IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 1 Ver. 3 (January. 2019), PP 78-85
www.iosrjournals.org

Assessment of Spinal Canal Diameters for Clinically Suspected Cases of Lumbar Canal Stenosis on MRI

[1]Dr. PawanSoni, [2]Dr. Dinesh Sood, [3]Dr. Ira Jamwal, [4]Dr. Rajeev Kapila
Department of Radiodiagnosis, Dr.Rajendra Prasad Government Medical College, Kangra at Tanda (176001) Himachal Pradesh, India
Corresponding author: Dr.Ira Jamwal

Abstract:
Background: *Lumbar canal stenosis means reduced space available for the neural and vascular elements in the lumbar spine leading to low backache or lower extremity pain. Magnetic resonance imaging (MRI) is the key non-invasive test for assessment of lumbar canal stenosis. Studies have been performed to develop the criteria for spinal stenosis in the lumbar spine. However, till date no consensus on quantitative criteria has been made. Imaging with MRI, in our study, can help in formulating a cause and critical quantitative criteria for stenosis that can provide evidence-based recommendations for proper evaluation needed for optimum treatment of clinically suspected patients.*
Materials and methods: *A total of 100 symptomatic cases who were suspected of lumbar canal stenosis, aged between 30 to 60 years, and 30 age matched asymptomatic controls underwent MRI of the lumbar spine. Patients were assessed for stenosis on the basis of six qualitative criteria, as given after the result of a Delphi survey in 2012. Various quantitative parameters were then measured at five levels (L1 to L5) and compared with the controls.*
Results: *The narrowest mid sagittal anteroposterior spinal canal diameter at body (mean 13.9 mm) and at disc (mean 12.2 mm) level were seen at L4 level and L5-S1 level respectively while narrowest thecal sac diameters at body (mean 11.2 mm) and at disc (mean 8.9 mm) levels were seen at L5 level and L4-L5 level respectively. The cut off limits for spinal canal stenosis were given for spinal canal diameter at body, thecal sac diameter at body, spinal canal diameter at disc and thecal sac diameter at disc as 13.5 cm, 10.5 cm, 13.5 cm and 7.5 cm respectively.*
Conclusion: *It was concluded that the thecal sac diameter at disc level with a critical value of 7.5 mm had highest sensitivity (87%) and specificity (84%) as far as canal stenosis was concerned and should be given highest priority while taking the measurements.*
Keywords: *Lumbar, Stenosis, Spinal canal diameters, MRI*

Date of Submission: 20-12-2018 Date of acceptance: 06-01-2019

I. Introduction

Lumbar canal stenosis encompasses a wide variety of structural and functional abnormalities that lead to diminished space for neural and vascular structures within the bony spinal canal causing symptoms like pain and paraesthesias in the buttock and lower limbs. From a radiological perspective, emphasizing the underlying structural anomaly, stenosis of the spinal canal with or without clinical manifestations is a more precise definition.[1]

It can be divided anatomically into central and lateral canal stenosis. Central canal stenosis causes neurogenic claudication while lateral canal stenosis leads to radicular pain. The concomitant stenotic atherosclerotic vascular disease causes vascular claudication, which may be difficult to differentiate from neurogenic claudication.[2]

Lumbar canal stenosis can be congenital or acquired. Congenital stenosis is most often due to diffuse skeletal dysplasias, such as achondroplastic dwarfism or spondyloepiphyseal dysplasia, Morquio's syndrome and spinal dysraphism (lipoma, myelomeningocele). Acquired stenosis may be a result of degenerative disease, trauma, spondylolisthesis, discitis, neoplastic or post-operative and various miscellaneous conditions such as ankylosingspondylosis, ossification of the posterior longitudinal ligament, acromegaly, Paget's disease, and fibrosis.[3, 4]

Different imaging techniques [radiography, myelography, computed tomography (CT), CT myelography, and magnetic resonance imaging (MRI)] have been applied in the diagnosis and evaluation of lumbar canal stenosis. MRI has provided the imaging capabilities without the need for an invasive procedure.

The spinal fluid provides a myelographic effect on MRI. So, it is considered the study of choice in the diagnosis of spinal stenosis because disc, soft tissue, bony changes, and intrathecal contents are visualized.[5-7]

The North American Spine Society states in their guidelines that MRI is the key non-invasive test for lumbar canal stenosis, but they provide no definitive radiological criteria for stenosis. Studies have been performed to develop the criteria for spinal stenosis in the lumbar spine.[8, 9]Till date no consensus on quantitative criteria has been made. However, the reliability and clinical-radiological association of qualitative criteria are well documented.

Our study aims in formulating a critical quantitative criteria for stenosis that can provide evidence-based recommendations for proper evaluation needed for optimum treatment of clinically suspected patients.

II. Materials and Methods

This prospective study was carried out for one year in the Department of Radiodiagnosis, Dr. Rajendra Prasad Government Medical College, Kangra at Tanda, Himachal Pradesh, after approval by the institutional ethics committee. The subjects were recruited from the patients who were referred for MRI lumbar spine.

Sample size: A total of 100 symptomatic cases who met the inclusion criteria were included in the study after obtaining informed consent. 30 age-matched individuals referred for MRI for other reasons were also included as asymptomatic controls.

Inclusion Criteria:

Patients of either sex in the age group 30-60 years referred to the Department of Radiodiagnosis with clinical symptoms indicative of lumbar canal stenosis such as the following, were included.

- Radiculopathy (radiating unilateral or bilateral lower limb pain, lower limb paraesthesias and weakness)
- Low back pain
- Claudication of a neurologic nature

Exclusion Criteria

The study excluded –

- Post-operative spine
- Lumbar vertebrae fractures
- Patients who have absolute contraindications to MRI (pacemaker, cochlear implants, aneurysm clips, intraocular metallic foreign bodies etc.)
- Claustrophobia
- Refusal for study

Methodology

The patients underwent MRI lumbar spine on 1.5 Tesla MRI machine (Signa Excite, GE Healthcare), in supine position. The sequences included 1) SAG T2W FSE, 2) SAG T1W FSE, 3) SAG STIR, 4) COR STIR 5) AXIAL T1W FSE and 6) AXIAL T2W FSE. Slice thickness used was 3 mm for axial, 4 mm for sagittal and 5 mm for coronal sections. Intravenous gadolinium agent as contrast material was administered when considered necessary. Patients were assessed for stenosis on the basis of following qualitative criteria, as given by Mamisch et al[8] after the result of a Delphi survey in 2012.

- presence of disk herniation
- lack of perineural intraforaminal fat
- presence of hypertrophic facet joint degeneration
- absence of fluid around the cauda equine
- hypertrophy of the ligamentum flavum
- redundant nerve roots of cauda equine

At any level, any two positive findings out of the above, were taken as stenosis at that level.

Following quantitative parameters were then measured at each lumbar spine level from L1 to L5.

1. **Spinal canal diameter at body level** - Anteroposterior diameter on T2W image at mid-sagittal level as the distance between the posterior border of the vertebra and the lamina posteriorly at the midline.
2. **Spinal canal diameter at disc level** - Anteroposterior diameter on T2W at mid-sagittal level as the distance between the posterior border of the disc and the lamina posteriorly at the midline.

3. **Thecal sac diameter at body level** - Anteroposterior diameter on T2W image at mid-sagittal level as the distance between the anterior and posterior border of the thecal sac at the midline at mid vertebral body level.
4. **Thecal sac diameter at disc level** - Anteroposterior diameter on T2W image at mid-sagittal level as the distance between the anterior and posterior border of the thecal sac at the midline at disc level.

Statistical analysis: The data was analyzed using SPSS (Statistical Product and Service Solutions or Statistical Package for the Social Sciences) software version 20. Independent t-test was used to compare the quantitative measurements of the cases and controls. ROC (Receiver Operating Characteristic) curve was used to calculate sensitivity, specificity and the critical cut-off values for canal diameters.

III. Results

Males outnumbered the females in both the study groups. Male to female ratio was 61:39 among cases and 17:13 among controls. The mean age of cases was 42.9 years while it was 41.6 years in case of controls rendering the two groups age matched.

We found that 71% cases had qualitative evidence of canal stenosis. The most commonly found criteria was the presence of disc herniation/bulge followed by lack of perineural intraforaminal fat.

71% stenosed cases had a total of 108 levels (out of 500) affected with stenosis on qualitative basis with maximum affection seen at L4-L5 (44.4%) followed by L5-S1 (31.5%), L3-L4 (19.4%), L2-L3 (3.7%) and L1-L2 (0.9%) levels. (Table 1)

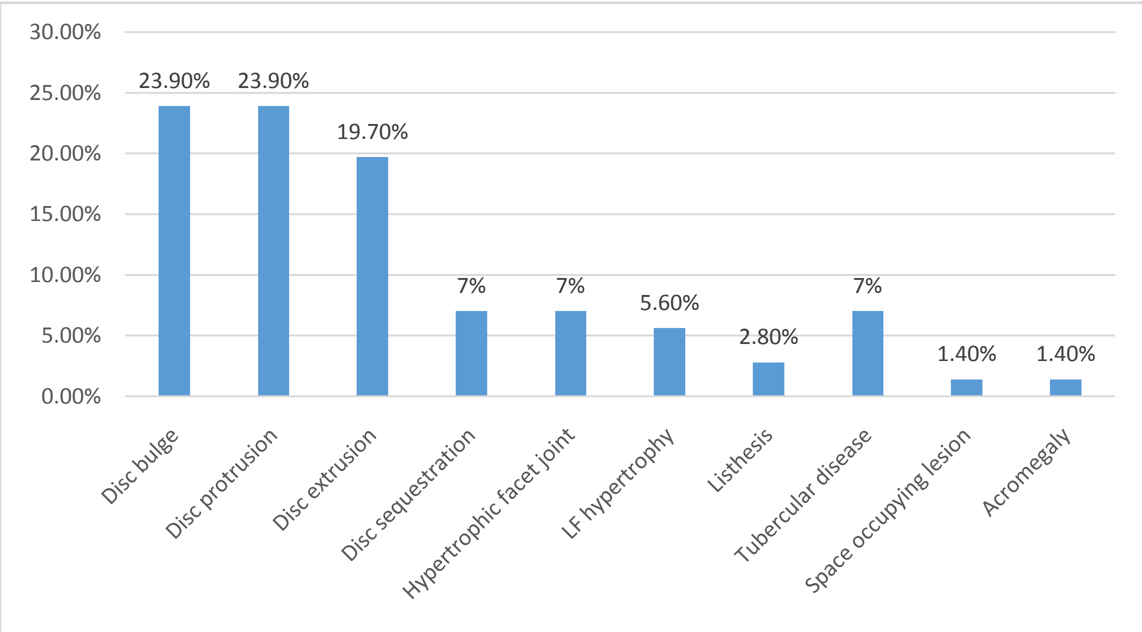
Table 1: Level wise distribution of lumbar canal stenosis in cases and controls.

Level of canal stenosis	Cases		Controls	
	Number	Percentage	Number	Percentage
L1/L1-L2	1	0.9%	0	0%
L2/L2-L3	4	3.7%	0	0%
L3/L3-L4	21	19.4%	0	0%
L4/L4-L5	48	44.4%	0	0%
L5/L5-S1	34	31.5%	0	0%
Total	108	100%	0	0%

Causes of canal stenoses

- Sixty four (89.9%) out of 71 stenosed cases had degenerative spine disease as the cause of stenosis. (Disc related causes - 74.5%, hypertrophic facet joint - 7%, ligamentum flavum hypertrophy - 5.6% and listhesis - 2.8%). Rest was contributed by tubercular disease (7%), acromegaly (1.4%) and space occupying lesion (1.4%).
- Disc related causes were bulge (23.9%), protrusion (23.9%), extrusion (19.7%) and sequestration (7%). (Figure 1)

Figure 1: Distribution of causes of lumbar canal stenosis.



Analysis of quantitative parameters

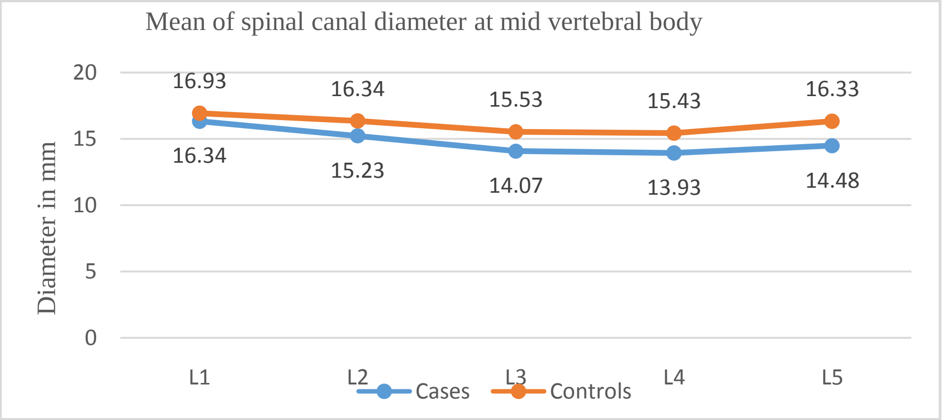
Mid vertebral body level

- The **spinal canal diameter at mid vertebral body** level showed a gradual decrease from L1 to L4 and then increased from L4 to L5 in both cases and controls. There was a significant difference (*p-value* < 0.05) in midsagittal diameter between the 2 groups from L2 to L5 levels. (Table 2, Figure 2)

Table 2: Mean of spinal canal diameter at mid vertebral body (mm).

Vertebral level	Cases	Std. Deviation	Controls	Std. Deviation	p-value
L1	16.34	1.65	16.93	1.79	0.094
L2	15.23	1.83	16.34	1.85	0.003
L3	14.07	2.06	15.53	1.65	0.001
L4	13.93	2.41	15.43	2.12	0.003
L5	14.48	2.97	16.33	2.64	0.003

Figure 2: Mean of spinal canal diameters at mid vertebral body.

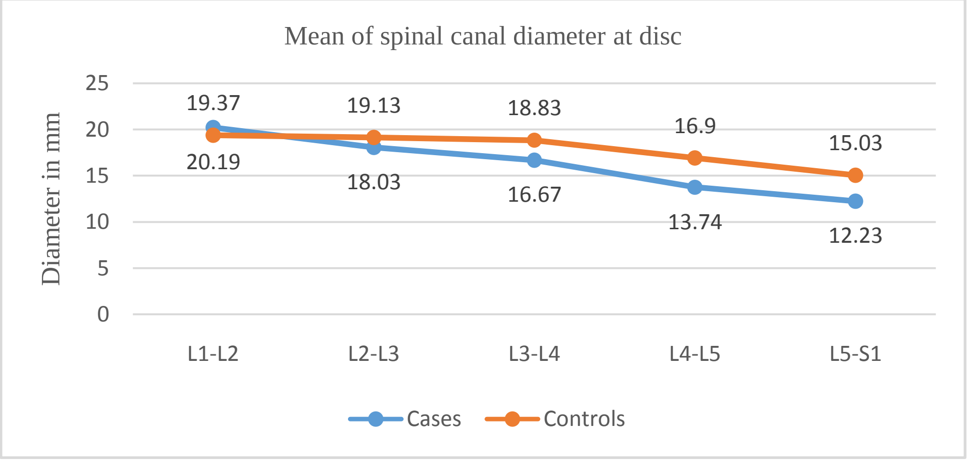


- The **thecal sac diameter at mid vertebral body** showed a decrease from L1 to L5 in cases; while in controls, it decreased from L1 to L4 and then increased from L4 to L5. However, the mean values of cases remained below the mean values of controls at all levels. There was significant difference (*p-value* < 0.05) in this measurement between 2 groups at all levels. (Table 3, Figure 3)

Table 3: Mean of spinal canal diameter at disc (mm).

Disc level	Cases	Std. Deviation	Controls	Std. Deviation	p-value
L1-L2	20.19	1.70	19.37	2.31	0.793
L2-L3	18.03	2.41	19.13	2.70	0.035
L3-L4	16.67	2.97	18.83	3.06	0.001
L4-L5	13.74	3.09	16.90	2.17	<0.001
L5-S1	12.23	2.83	15.03	1.60	<0.001

Figure 3: Mean of spinal canal diameter at disc.



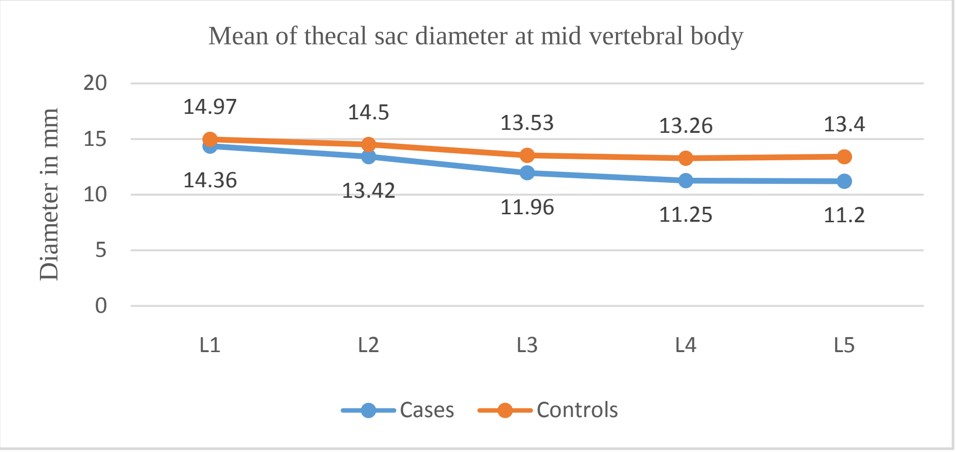
Disc level

- The **spinal canal diameter at intervertebral disc** showed a gradual decrease from L1-L2 to L5-S1 in both the study groups. There was a significant difference (*p-value* < 0.05) in this diameter between 2 groups from L2 to L5. (Table 4, Figure 4)

Table 4: Mean of thecal sac diameter at mid vertebral body (mm).

Vertebral level	Cases	Std. Deviation	Controls	Std. Deviation	p-value
L1	14.36	1.30	14.97	1.62	0.037
L2	13.42	1.51	14.50	1.59	0.001
L3	11.96	1.80	13.53	1.45	<0.001
L4	11.25	2.11	13.26	1.61	<0.001
L5	11.20	2.39	13.40	1.56	<0.001

Figure 4: Mean of thecal sac diameter at mid vertebral body.

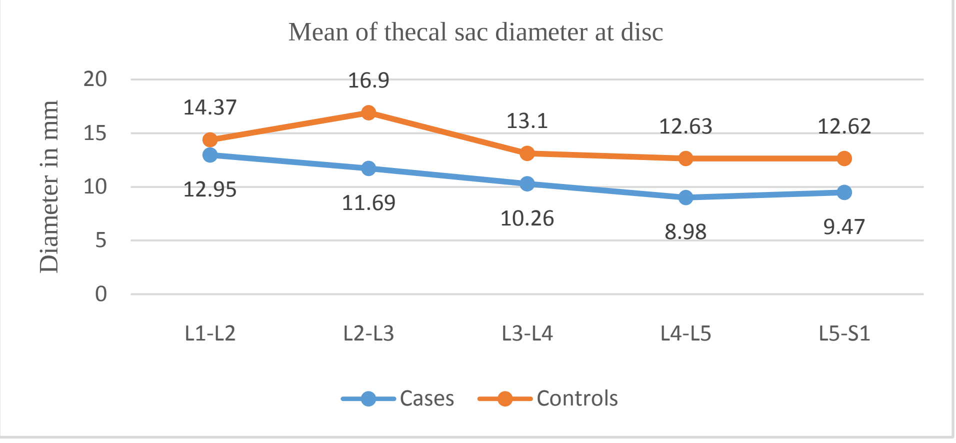


- The **thecal sac diameter at disc** level showed decreased from L1-L2 to L4-L5 and then increased from L4-L5 to L5-S1 in cases. However, in controls, it showed increase from L1-L2 to L2-L3 and decreased thereafter from L2-L3 to L5-S1. There was significant difference (*p-value* < 0.05) between 2 study groups at all levels except L2-L3. (Table 5, Figure 5)

Table 5: Mean of thecal sac diameter at disc (mm).

Disc level	Cases	Std. Deviation	Controls	Std. Deviation	p-value
L1-L2	12.95	1.74	14.37	1.60	<0.001
L2-L3	11.69	1.82	16.90	1.80	0.125
L3-L4	10.26	2.28	13.10	1.70	<0.001
L4-L5	8.98	2.71	12.63	1.51	<0.001
L5-S1	9.47	2.80	12.62	1.15	<0.001

Figure 5: Mean of thecal sac diameter at disc.



Proposed cut off values for canal diameters

The diagnostic accuracy was obtained using software named SPSS version 20 (Statistical Product and Service Solutions or Statistical Package for the Social Sciences). It was given by the area under ROC curve and was highest for **thecal sac diameter at the disc level** (0.94) showing that this parameter related closest with the canal stenosis. It was lowest for the **spinal canal diameter at the body level** (0.65).

The cut-off values for the above parameters were taken as shown in the table 6 with the sensitivity and specificity mentioned ahead.

Table 6: Proposed cut off values for canal and sac diameters at body and disc level.

Test Result Variables	Value(mm)	Sensitivity	Specificity
Spinal canal diameter at body	13.5	56%	44%
Thecal sac diameter at body	10.5	73%	72%
Spinal canal diameter at disc	13.5	70%	80%
Thecal sac diameter at disc	7.5	87%	84%

IV. Discussion

The present study was undertaken to evaluate MRI features in clinically suspected cases of lumbar canal stenosis. A total of 100 cases were recruited for the MRI scan of the lumbar spine, who had a clinical suspicion of lumbar canal stenosis. Other 30 subjects who were referred for MRI for some other reasons were included in the study as asymptomatic controls.

Anteroposterior spinal canal diameter at mid vertebral body

Maximum and minimum mean value for this parameter were seen at L1 in controls (16.93 mm) and L4 in cases (13.93 mm) respectively. This was partly consistent with the studies done by Pawar et al[9] and Chatha et al[10] who also found the canal widest at L1, however, they found minimum diameter at L5 level. The mean diameters showed a gradual decrease from L1 to L4 and then increased slightly from L4 to L5 level making L4 the most consistently constricted level in our study. This could be because the anteroposterior and transverse diameter of the lumbar vertebral body significantly increases from L4 to L5. Even the anteroposterior length of the pedicle increases slightly at this transition making the lumbar canal wider (in anteroposterior dimension) at L5 level. This explanation is consistent with the results found in the study done by Vega et al[11] regarding morphometry of pedicles and vertebral body.

We found maximum number of stenotic cases at L4-L5 level (44.4%) which is consistent with the study done by Sutharet al[12] who also found maximum affection of L4-L5 level (38.6%).

Anteroposterior spinal canal diameter at disc

This diameter showed a gradual decrease from L1-L2 level to L5-S1 level which was similar to the results found by Pawar et al[9] and Chatha et al[10] in their study.

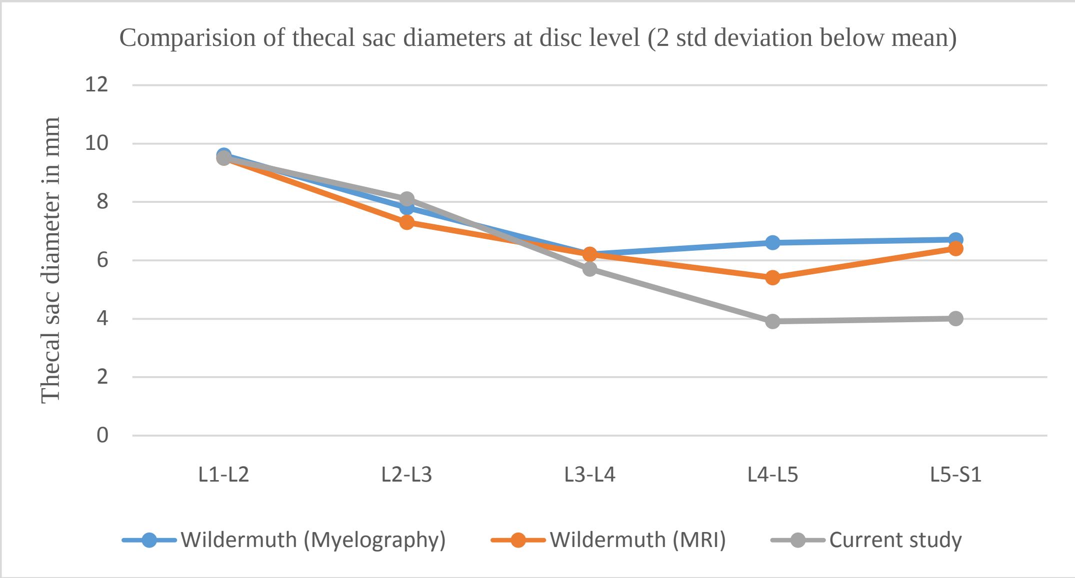
The decrease at the last two **disc levels** (i.e. L4-L5 and L5-S1) was much more when compared to the decrease in diameter measured at the **mid vertebral body** at the same levels. This implies that the measurement of the spinal canal becomes more important at the disc level than at the mid vertebral body level. The fact that we found disc related causes as the major cause of stenosis in our study supports this conclusion {bulge (23.9%) + protrusion (23.9%) + extrusion (19.7%) + sequestration (7%) = total (74.5%)}.

Anteroposterior thecal sac diameter at body and thecal sac diameter at disc

Thecal sac measurement is more important than the osseous spinal canal diameter. This fact has been supported by Bolenderet al[13] in their study which suggested that a narrow dural sac, demonstrated by myelography or by CT, reliably indicates central spinal stenosis. In our case, however, the measurement was done by MRI, the accuracy of which is well established.

We compared thecal sac diameter at disc levels using 2 standard deviations below mean with the study done by Wildermuthet al[14] who measured thecal sac diameter separately using myelography and MRI. Our results are comparable to their study at 3 levels as shown in figure 6, however, our sac diameters are markedly less at L4-L5 and L5-S1. This was expected as we had maximum number of canal stenosis at these 2 levels. So most stenotic thecal sacs were seen here.

Figure 6: Comparison of thecal sac diameters at disc in two different studies.



Proposed cut off limits for the sagittal anteroposterior diameters

As per ROC (Receiver Operating Characteristic) curve, we propose a value of 13.5 mm for **spinal canal diameter at body** and **spinal canal diameter at disc** level as critical limit for canal stenosis. This was in contrast to Pawar et al[9] who gave a cut-off limit of 11.13 mm at body level. They had sensitivity of 93.33% and specificity 60%. The possible reason could be that we used a large sample size of 100 individuals as compared to a sample of 30 cases in their study. We analyzed more number of patients, probably having wider canal dimensions. After using a wider sample we found that the cut off limits of **spinal canal diameter at body** level had sensitivity 56% and specificity 44%. In addition to this we also measured **spinal canal diameter at disc** level and showed that as per our study, it had sensitivity 70% and specificity 80%. So correlation of spinal canal diameters whether taken at body or disc level, with canal stenosis, was not very good. However, the specificity can be increased from 44% to 80% when the spinal canal diameters are measured at **disc level**.

Chatha et al[10] gave a cut-off limit of 9 mm for canal stenosis, however, they did not use ROC curves for obtaining the critical values. They calculated values by taking 2 standard deviations below mean as cut off limits which is a crude method for evaluation.

We propose a cut-off limit of 10.5 mm and 7.5 mm for **thecal sac diameter at body** and **thecal sac diameter at disc** levels respectively. (Table 6). The last mentioned parameter (i.e. **thecal sac diameter at disc**) had shown best correlation with the canal stenosis as it showed highest sensitivity (87%) and specificity (84%). So our ***study suggests that thecal sac diameter at disc level with a critical value of 7.5 mm in sagittal anteroposterior dimension is the most reliable predictor of lumbar canal stenosis***.

V. Conclusion

We conclude that degenerative spine disease is the major cause of lumbar canal stenosis. The disc related causes play a major role (mainly bulge and protrusions). The other causes being infection (tuberculosis in Indian setup), developmental (acromegaly) and space occupying lesions. The affection is predominantly seen at L4-L5 level as per our study.

The proposed quantitative diameter to be measured for lumbar canal stenosis is **thecal sac diameter at disc** level as this came out as being most closely related parameter with canal stenosis as per our study (with sensitivity 87% and specificity 84%). We propose this diameter as the best predictor of stenosis with a cut-off limit of 7.5 mm as the critical value.

References

[1]. Botwin KP, Gruber RD. Lumbar spinal stenosis: Anatomy and pathogenesis. Phys Med RehabilClin N Am 2003;14:1-15.
[2]. Binder DK, Schmidt MH, Weinstein PR. Lumbar Spinal Stenosis. SeminNeurol 2002;22:157-66.
[3]. 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. ClinOrthopRelat Res 1976;115:4-5.
[4]. Ross J. Postoperative spine in magnetic resonance of the imaging of the spine. St. Louis: Mosby Year Book; 1994:151-90.
[5]. Andreisek G, Hodler J, Steurer J. Uncertainties in the Diagnosis of Lumbar Spinal Stenosis. Radiology 2011;261:681–4.
[6]. Richmond BJ, Ghodadra T. Imaging of spinal stenosis. Phys Med RehabilClin N Am 2003;14:41–56.
[7]. Andreisek G, Imhof M, Wertli M, Winklhofer S, Pfirrmann CW, Hodler J, et al. A systematic review of semiquantitative and qualitative radiologic criteria for the diagnosis of lumbar spinal stenosis. AJR Am J Roentgenol 2013;201:W735-46.

[8]. Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J. Radiologic Criteria for the Diagnosis of Spinal Stenosis: results of a Delphi survey. Radiology 2012;264:174-9.
[9]. 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.
[10]. Chatha DS, Schweitzer ME. MRI criteria of developmental lumbar spinal stenosis revisited. Bull NYU HospJt Dis 2011;69:303–7.
[11]. Vega EU; Omana RE; Castro OG, Lopez SG. Morphometry of pedicle and vertebral body in a mexican population by CT and fluoroscopy. Int. J. Morphol 2009;27:1299-1303.
[12]. Suthar P, Patel R, Mehta C, Patel N. MRI evaluation of lumbar disc degenerative disease. J ClinDiagn Res 2015;9:4-9.
[13]. Bolender NF, Schornstrom 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.
[14]. Wildermuth S, Zanetti M, Duewell S, Schmid MR, Romanowski B, Benini A et al. Lumbar spine: quantitative and qualitative assessment of positional (upright flexion and extension) MR imaging and myelography. Radiology 1998;207:391-8.

Dr.Ira Jamwal. “Assessment of Spinal Canal Diameters for Clinically Suspected Cases of Lumbar Canal Stenosis on MRI.” IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 1, 2019, pp 78-85.