Magnetic resonance imaging in the diagnosis of lumbar canal stenosis in Indian patients

Inder Pawar, Supreethi Kohli[1], Vipin Dalal, Vinod Kumar[1], Seema Narang[1], Anu Singhal[1]

Departments of Orthopedics and [1]Department of Radiology,
ESI Model Hospital and Post-Graduate Institute of Medical Sciences and Research, Basaidarapur, New Delhi, India

Address for correspondence:
Dr. Supreethi Kohli,
Tower 5, flat no-1403, Sushant Estate, Sector 52, Gurgaon, Haryana 122 002, India.
E-mail: supreethikohli@gmail.com

Access this article online

Quick response code	
	Website: www.joas.in
	DOI: 10.4103/2319-2585.134200

ABSTRACT

Introduction: Magnetic resonance imaging (MRI) has become the choice of imaging modality for lumbar canal stenosis (LCS) due to limitations and radiation risks of computed tomography (CT) and spinal radiography. The radiological criteria for diagnosis of LCS are still ambiguous. Aim of this study is to find out the radiological dimensions on MRI of lumbar spinal canal in Indian patients and the critical dimensions at which the symptoms occur. **Materials and Methods:** A cross-sectional study was conducted in ESI Hospital, New Delhi from July 2011 to 2013. Two study groups were studied, the symptomatic LCS group, consisted of 30 individuals of either sex in age group of 45-65 years. The control group consisted of 30 asymptomatic age matched individuals. MRI scans were performed on 1.5 Tesla scanner. Dimensions of lumbar canal at all the levels (L1-L5) of lumbar vertebra of 60 patients were measured. **Results:** In our study, in symptomatic group, narrowest mid-sagittal diameter antero-posterior (mean 10.61) was at L5-S1 level. The interligamentous diameter (ILD) showed no significant difference between the two groups. Lateral recess depths showed a significant difference between the two groups at all levels except L1 on right side and L1 and L2 on left side. Critical canal dimension was found to be 11.13 mm. **Conclusion:** MRI can effectively evaluate the lumbar canal stenosis. The critical canal dimensions at which symptoms of stenosis appear were 11.13.

Keywords: *Lumbar canal, magnetic resonance imaging, stenosis*

Introduction

Lumbar spinal stenosis (LSS) is a source of neurogenic claudication causing bilateral or unilateral lower limb pain, numbness, paresthesia or weakness.[1-4] Accurate diagnosis of the clinical syndrome of spinal stenosis is important because of the substantial differential diagnoses and because the range of treatments includes spinal surgery, which is associated with some morbidity and treatment failure in the elderly population.[5-8] There has not been convincing evidence of a relationship between symptoms or surgical results and any anatomical measurement.[7-12] The LSS has been defined as any type of narrowing of the spinal canal.[13] It may be developmental (congenital) or acquired.[13] Developmental stenosis is rare, characterized by short pedicles and narrowing of the spinal canal dimensions,[14,15] whereas acquired degenerative stenosis is most common.[16] Anatomically, LSS could be involved in the central canal, lateral recess, foramina or any combination of these locations. Central spinal stenosis (CSS) is most common at the L2-L3, L3-L4, L4-L5 and patients present with symptoms of radiculopathy or myelopathy often acquired with bilateral extremity claudication on exertion. The most common canal stenotic conditions are acquired along with developmental conditions; such as, narrowed or abnormally shaped spinal canal. The most common shape of canal is round and ovoid; perhaps 15% of humans have a trefoil canal. Lateral recess stenosis is present when the distance between the superior facets antero-medially and the posterior vertebral body margin is less than 4 mm. Hypertrophic inferior facets narrow the lateral recess by reducing the interlaminar angle.[8] Diagnosis and imaging is based on clinical findings. Neurologic findings on physical examination are unusual. Some patients can have a narrowed canal without symptoms and do not require therapy. Several studies have attempted morphometrically to characterize the lumbar spine in individuals with degenerative lumbar spinal stenosis (DLSS) with diverse results.[1,17-25] Some radiological studies have reported that the changes in the anterior-posterior (AP) diameter, transverse diameter and cross-section area (CSA) of the spinal canal and dural sac are risk factors for developing spinal stenosis.[20,21,26,27]

The poor correlation between radiological manifestations and the clinical picture,[28-31] emphasizes the fact that more studies are required to determine the natural course of this syndrome. MRI is extensively used for imaging of lumbar spine, as it is noninvasive and also gives complete overview of osseous canal along with its soft tissue components. The transverse and sagittal dimensions of the central canal are best depicted by the orthogonal planes on T2W sequences, providing the best views of thecal sac dimensions. Peripheral stenosis is best appreciated on T1W images, the parasagittal and axial images allow identification of lateral recess and the neural foramina. Upright MRI, a recent advancement, loads the spine, allows for flexion, extension and makes stenosis more obvious. Studying the morphometric characteristics of the lumbar vertebrae in the DLSS population may assist in developing useful conservative treatments and improvement of surgical procedures. In addition, detecting specific features in an asymptomatic population can be important in preventing or delaying the onset of symptoms in this group.

The aim of this study to assess the radiological dimensions of lumbar spine canal in symptomatic patients of lumbar canal stenosis with reference to age matched asymptomatic population and to find out critical canal dimension in AP dimension at which the symptoms appear.

Materials and Methods

A cross-sectional study conducted by the Department of Orthopedics and Radiology, ESI Hospital, New Delhi from July 2011 to 2013. All patients were assessed by a structured performa for epidemiological and clinical details. Investigations to be performed were explained to each patient and written consent was taken. The study was approved by Ethical Committee of the Institute.

Study groups

A total of two study groups were studied. The symptomatic LCS group consisted of 30 individuals of either sex in age group of 45-65 years with signs and symptoms related to LCS. All individuals in this group were interviewed and examined using a defined protocol. They exhibited intermittent neurogenic claudication and were often accompanied by other symptoms, such as radiculopathy or low backache. The control group consisted of 30 asymptomatic age-matched individuals. They were interviewed to exclude possible LCS-related symptoms.

Exclusion criteria

(1) Lumbar vertebrae fracture (2) vertebral abnormalities (3) previous spinal surgery (4) Spinal tumors (5) Pott's spine (6) Paget's disease (7) gross spinal pathology (e.g., spondylolisthesis, retrolisthesis and disc-space collapse).

All study subjects underwent magnetic resonance imaging (MRI) of the lumbar spine. MRI radiologist was blind to the subject status. The MRI scan was performed on Philips Acheiva (Philips Health Care, Netherlands, BV) 1.5 Tesla scanner, coil used was sense spine, 4 mm slice thickness, sequence included (1) T2W FSE SAG, (2) T1W FSE SAG, (3) STIR COR, 4T1W FSE AXIAL (5) T2W FSE AXIAL (6) T2 FSE DRIVE AXIAL (high resolution) sequence using DRIVE with a small FOV to reduce cerebrospinal fluid (CSF) flow artefacts. Dimensions of lumbar canal at all the levels (L1-L5) of lumbar vertebra of 60 patients were measured. MRI measurements were taken at all levels from L1 to L5: (1) Antero-posterior diameter was measured on T2W at mid-sagittal level as the distance between the posterior border of the vertebra and the lamina posteriorly at the midline [Figure 1]. (2) Interpedicular distance was measured on T2W axial at the mid pedicular level as the distance between the inner borders of both the pedicles of vertebral bodies [Figure 2]. (3) Inter-ligamentous diameter (ILD) was measured on T2 W axial as the distance between the inner borders of ligamentum flavum at the point joining the facets in MRI. (4) Lateral recess depth (LRD) was measured from the dorsal surface of vertebral body to the most ventral segment of the superior articular facet.

Statistical analysis

It was performed using mean, standard deviation (SD), standard error and Student's *t*-test. A *P* value less than 0.05 were considered statistically significant.

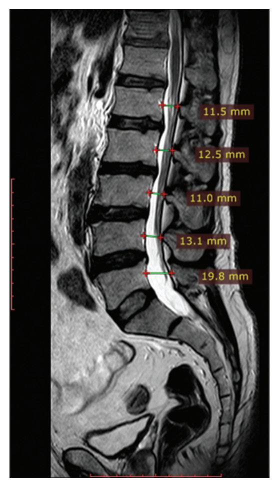

Figure 1: Sagittal T2w image with spinal canal diameter at various levels

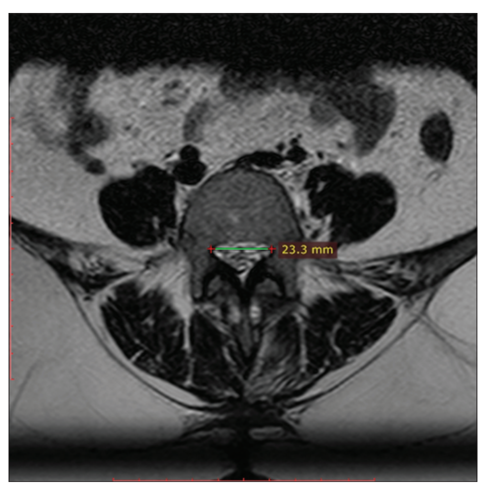

Figure 2: Axial T2w image with interpedicular distance

Results

Out of 2 study groups, the symptomatic LCS group consisted of 16 males and 14 females with mean age 52.65 years (range 45-65) [Table 1 and Figure 3]and the other normal (asymptomatic) group consisted of 17 males and 13 females with mean age 54.50 years (range 46-64) [Table 1 and Figure 3]. Overall, there were 33 males (55%) and 27 females (45%) in our study [Table 2].

Mid-sagittal diameter on MRI

In normal group, the mean of mid-sagittal (antero-posterior) diameter in millimeter from L1 to L5 showed a steady increase in diameter [Table 3]. Whereas in symptomatic LCS group, there was a steady increase from L1 to L3 and then diameter decreased from L3 to L5 as shown in figure below. There was a significant difference ($P < 0.05$) in midsagittal diameter between the 2 groups at L4 and L5 levels.

Table 1: Chart shows age distribution of Normal and symptomatic groups (in years)

Age (years) distribution					
Group	*N*	Mean	Std. deviation	Minimum	Maximum
Normal	30	54.50	6.203	46	64
Symptomatic LCS group	30	52.65	6.699	45	65
Total	60	53.57	6.441	45	65

LCS = Lumbar canal stenosis

Table 2: Charts shows sex distribution of the symptomatic and normal group
Sex distribution

	Group		Total
	Normal	Symptomatic LCS Group	
Sex			
F			
Count	13	14	27
% within group	43.33%	46.67%	45%
M			
Count	17	16	33
% within group	56.67%	53.33%	55%

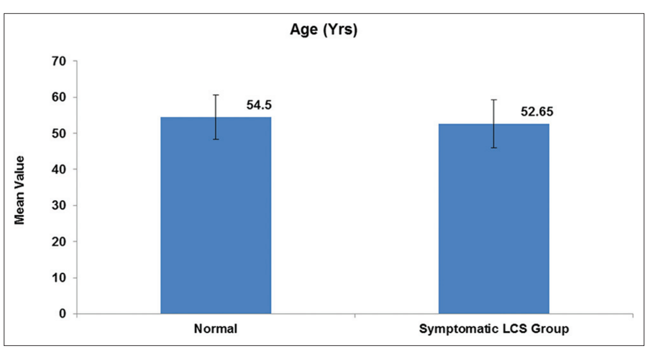

Figure 3: Bar diagram shows age distribution of normal and symptomatic lumbar canal stenosis group

The mean mid-sagittal (antero-posterior) diameter of lumbar central canal in the normal group showed gradual increase in diameter from L1 to L5 [Table 3], whereas in symptomatic LCS group there was decrease in values [Tables 3]. More number of patients in symptomatic group had AP diameter less than 11.13 mm as compared to asymptomatic patients [Table 4].

The diagnostic accuracy as given by the area under ROC curve is 0.815 (95% CI 0.681-0.949). Taking 11.13 mm spinal canal diameter as cut-off for symptoms on sagittal images has high specificity (93.33%), however it has less sensitivity (60%) [Table 5].

Inter-pedicular diameter

The mean diameter in both groups showed no significant difference. The range at all the levels was 17 to 36 mm in the normal group and 15.30 to 36 mm in symptomatic LCS group [Table 6]. The measurement of the lumbar vertebrae showed a steady increase in the interpedicular distance from L1 to L5 in both the groups.

Inter-ligamentous diameter on MRI

There was no significant difference between the mean diameters between the two groups [Table 7]. In normal group, there was an increasing pattern in the mean diameters from L1 to L5.

Lateral recess depth of right side on MRI

There was a significant difference between the mean measurements of left side lateral recess depth between the 2 groups at all levels except L1 [Table 8].

Lateral recess depth of left side on MRI

There was a significant difference between the mean measurements of left side lateral recess depth between the 2 groups at all levels except L1 [Table 9].

Discussion

North American Spine Society states in their guideline that imaging is the key non-invasive test for LSS but they provide no radiological criteria for stenosis in these guidelines. MRI has become investigation of choice as it is non-invasive, with no radiation risks and gives overview of spine along with its soft-tissue components. Our cross-sectional study, which included 30 study subjects in symptomatic LCS group and 30 normal groups shows that MRI can effectively be used for analysis of LSS.

In our study, the narrowest and widest mid-sagittal diameters on MRI were at L5-S1 (mean 10.61) in symptomatic LCS group and L1-L2 in normal group. Our results were consistent with the study done by Deep S. Chatha and Mark E. Schweitzer (2011) also the narrowest level was at L5-S1 (mean 11.6 mm) and widest at L1-L2 (mean15.6 mm).[32] The mean Inter-pedicular diameter (IPD) between the two groups showed no significant difference. The range at all the levels was 17 to 36 mm in the normal group and 15.30 to 36 mm in symptomatic group. The measurement of lumbar vertebrae showed a steady increase in the IPD from L1 to L5 in both the groups, which is consistent with other studies like Eisenstien [20], Karantanas *et al*.,[33] Rapala *et al*.,[34] ILD showed a steady increase L1 to L5 and there was no significant difference between the two groups. The minimum value (mm) from L3 to L5 in our study were 10-17, 13.6-19.6 and 14.2-25.1, whereas in a study of Karantanas (1998), ranges were 7.3-23.6, 8.4-26.58 and 11.4-28.8 mm.[33] In our study, there was significant difference between the mean measurements of the right lateral recess depth between the two groups except L1. There was a significant difference between the mean measurements of the left lateral recess depth between the two groups from L2 to L5. The findings of this study were compatible with other studies of Bolender *et al*.,[35] 1985, Beers *et al*.,[36] 1985, Schonstrom *et al*.,[37] 1985, where lateral recess was studied though not in central spinal canal stenosis entity.

For measurement of critical canal dimensions ROC curve analysis of MRI-AP was used. It found a cutoff value that minimizes the number of false positives and false negatives. Minimizing the false positives and false negatives is the same as maximizing the sensitivity and specificity. Thus a good first choice for a test cutoff value is that value, which corresponds to a point on the ROC curve nearest to the upper left corner of the ROC graph, which is 11.13 mm Fukusaki *et al*.,[38] (1998) reported it to be <15 mm, whereas Koc *et al*.,[39] (2009) reported it to be <12 mm but these two studies did not report the measurement points.

Conclusion

According to our cross-sectional study, MRI was able to differentiate between symptomatic and asymptomatic

Table 3: Chart shows mean spinal canal diameter values on sagittal images in normal and symptomatic group

MRI AP	Normal (*n*=30)		Symptomatic LCS Group (*n*=30)		*P* value
	Mean±SD	Min-max	Mean±SD	Min-max	
L1	11.85±1.14	10.2-14.0	11.89±1.51	9.1-14.4	0.925
L2	12.27±1.20	10.3-14.2	11.95±1.69	9.1-15.2	0.495
L3	12.73±1.15	10.7-14.9	12.02±1.92	9.0-16.3	0.164
L4	12.98±1.09	11.0-15.1	10.60±1.66	8.4-14.8	<0.001
L5	13.11±1.40	9.1-15.1	9.05±1.76	6.1-12.0	<0.001

SD = Standard deviation, MRI = Magnetic resonance imaging, AP = Anterior-posterior, LCS = Lumbar canal stenosis

Table 4: Chart shows number of patients in normal and symptomatic group with reference to spinal canal diameter value 11.13 mm on sagittal images

AP diameter	Symptomatic LCS	Normal	Total	*P* value
≤11.13	18	2	20	<0.001
>11.13	12	28	40	
Total	30	30	60	

LCS =Lumbar canal stenosis, AP = Anterior-posterior

Table 5: Chart shows various statistical values of AP spinal canal diameter value 11.13 as cut-off for symptoms

Sensitivity	60%
Specificity	93.33%
Predictive value of positive test	90%
Predictive value of negative test	93.33%

AP = Anterior-posterior

Table 6: Chart shows inter-pedicular diameter (in mm) in normal and symptomatic groups

IPD	Normal (*n*=30)		Symptomatic LCS Group (*n*=30)		*P* value
	Mean±SD	Min-max	Mean±SD	Min-max	
L1	21.96±2.53	17.2-29.3	21.58±2.93	15.3-25.7	0.659
L2	22.06±2.37	17 – 28	21.93±2.82	16-26	0.875
L3	23.25±2.33	18.3-29.1	23.17±2.52	16.5-27.0	0.923
L4	26.45±2.52	22.6-32.5	26.37±2.20	23.5-30.7	0.910
L5	30.59±2.95	26-36	30.34±2.98	26-36	0.795

IPD = Inter-pedicular diameter, SD = Standard deviation, LCS = Lumbar canal stenosis

Table 7: Chart shows inter-ligamentous diameter (in mm) in normal and symptomatic groups

MRI ILD	Normal (*n*=30)		Symptomatic LCS Group (*n*=30)		*P* value
	Mean±SD	Min-max	Mean±SD	Min-max	
L1	12.67±1.90	9-16	12.12±3.52	8-19	0.543
L2	12.88±1.95	10-17	12.01±4.26	4-19	0.416
L3	13.23±2.02	10-17	12.90±4.62	6-22	0.772
L4	15.96±1.57	13.6-19.6	14.02±4.82	6.9-23.1	0.101
L5	16.88±2.41	14.2-25.1	15.68±5.43	7.4-26.0	0.375

SD = Standard deviation, MRI = Magnetic resonance imaging, LCS = Lumbar canal stenosis, ILD = Interligamentous diameter

Table 8: Chart shows lateral recess depth (in mm) on right side in normal and symptomatic group

MRI LRD	Normal (*n*=30)		Symptomatic LCS Group (*n*=30)		*P* value
	Mean±SD	Min-max	Mean±SD	Min-max	
L1	5.15±0.72	3.9-6.6	4.81±1.22	2.1-7.8	0.282
L2	5.34±0.56	4.2-6.6	3.88±1.03	1.6-5.3	<0.001
L3	5.36±0.43	4.3-6.2	3.13±1.18	1.2-5.5	<0.001
L4	4.99±0.66	4-6	2.98±1.13	1-5	<0.001
L5	4.72±0.58	3.8-5.8	2.97±1.23	1.4-6.4	<0.001

SD = Standard deviation, MRI = Magnetic resonance imaging, LCS = Lumbar canal stenosis, LRD = Lateral recess depth

Table 9: Chart shows lateral recess depth (in mm) on left side in normal and symptomatic group

MRI LRD (L)	Normal (*n*=30)		Symptomatic LCS Group (*n*=30)		*P* value
	Mean±SD	Min-max	Mean±SD	Min-max	
L1	4.73±0.58	3.9-6.4	4.43±1.21	2.2-8	0.326
L2	4.96±0.71	3.9-6.4	3.70±1.38	1.9-7.2	<0.001
L3	4.38±0.54	3.7-5.7	2.93±1.06	1.4-5.7	<0.001
L4	4.31±0.65	2.1-5.3	2.56±1.51	1.2-6.2	<0.001
L5	4.42±0.39	3.8-5.3	2.97±1.39	0.8-6.3	<0.001

SD = Standard deviation, MRI = Magnetic resonance imaging, LCS = Lumbar canal stenosis, LRD = Lateral recess depth groups with good reliability of the measurements. There were significant differences in AP dimensions of lumber spinal canal in symptomatic patients, which is a measure of central canal stenosis. The critical AP canal dimension for symptoms to appear in our study on basis of ROC curve analysis is 11.13. It was also found that there were significant differences in the lateral recess depth on both right and left side indicating that MRI is also beneficial to assess LCS. Limitations and radiation risk of CT scan and spinal radiography suggest that MRI represents the best imaging modality for assessment of lumbar canal stenosis. A limitation to this study is small sample size.

References

1. Amundsen T, Weber H, Lilleås F, Nordal HJ, Abdelnoor M, Magnaes B. Lumbar Spinal Stenosis. Clinical and radiologic features. Spine (Phila Pa 1976) 1995;20:1178-86.
2. Jonsoon B, Annertz M, Sjoberg C, Stromqvist B. A prospective and consecutive study of surgically treated lumbar spinal stenosis. Part I: Clinical features related to radiographic findings. Spine (Phila Pa 1976) 1997;22:2932-37.
3. Berthelot JM, Bertrand-Vasseur A, Rodet D, Maugars Y, Prost A. Lumbar spinal stenosis: A review. Rev Rhum Engl Ed 1997;64:315-25.
4. Radu AS, Menkes CJ. Update on lumbar spinal stenosis. Retrospective study of 62 patients and review of the literature. Rev Rhum Engl Ed 1998;65:337-45.
5. Vitaz TW, Raque GH, Shields CB, Glassman SD. Surgical treatment of lumbar spinal stenosis in patients older than 75 years of age. J Neurosurg 1992;91:181-5.
6. Benz RJ, Ibrahim ZG, Afshar P, Garfin SR. Predicting complications in elderly patients undergoing lumbar decompression. Clin Orthop Relat Res 2001;384:116-21.
7. Enzmann DR. On low back pain. AJNR Am J Neuroradiol 1994;15:109-13.
8. Herron LD, Mangelsdorf C. Lumbar spinal stenosis: Results of surgical treatment. J Spinal Disord 1991;4:26-33.
9. Uden A, Johnsson KE, Jonsson K, Pettersson H. Myelography in the elderly and the diagnosis of spinal stenosis. Spine (Phila Pa 1976) 1985;10:171-4.
10. Weir R, de Leo R. Lumbar stenosis: Analysis of factors affecting outcome in 81 surgical cases. Can J Neurol Sci 1981;8:295-8.
11. Postacchini F, Pezzeri G, Montanaro A, Natali G. Computerized tomography in lumbar stenosis: a preliminary report. J Bone Joint Surg Br 1980;62:78-82.
12. Verbiest H. Results of surgical treatment of idiopathic developmental stenosis of the lumbar vertebral canal. A review of twenty-seven years' experience. J Bone Joint Surg Br 1977;59:181-8.
13. Arnoldi CC, Brodsky AE, Cauchoix J, Crock HV, Dommisse GF, Edgar MA, *et al*. Lumbar spinal stenosis and nerve root entrapment syndromes. Definition and classification. Clin Orthop Relat Res 1976;115:4-5.
14. Lutter LD, Longstein JE, Winter RB, Langer LO. Anatomy of the achondroplastic lumbar canal. Clin Orthop Relat Res 1977;126:139-42.
15. Singh K, Samartzis D, Vaccaro AR, Nassr A, Andersson GB, Yoon ST, *et al*., Congenital lumbar spinal stenosis: A prospective, control-matched, cohort radiographic analysis. Spine J 2005;5:615-22.
16. Kirkaldy-Willis WH, Wedge JH, Yong-Hing K, Reilly J. Pathology and pathogenesis of lumbar spondylosis and stenosis. Spine (Phila Pa 1976) 1978;3:319-28.
17. Chynn KY, Altman I, Shaw WI, Finby N. The roentgenographic manifestations and clinical features of lumbar spinal stenosis with special emphasis on the superior articular process. Neuroradiology 1978;16:378-80.
18. Eisenstein S. Measurements of the lumbar spinal canal in 2 racial groups. Clin Orthop Res 1976;115:42-6.
19. Eisenstein S. The morphometry and pathological anatomy of the lumbar spine in South African Negroes and Caucasoid with specific reference to spinal stenosis. J Bone Joint Surg Br 1977;59:173-80.
20. Eisenstein S. The trefoil configuration of the lumbar vertebral canal. A study of South African skeletal material. J Bone Joint Surg Br 1980;62B:73-7.
21. Sheldon JJ, Russin LA, Gargano FP. Lumbar spinal stenosis. Radiographic diagnosis with special reference to transverse axial tomography. Clin Orthop 1976;115:53-67.
22. Ullrich CG, Binet EF, Sanecki MG, Kieffer SA. Quantitative assessment of the lumbar spinal canal by computed tomography. Radiology 1980;134:137-43.
23. Urso S, Pacciani E, Donnetti L. The radiological diagnosis of spinal stenosis in the lumbar spinal canal. Ital J Orthop Traumatol 1986;12:93-108.
24. Bartolozzi P, Salvi M, Misasi M. The diagnosis of lumbar stenosis. Chir Organi Mov 1992;77:15-8.
25. Luarencin CT, Lipson SJ, Senatus P, Botchwey E, Jones TR, Koris M, *et al*. The stenosis ratio: A new tool for diagnosis of degenerative spinal stenosis. Int J Surg Investig 1999;1:127-31.
26. Schonstrom N, Lindahl S, Willen J, Hansson T. Dynamic changes in the dimensions of the lumbar spinal canal: An experimental study *in vitro*. J Orthop Res 1988;7:115-21.
27. Ogikubo O, Forsberg L, Hansson T. The relationship between the cross section area of cauda equina and preoperative symptoms in central lumbar spinal stenosis. Spine (Phila Pa 1976) 2007;32:1423-8.
28. Herno A, Airaksinen O, Saari T. Computed tomography after laminectomy for lumbar spinal stenosis. Patients' pain patterns, walking capacity, and subjective disability had no correlation with computed tomography findings. Spine (Phila Pa 1976) 1994;19:1975-8.
29. Herno A, Saari T, Suomalainen O, Airaksinen O. The degree of decompressive relief and its relation to clinical outcome in patients undergoing surgery for lumbar spinal stenosis. Spine (Phila Pa 1976) 1999;24:1010-4.
30. Wiesel SW, Tsourmas N, Feffer HL, Citrin CM, Patronas N. A study of computer-assisted tomography I. The incidence of positive CAT scans in an asymptomatic group of patients. Spine (Phila Pa 1976) 1984;9:549-51.
31. Boden SD, Davis DO, 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.
32. Chatha DS, Schweitzer ME. MRI criteria of developmental lumbar spinal stenosis revisited. Bull NYU Hosp Jt Dis 2011;69:303-7.
33. Karantanas AH, Zibis AH, Papaliagia M, Georgiou E, Rousogiannis S. Dimensions of lumber spinal canal: Variations and correlations with somatometric parameters using CT. Eur Radiol 1998;8:1581-5.
34. Rapala K, Chaberek S, Truszczynska A, Lukawsli S, Walczak P. Assessment of lumber spinal canal morphology with digital computed tomography. Ortop Traumatol Rehabil 2009;11:156-63.
35. Bolender NF, Schonstrom NS, Spengler DM. Role of computed tomography and myelography in the diagnosis of central spinal stenosis. J Bone Joint Surg Am 1985;67:240-6.
36. Beers GJ, Carter AP, Leitern BE, Tilak SP, Shah RR. Interobserver discrepancies in distance measurements from lumber spine CT scans. AJR Am J Roentgenol 1985;144:395-8.
37. Schonstrom NS, Bolender N, Spengler DM. The pathomorphology of spinal stenosis as seen on CT scans of the lumbar spine. Spine (Phila Pa 1976) 1985;10:806-11.
38. Fukusaki M, Kobayasi, Hara T, Summikawa K. Symptoms of spinal stenosis do not improve after epidural steroid injection. Clin J Pain 1998;14:148-51.
39. Koc Z, Ozcakir S, Sivrioglu K, Gurbet A, Kucikoglu S. Effectiveness of physical theraphy and epidural steroid injections in lumber spinal stenosis. Spine (Phila Pa 1976) 2009;34:985-9.

How to cite this article: Pawar I, Kohli S, Dalal V, Kumar V, Narang S, Singhal A. Magnetic resonance imaging in the diagnosis of lumbar canal stenosis in Indian patients. J Orthop Allied Sci 2014;2:3-7.

Source of Support: Nil, Conflict of Interest: None declared.