute low back pain: a kinematic analysis. Clin Kinesiol: J Am Kinesiother Assoc 2005.

(2) Hiwatashi Akio, Danielson Barbro, Moritani Toshio, Bakos Robert S, Rodenhause Thomas G, Pilcher Webster H, et al. Axial loading during MR imaging can influence treatment decision for symptomatic spinal stenosis. AJNR Am J Neuroradiol 2004;25:170–4.

(3) Willén J, Danielson B, Gaulitz A, Niklason T, Schönström N, Hansson T. Dynamic effects on the lumbar spinal canal: axially loaded CT-myelography and MRI in patients with sciatica and/or neurologic claudication. Spine 1997;22:2968–76.

(4) Danielson BI, Willén J, Gaulitz A, Niklason T, Hansson TH. Axial loading of the spine during CT and MR in patients with suspected lumbar spinal stenosis. Acta Radiol 1998;39:604–11.

(5) Danielson B, Willén J. Axially loaded magnetic resonance image of the lumbar spine in asymptomatic individuals. Spine 2001;26:2601–6.

(6) Willén J, Danielson B. The diagnostic effect from axial loading of the lumbar spine during computed tomography and magnetic resonance imaging in patients with degenerative disorders. Spine 2001;26:2607–14.

(7) Kimura S, Steinbach GC, Watenpaugh DE, Hargens AR. Lumbar spine disc height and curvature responses to an axial load generated by a compression device compatible with magnetic resonance imaging. Spine 2001;26:2596–600.

(8) Meakin JR, Smith FW, Gilbert FJ, Aspden RM. The effect of axial load on the sagittal plane curvature of the upright human spine in vivo. J Biomech 2008;41:2850–4.

(9) O'Connell GD, Johannessen W, Vresilovic EJ, Elliott DM. Human internal disc strains in axial compression measured noninvasively using magnetic resonance imaging. Spine 2007;32:2860–8.

(10) Willén J, Danielson B. The diagnostic effect from axial loading of the lumbar spine during computed tomography and magnetic resonance imaging in patients with degenerative disorders. Spine 2001;26:2607–14.

(11) Willén J, Danielson B, Gaulitz A, Niklason T, Schönström N, Hansson T. Dynamic effects on the lumbar spinal canal: axially loaded CT-myelography and MRI in patients with sciatica and/or neurogenic claudication. Spine 1997;22:2968–76.

(12) Hansson Tommy, Suzuki Nobuyuki, Hebelka Hanna, Gaulitz Arne. The narrowing of the lumbar spinal canal during loaded MRI: the effects of the disc and ligamentum flavum. Eur Spine J 2009;18:679–86.

(13) Bazhin A, Egorova E, Kozlov E. Moscow/RU. Lumbar spine MRI in upright position for diagnosing degenerative disorders. Poster No.: C-0643. ECR 2014.

(14) Danielson BI, Willén J, Gaulitz A, Niklason T, Hansson TH. Axial loading of the spine during CT and MR in patients with suspected lumbar spinal stenosis. Acta Radiol. 1998;39:604–11.

(15) Choi Kyung-Chul, Kim Jin-Sung, Jung Byungjoo, Lee Sang-Ho. Dynamic lumbar spinal stenosis: the usefulness of axial loaded MRI in preoperative evaluation. J Korean Neurosurg Soc 2009;46:265–8.