# Magnetic resonance imaging characteristics of patients with low back pain and those with sciatica

Shobeiri E, Khalatbari M R, Taheri M S, Tofighirad N, Moharamzad Y

**ABSTRACT**

**Introduction: This study aimed to compare the characteristics of magnetic resonance (MR) imaging in patients with low back pain (LBP) and those with sciatica.**

**Methods: Clinical examination and MR imaging were performed on 100 sciatic and 100 LBP patients who were matched by age and gender. Different findings, including spinal canal stenosis, spondylolisthesis, the degree of disc herniation (bulge, protrusion, and extrusion) and nerve root compression, were documented. MR imaging findings were compared using the chi-square and Mann-Whitney U tests.**

**Results: 11 percent of LBP patients and 37 percent of sciatic patients had spinal canal stenosis (p-value is less than 0.001). Spondylolisthesis was found in 12 percent of LBP patients and 14 percent of sciatic patients (p-value is 0.6). Disc extrusion was more common in patients with sciatica as compared to LBP patients at the L4–L5 level (29 percent vs. 4 percent; p-value is less than 0.001) and at the L5–S1 level (24 percent vs. 3 percent; p-value is less than 0.001). Nerve root compression was also more common in sciatic patients in the thecal sac (58 percent vs. 20 percent; p-value is less than 0.001) and in the lateral recess (73 percent vs. 19 percent; p-value is less than 0.001) than in LBP patients.**

**Conclusion: Patients with sciatica were more likely to have spinal canal stenosis, disc extrusion (at L4–L5 and L5–S1 levels) and nerve root compression in the thecal sac and lateral recess.**

**Keywords: disc extrusion, low back pain, magnetic resonance imaging, nerve root compression, sciatica, spinal canal stenosis**

*Singapore Med J 2009;50(1):87-93*

**Table I. Distribution of leg pain and numbness in sciatic patients according to the involved dermatome.**

| Involved dermatome | Leg pain | Numbness |
|---|---|---|
| L2 and L3 | 2 | 0 |
| L4 | 2 | 11 |
| L5 | 6 | 13 |
| S1 | 12 | 13 |
| L4 and L5 | 7 | 3 |
| L4 and S1 | 8 | 1 |
| L5 and S1 | 36 | 21 |
| L4, L5, and S1 | 27 | 10 |
| Total | 100 | 72 |

**Table II. Comparison of spinal canal stenosis and spondylolisthesis on MR imaging in LBP and sciatic patients.**

| | LBP patients (n = 100) | Sciatic patients (n = 100) | p-value |
|---|---|---|---|
| Spinal canal stenosis | 11 | 37 | < 0.001 |
| Absolute | 7 | 30 | 0.2 |
| Partial | 4 | 7 | |
| Spondylolisthesis | 12 | 14 | 0.6 |
| L3–L4 | 0 | 2 | 0.2 |
| L4–L5 | 5 | 7 | |
| L5–S1 | 7 | 5 | |

## INTRODUCTION

Sciatica due to a lumbar intervertebral disc (IVD) herniation is the most common cause of radicular leg pain in the adult working population, and is an important medical and socioeconomic problem.[1,2] Sciatic pain is usually characterised as a sharp pain that radiates from the back into the dermatome of the affected nerve root, or as non-radicular pain which radiates in the leg in a non-dermatomal pattern, and is often associated with numbness or paresthesia.[3,4] Mixter and Barr were the first to demonstrate the relationship between disc herniation and sciatica.[5] Nerve root compression by a herniated disc is the major pathological factor inducing sciatica.[6] In contrast, simple low back pain (LBP) is usually a benign and self-limited condition. About 10%–15% of sciatic patients with persistent or severe symptoms require surgery for the excision of the herniated disc.[7]

**Department of Radiology, Imam Reza Hospital, Kermanshah University of Medical Sciences, Bagh-e-Abrisham Avenue, Kermanshah, Iran**

Shobeiri E, MD
Assistant Professor

Moharamzad Y, MD
General Physician

**Rasoul Akram Hospital, Iran University of Medical Sciences, Tehran, Iran**

Khalatbari MR, MD
Neurosurgeon

**Department of Radiology, Shohada Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran**

Taheri MS, MD
Assistant Professor

**Department of Radiology, Amiralmomenin Hospital, Azad University of Medical Sciences, Tehran, Iran**

Tofighirad N, MD
Assistant Professor

**Correspondence to:** Dr Yashar Moharamzad,
Tel : (98) 831 727 4253
Fax: (98) 831 728 2010
Email: yasharpop@hotmail.com

**Table III. Comparison of disc herniation at different lumbar levels in LBP and sciatic patients.**

| MR imaging findings | LBP patients (n = 100) | Sciatic patients (n = 100) | p-value |
|---|---|---|---|
| L1–L2 | | | |
| Bulging or protrusion | 11 | 21 | 0.01* |
| Extrusion | 0 | 2 | |
| Total | 11 | 23 | 0.02** |
| L2–L3 | | | |
| Bulging or protrusion | 22 | 30 | 0.1* |
| Extrusion | 0 | 2 | |
| Total | 22 | 32 | 0.1** |
| L3–L4 | | | |
| Bulging or protrusion | 33 | 47 | 0.02* |
| Extrusion | 3 | 4 | |
| Total | 36 | 51 | 0.03** |
| L4–L5 | | | |
| Bulging or protrusion | 83 | 58 | < 0.001* |
| Extrusion | 4 | 29 | |
| Total | 87 | 87 | 1** |
| L5–S1 | | | |
| Bulging or protrusion | 58 | 45 | 0.002* |
| Extrusion | 3 | 24 | |
| Total | 61 | 69 | 0.2** |

* p-values compare the degree of disc herniation using the Mann-Whitney U test.
** p-values compare the presence of disc herniation using the chi-square test.

Magnetic resonance (MR) imaging has replaced conventional radiography to become the modality of choice in the evaluation of IVD and the diagnosis of painful spinal disorders.[8,9] However, several studies have indicated a high prevalence of abnormal MR imaging findings among asymptomatic patients.[10–12] Thus, controversy has arisen regarding disc pathology as a cause of LBP and lower extremity radiculopathy. Degenerated, bulging and herniated discs are frequently incidental findings and may be misleading. Different degrees of single or multilevel degenerations or disc bulge are visible on the MR images of 28%–85% of the adult male and female population who do not have activity-limiting LBP.[9] The purpose of this study was to compare MR imaging findings between LBP patients and sciatic patients who were potential candidates for surgical intervention, in order to clarify the anatomical changes responsible for radiculopathy.

## METHODS

During a six-month period, from February to July 2006, 100 sciatic patients (47 males and 53 females) with lower extremity radiculopathy symptoms lasting for at least one month and referred to the neurosurgery and/or orthopaedic clinics of our university hospital, were entered into the study. For the sake of comparison, 100 patients (47 males and 53 females) complaining of LBP for at least a month, referred directly from primary care settings, were also included in the study. The mean and standard deviation of the age of the patients in the sciatic and LBP groups were 45.9 ± 13 and 43.9 ± 12.7 years, respectively (p = 0.1). The median (25%–75% interquartile range) duration of symptoms in the sciatic and LBP groups were three (1–9.75) months and three (1–8.75) months, respectively. Both groups were given bed rest, physical therapy, analgesics, muscle relaxants and conservative treatment. Informed consent was obtained from all patients prior to enrollment. Those with a history of former lumbar spine surgery, vertebral fractures, infection or tumour at the back region, connective tissue disease, metabolic bone disease and neoplastic or inflammatory disease were excluded.

A clinical examination of each patient was conducted within 48 hours before MR imaging. Radiating leg pain and numbness in different dermatomes (L2, L3, L4, L5, and S1) as well as the presence of other concomitant findings of radiculopathy such as muscle weakness or atrophy, were evaluated for sciatic patients. Straight leg-raising (SLR) and reverse SLR tests were performed in all patients. Those who complained of leg pain but had negative SLR tests were excluded. Patients with LBP in which either SLR or reverse SLR tests were positive were also excluded. To classify sciatic patients by pain distribution, all subjects were divided according to the clinical manifestations of nerve root involvement as follows: L2 (anterior thigh); L3 (anterior thigh and knee); L4 (anterolateral thigh, knee and medial calf); L5 (lateral calf, dorsal foot, posterolateral thigh and buttocks); and S1 (bottom foot, posterior calf, posterior thigh and buttocks).

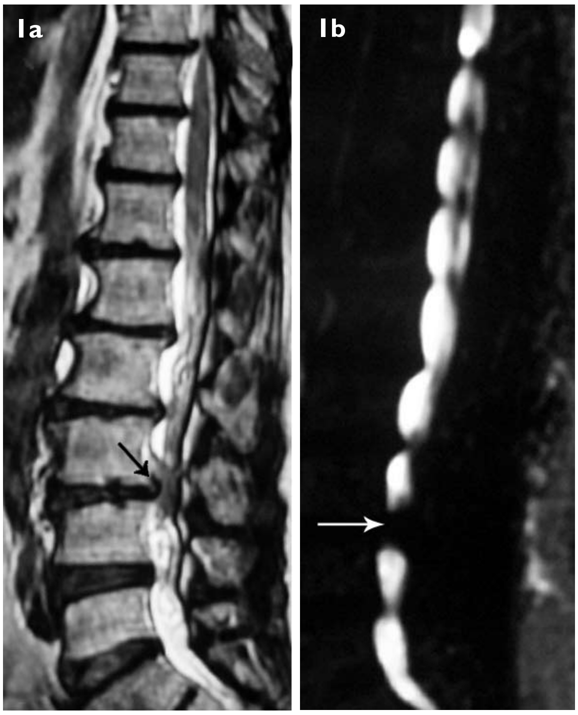


**Fig. 1** (a) Sagittal T2-W MR image and (b) the corresponding myelogram show partial canal stenosis through the entire lumbar spine (sagittal diameter of canal is 8 mm). A disc protrusion is also seen at L3–L4 level (arrow).

**Fig. 2** Sagittal T2-W MR image shows discovertebral degeneration with anterior spondylolisthesis at L4–L5 level (arrow).

MR imaging of all patients were performed with a 1.0 tesla imaging system (Philips, The Netherlands). The scans consisted of sagittal and axial T1-weighted (repetition time/echo time (TR/TE) of 500/15 ms) and T2-weighted (TR/TE of 3,500/120 ms) turbo spin echo images of the lumbar spine. The slice thickness and interslice gap were 6 mm and 0.9 mm, respectively, for both sagittal and axial images, with 250 × 240 matrix and a field of view of 395 mm for sagittal images, and 256 × 256 matrix and a field of view of 225 mm for axial images. All of the MR imaging readings was performed by a board-certified MR imaging radiologist who was blinded to the patient's symptoms, clinical examination findings and diagnosis. Initially, all images were screened for evidence of neoplastic, inflammatory or infectious disorders, and if any were observed, the patient was excluded from the study. Each spinal level was evaluated separately.

The variables assessed on MR imaging were as follows:

1. Spinal canal stenosis (narrowing of the spinal canal anterior-posterior diameter anywhere along its axis) and was graded as partial (7–9 mm) and absolute (< 7 mm).
2. Spondylolisthesis (anterior or posterior slipping of a vertebra from any cause).
3. Disc herniation was graded as normal; bulge (circumferential enlargement of the disc contour in a symmetric fashion); protrusion (a bulging disc that is eccentric to one side); or extrusion (extension of nucleus pulposus through a complete tear of the annulus and is contained only by the posterior longitudinal ligament).
4. Nerve root compression by disc herniation and its location (thecal sac, lateral recess and foramen). The location of a herniation that was present in more than one of the places mentioned (i.e. thecal sac, lateral recess or foramen) was defined as "multiple places". Nerve compression was also defined as the presence of a mass effect on the nerve root.

Descriptive indices, like frequency, percentage, mean and standard deviation, were used to summarise patient demographic and MR imaging-reported characteristics. Chi-square and Mann-Whitney U tests were used for the comparison of radiological findings between the two studied groups. A p-value of 0.05 was considered to indicate a statistically significant difference. All analyses was performed using the Statistical Package for Social Sciences version 13.0 (SPSS Inc, Chicago, IL, USA).

**Table IV. Comparison of nerve root compression in different locations in LBP and sciatic patients.**

| Location of nerve root compression | LBP patients (n = 100) | Sciatic patients (n = 100) | p-value |
|---|---|---|---|
| Thecal sac | | | |
| Mild or moderate | 15 | 25 | < 0.001* |
| Severe | 5 | 33 | |
| Total | 20 | 58 | < 0.001** |
| Lateral recess | | | |
| Mild or moderate | 15 | 19 | < 0.001* |
| Severe | 4 | 54 | |
| Total | 19 | 73 | < 0.001** |
| Foramen | | | |
| Mild or moderate | 9 | 9 | 0.6* |
| Severe | 6 | 11 | |
| Total | 15 | 20 | 0.3** |
| Multiple locations | | | |
| Mild or moderate | 2 | 4 | 0.09* |
| Severe | 0 | 5 | |
| Total | 2 | 9 | 0.03** |

* p-values compare the degree of nerve root compression using the Mann-Whitney U test.
** p-values compare the presence of nerve root compression using the chi-square test.

## RESULTS

In the sciatic group, 41 (41%) complained of right leg radiating pain, 36 (36%) of left leg and 23 (23%) suffered from pain in both legs. The most commonly-involved dermatome for both radiating pain and numbness was at the L5 and S1 levels observed in 36 (36%) and 21 (21%) patients, respectively (Table I). 11 sciatic patients had muscle atrophy (six in the thigh and five in the calf muscles). Muscular weakness upon dorsiflexion of the foot was seen in 19 cases (19%), followed by plantar flexion of the foot (17%) and knee extension (14%).

On MR imaging, patients with radiculopathy often had spinal canal stenosis in contrast to patients with only LBP. This finding was observed in 37 (37%) sciatic patients and 11 (11%) LBP patients ($p < 0.001$). Partial and absolute stenoses were seen in 7 (18.9%) and 30 (81.1%) sciatic patients, respectively (Fig. 1). In the LBP group, four had partial stenosis and seven had absolute stenosis. There was no significant difference in the distribution of partial and/or absolute spinal canal stenosis between the two groups ($p = 0.2$). The prevalence rate of spondylolisthesis (Fig. 2) was 12% in patients with LBP and 14% in sciatic patients ($p = 0.6$). Table II summarises absolute and partial spinal canal stenoses and spondylolisthesis observed in LBP and sciatic patients. Almost all patients (93% of the LBP group and 99% of sciatic patients) had at least a single herniation. The most common level of herniation in both studied groups was L4–L5 which was found in 87% of the patients in each group. MR imaging findings addressing the presence of disc herniation and its degree (bulge, protrusion and extrusion) in both groups are shown in Table III.

Overall, 36% of LBP patients and 91% of the sciatic group had at least one finding of nerve root compression. In sciatica patients, the most common location of nerve compression was in the lateral recess which was observed in 73 (73%) patients; whereas the thecal sac was the most prevalent location of nerve compression in the LBP group (20%). Distribution of nerve root compressions in different locations (thecal sac, lateral recess, foramen and multiple) and their degree (mild, moderate, severe) in both groups are presented in Table IV. All types of herniations (bulge, protrusion and extrusion) in different locations are shown in Figs. 3–6.

## DISCUSSION

The role of diagnostic imaging in patients with LBP with or without radiculopathy is an important one in today's healthcare environment. The purpose of diagnostic imaging is to provide accurate anatomic information and to aid the therapeutic decision-making process.[13] MR imaging has become the examination of choice for diagnosing lumbar disc herniations. It has the advantage of having no known side effects or morbidity, no radiation exposure and is noninvasive. In addition, it is possible to identify separate constituents of the disc, based on the differing concentrations of water, proteoglycan and collagen. A disadvantage of MR imaging is that it cannot directly visualise the cortical bone, which does not have mobile protons and produces a black "signal void" on MR images.[14] Degenerative changes of the IVD are characterised by a loss of hydration of the nucleus pulposus and a disruption of the annulus fibrosus.[9] MR imaging can also show spinal canal stenosis, nerve root swelling, annular tears and can be used to clarify the herniation from a simple annular bulging to extruded herniations.[15]

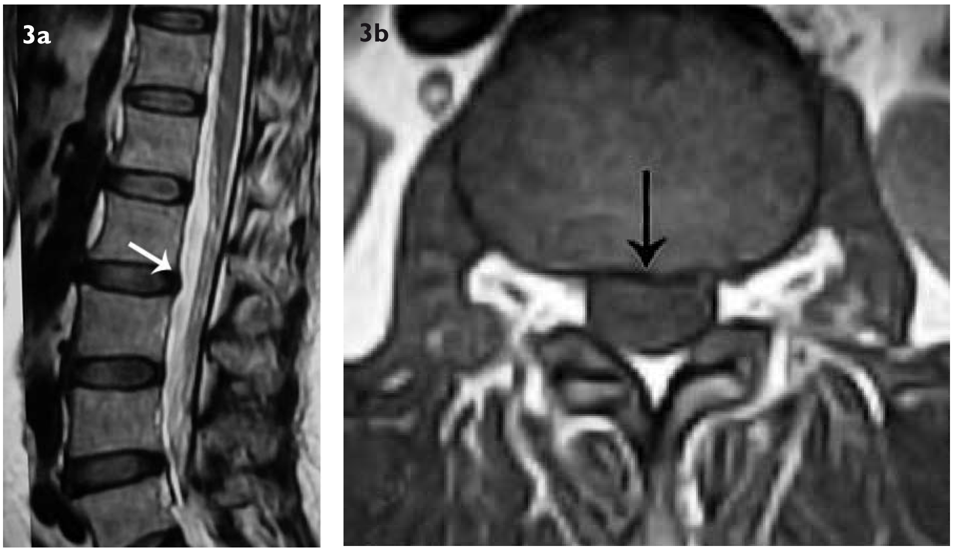


**Fig. 3** (a) Sagittal T2-W MR image shows disc bulging at L2–L3 level (arrow). (b) Axial T1-W image taken at L2–L3 level shows minimal posterior impression on epidural fat, compatible with disc bulging (arrow).

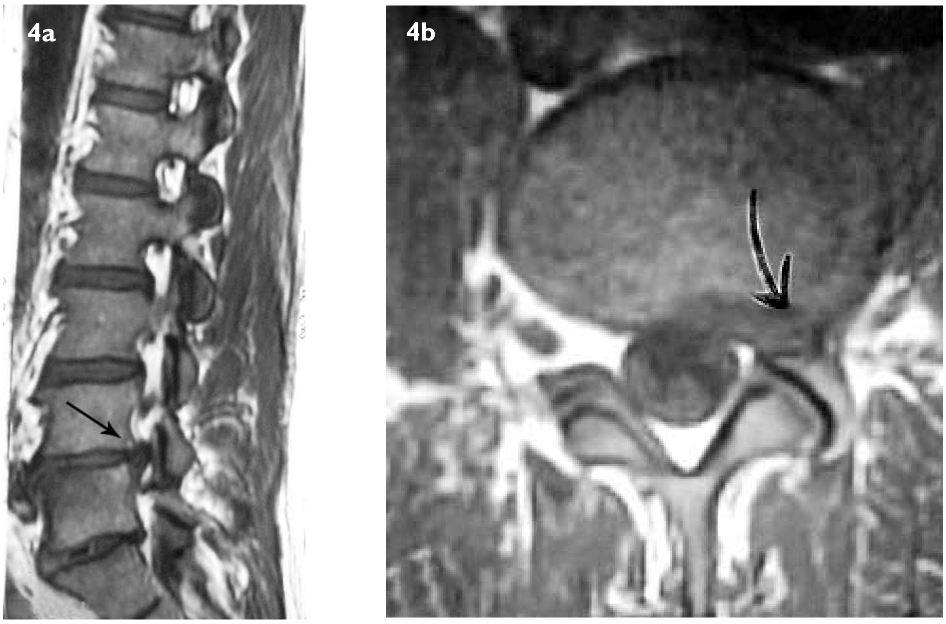


**Fig. 4** (a) Sagittal and (b) axial T1-W MR images show a left foraminal disc protrusion at L4–L5 level (arrow) without significant root compression.

In the current study, all patients underwent a similar MR imaging technique, and both sagittal and axial views of all images were interpreted to locate any abnormal findings. A high prevalence of abnormalities in the lumbar spine was found on MR imaging in both groups compared to that reported in the adult population who do not have activity-limiting LBP.[9] However, the degree of herniation was significantly different between the two groups. For example, 87 L4–L5 herniations were found in each group, but patients with radiculopathy were more likely to have an extrusion (33.3%) compared to the LBP group, in which there were only four cases (4.5%) with this finding. Such a difference was also observed at the L2–L3 and L5–S1 levels. At the L1–L2 and L3–L4 levels, both the presence of herniation and its degree showed significant statistical difference between the two groups. Modic et al have reported that the prevalence of disc herniations in patients with LBP and those with radiculopathy were similar.[13] We believe that this discrepancy could be related to patient selection, as greater pain in the back region or the leg was the basis for dividing patients into the LBP or the radiculopathy group. However, in this study, LBP patients did not have any lower extremity-related radiculopathy symptoms or signs. In addition, our patients had a longer history of symptoms compared to the other study in which patients who had acute symptoms of < 3 weeks were included in the study.[13]

Our findings showed that sciatic patients had more frequent nerve root compression in all observed places

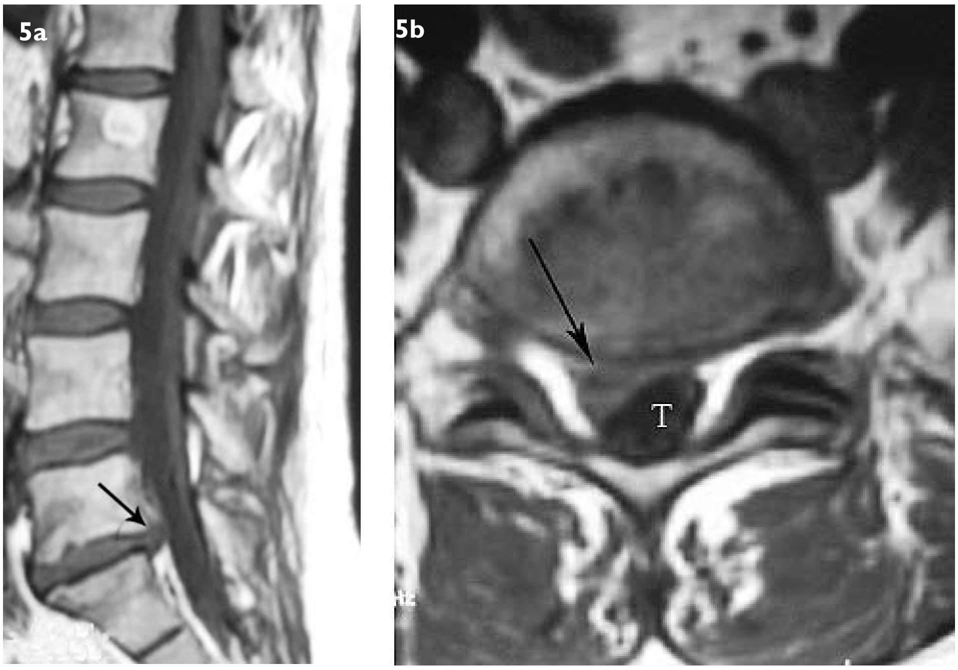


**Fig. 5** (a) Sagittal and (b) axial T1-W MR images show a right paracentral disc extrusion (arrow) associated with moderate thecal sac (T) impression at L5–S1 level.

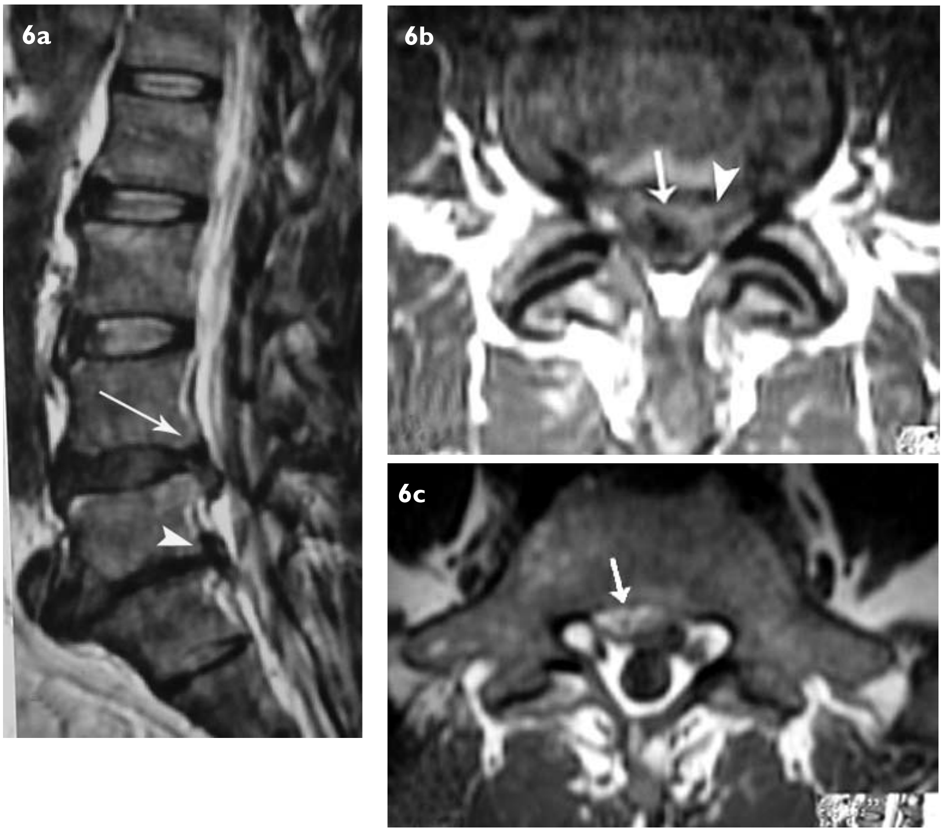


**Fig. 6** (a) Sagittal T2-W MR image shows two-level disc extrusions at L4–L5 (arrow) and L5–S1 (arrowhead) levels. Caudal subligamentous migration of extruded disc at L4–L5 level is seen. (b) Axial T1-W image taken at L4–L5 level shows disc extrusion associated with mild thecal sac impression (arrow), and severe left lateral recess nerve root compression (arrowhead). (c) Axial T1-W image taken at L5–S1level shows a disc extrusion (arrow) with mild nerve root compression.

except in the foramen; in other places especially the thecal sac and lateral recess, the observed difference between the two groups was more significant. The lateral recess in the sciatic group and the thecal sac in the LBP group were the most frequently involved places for nerve root compression, respectively. In the lateral recess, 73.9% of all nerve compressions were of the severe type (in the sciatica group). However, such a situation was not seen in the LBP group and visible abnormalities were distributed nearly to an equal extent among mild, moderate and severe degrees. With regard to the severity of nerve entrapment, it was also found that the severe form of nerve compression was more visible in sciatic patients. In the thecal sac and the lateral recess, the statistical difference was more obvious ($p < 0.001$). The fact that nerve compression by the herniated nucleus pulposus is responsible for the majority of the symptoms in sciatic patients, has been considered earlier, and sciatica has subsequently been treated with surgical excision of the herniated disc.[6]

MR imaging, by providing high resolution images, plays an important role in the successful surgical management of a sciatic patient undergoing an operation. The prevalence of MR imaging abnormalities appear to exceed those reported in studies of symptomatic individuals of a similar age, and a higher frequency of abnormalities in this study was observed in the lower levels of the lumbar spine. It should be mentioned that no sequestered discs were found in the studied population. A limitation encountered was the 6-mm slice thickness that can reduce the sensitivity of MR imaging in the detection of smaller disc protrusions and their effect on the thecal sac. In conclusion, the findings of this study indicate that patients with radiculopathy were more likely to have spinal canal stenosis, disc extrusion in lower lumbar levels and nerve root compression in the thecal sac and lateral recess. These radiological findings should receive more emphasis during the interpretation of MR images of sciatic patients, especially when their symptoms have become chronic.

## REFERENCES

1. Atlas SJ, Keller RB, Wu RA, Deyo RA, Singer DE. Long-term outcomes of surgical and nonsurgical management of lumbar spinal stenosis: 8 to 10 year results from the maine lumbar spine study. Spine 2005; 30:936-43.
2. Hou SX, Tang JG, Chen HS, Chen J. Chronic inflammation and compression of the dorsal root contribute to sciatica induced by the intervertebral disc herniation in rats. Pain 2003; 105:255-64.
3. van Akkerveeken PF. Pain patterns and diagnostic blocks. In: Wiesel SW, Weinstein JN, Herkowitz H, eds. The Lumbar Spine. Philadelphia: WB Saunders, 1996: 105-22.
4. Karppinen J, Malmivaara A, Tervonen O, et al. Severity of symptoms and signs in relation to magnetic resonance imaging findings among sciatic patients. Spine 2001; 26:149-54.
5. Mixter W, Barr J. Rupture of the intervertebral disc with involvement of the spinal canal. N Engl J Med 1934; 211:210-5.
6. Omarker K, Myers RR. Pathogenesis of sciatic pain: role of herniated nucleus pulposus and deformation of spinal nerve root and dorsal root ganglion. Pain 1998; 78:99-105.
7. Bush K, Cowan N, Katz DE, Gishen P. The natural history of sciatica associated with disc pathology: a prospective study with clinical and independent radiologic follow-up. Spine 1992; 17:1205-12.
8. Jarvik JG, Hollingworth W, Martin B, et al. Rapid magnetic resonance imaging versus radiographs for patients with LBP: a randomized controlled trial. JAMA 2003; 289:2810-8.
9. Beattie P. The relationship between symptoms and abnormal magnetic resonance images of lumbar intervertebral disks. Phys Ther 1996; 76:601-8.
10. Jarvik JG, Deyo RA. Imaging of lumbar intervertebral disk degeneration and aging, excluding disk herniations. Radiol Clin North Am 2000; 38:1255-66.
11. Jensen MC, Brant-Zawadzki MN, Obuchowski N, et al. Magnetic resonance imaging of the lumbar spine in people without back pain. N Engl J Med 1994; 331:69-73.
12. Boden S, Davis D, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. J Bone Joint Surg Am 1990; 72:403-8.
13. Modic MT, Obuchowski NA, Ross JS, et al. Acute low back pain and radiculopathy: MR imaging findings and their prognostic role and effect on outcome. Radiology 2005; 237:597-604.
14. Jarvik JC, Deyo RA. Diagnostic evaluation of low back pain with emphasis on imaging. Ann Intern Med 2002; 137:586-97.
15. Vroomen PC, Van Hapert SJ, Van Acker RE, et al. The clinical significance of gadolinium enhancement of lumbar disc herniations and nerve roots on preoperative MRI. Neuroradiology 1998; 40:800-6.