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Radiological analysis of central lumbar spinal canal in clinically suspected cases of lumbar spinal stenosis on MRI

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Abstract
Introduction: Lumbar spinal stenosis is a severe degenerative condition of the spinal channel with its concentric narrowing with presence of specific clinical syndrome. The relationship between its symptoms and dural sac diameter is not apparent .With relation to the numerous difficulties one encounters in going ahead with the therapy for patients with lumbar canal stenosis, this study aims to find any correlation between degree of spinal canal narrowing based on the canal anatomy and the patients functional status based on Oswestry disability index scores to provide a definitive management guideline.
Methodology: 121 patients with clinical suspicion of stenosis on the basis of ODI score and canal anatomy by the means of MRI were studied where in the lumbar spinal canal was evaluated on the basis of dural sac crossectional area (DSCA), mid sagittal diameter (MSD) and separation of cauda equina (SCE).The relationship between the ODI and canal anatomy was established.
Observations and Results: Oswestry Disability Indices of patients were obtained and classified as mild, moderate, severe, crippled and bedridden. On imaging central canal stenosis was classified separately on the basis of DSCA, MSD and SCE depending on their MRI findings. Percentages of patients belonging to each group was determined and with the help of a chi square test a correlation was established between severity of radiological stenosis and clinical function.
Conclusion: No significant correlation found between radiological central canal stenosis and ODI in clinically suspected cases of lumbar spinal stenosis.

Keywords: lumbar canal stenosis, ODI (Oswestry Disability Index), dural sac crossectional area (DSCA), mid sagittal diameter (MSD) and Separation of cauda equina (SCE)

Introduction

Radiographic lumbar canal stenosis (LCS) is defined as a narrowing of the lumbar canal with encroachment of neural structures by surrounding bone and soft tissue. It encompasses a wide variety of structural and functional abnormalities that lead to diminished space for neural and vascular structures within the bony spinal canal. It can be asymptomatic or symptomatic (resulting in weakness, reflex alterations, gait disturbances, motor and sensory changes, radicular pain). The compression to the nerve roots of cauda equina lead to neural root ischemia. It can present as bowel and bladder dysfunction, saddle anaesthesia, unilateral or bilateral sciatica and neurogenic claudication. 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, lateral and foraminal stenosis. Central canal stenosis causes neurogenic claudication while lateral canal stenosis leads to radicular pain [2].

Diagnosis of lumbar canal stenosis typically relies on the detailed history, clinical assessment are followed by Oswestry Disability Index Score. The patients with clinical suspicion of LCS were subjected to radiological assessment.

The ODI version 2.1 is a self-administered questionnaire consisting of ten items to assess the extent of the patient's back pain and difficulty in carrying out nine different activities of daily life including personal care, lifting, walking, sitting, standing, sleeping, sex life, social life and travelling. The questionnaire is completed in reference to the patient's functional status "today". Each item is scored from 0 to 5, with higher values representing greater disability.

The total score is multiplied by 2, and normally expressed as a percentage and this percentage is simply referred to as "the ODI score" and discussed in terms of points (0–100). Scoring methods is as follows: 0% to 20%: Minimal disability; 21%- 40%: Moderate Disability; 41%-60%: Severe Disability; 61%- 80%: Crippling back pain; 81%-100% [3].

The role of radiology is to support a clinical diagnosis by confirming the presence of stenosis and to demonstrate which levels are affected, severity of stenosis and pathology causing nerve compression. As of now, no classification combines clinical & radiographic severity of spinal stenosis, instead

nonspecific health related quality of life metrices i.e ODI is used. The relationship between the imaging studies and clinical symptoms has been uncertain, as there are a large number of patients with marked clinical findings with minimal imaging findings and vice versa. Different imaging technique like X-rays, myelography, computed tomography (CT) and magnetic resonance imaging (MRI) are used in the radiographic evaluation of LCS.

The criteria for central stenosis include a description of spinal canal compression in relation to its anteroposterior diameter of spinal canal, dural sac surface area, obliteration of the anterior CSF space and degree of separation of the cauda equina on axial T2-weighted images. Evaluation of causes contributing to central stenosis can be done by assessment for the nerve root sedimentation sign, thickness of the ligamentum flavum, presence of enlarged, elongated, and tortuous nerve roots and absence or reduction of posterior epidural fat and excessive deposition of epidural fat in the central spinal canal.

The aim of this study was to determine the degrees of radiological lumbar canal stenosis using MRI, its correlation with the patient's functional status and disability level using ODI in order to assist in decision making for definitive management of the patients.

Material and methods

This prospective study was carried in the Department of Radiodiagnosis, Imaging & Interventional Radiology Subharti Medical College associated with Chhatrapati Shivaji Subharti Hospital, Subhartipuram, Swami Vivekanand Subharti University, Meerut. After obtaining approval from institutional ethics committee on cases with clinically suspected cases of spinal stenosis referred from the OPD/IPD of the C.S.S Hospital for the period of 2 years. A total of one twenty-one (121) patients of different age group after meeting the inclusion criteria - radiculopathy, Severe backache, buttock & lower extremity pain, claudication pain and insufficient effect of structured physiotherapy or chiropractic treatment for at least 6 months were included. Patients with seropositive arthritis, scoliosis, kyphosis, post-operative spine, post traumatic, spinal tumour, suspicion of tumour metastases and Patients who have absolute contraindications to MRI (pacemaker, aneurysm clips, intraocular metallic foreign bodies, claustrophobia etc) were excluded from the present study.

Detailed history and clinical evaluation of patient was performed followed by a self-administered ODI. Once the functional outcome was calculated, then central canal stenosis was quantified on the basis of MRI imaging in suspected cases.

All patients underwent a non-contrast lumbo-sacral spinal MRI scan in supine position on Signa HDe contour GE 1.5 Tesla Feiloversikt included sagittal T1 and T2 weighted, axial T1- and T2-weighted, sagittal and coronal STIR images from the first lumbar to first sacral level in a 1.5 Tesla(T) imaging system in our institution with the appropriate spine surface coil. The slice thickness of 5mm was used in both sagittal and coronal, and 3mm for axial images. The interspace gap of 0.5-2 mm used with 512 x 256 matrix and field of view of 30x30 used for sagittal and 448x256 matrix and field of view 20x20 with for axial images and TR/TE of 600/15 for T1 and 3000/100 for T2 weighted images. Dimensions of lumbar canal at all the IVD levels (L1-L5) of lumbar vertebra of cases were measured.

Radiological parameters for grading on the basis of DSCA, MSD, SCE for the diagnosis of central lumbar canal stenosis was evaluated as mentioned below. The parameters were determined using OSIRIX imaging software.

LCS was evaluated at total of 605 levels (at each intervertebral disc level in lumbar region) Grading for lumbar canal stenosis Central canal stenosis

- Dural sac cross sectional area (DSCA) > 100 mm^2 as normal, > 76 to 100 mm^2 as moderately stenotic and < 76 mm^2 as severely stenotic [4]. [figure 1]
- Degree of separation of cauda equina (SCE) on T2W axial image for no central LCS (Grade 0) as the anterior CSF space is not obliterated, mild central LCS (Grade 1) in which the anterior CSF space is mildly obliterated, but the cauda equina can be clearly separated, moderate central LCS(Grade 2) in which the anterior CSF space is moderately obliterated, and the cauda equina is partially aggregated and severe central LCS (Grade 3) in which the anterior CSF space is obliterated so severely as to show marked compression of the Dural sac, and cauda equina cannot be visually separated, appearing instead as a bundle [5]. [figure 2]
- Spinal canal mid sagittal diameter (MSD) 15mm or more as no stenosis,12-14mm as mild stenosis,10-12mm as moderate stenosis and <10mm as severe stenosis [6]. [figure 3]

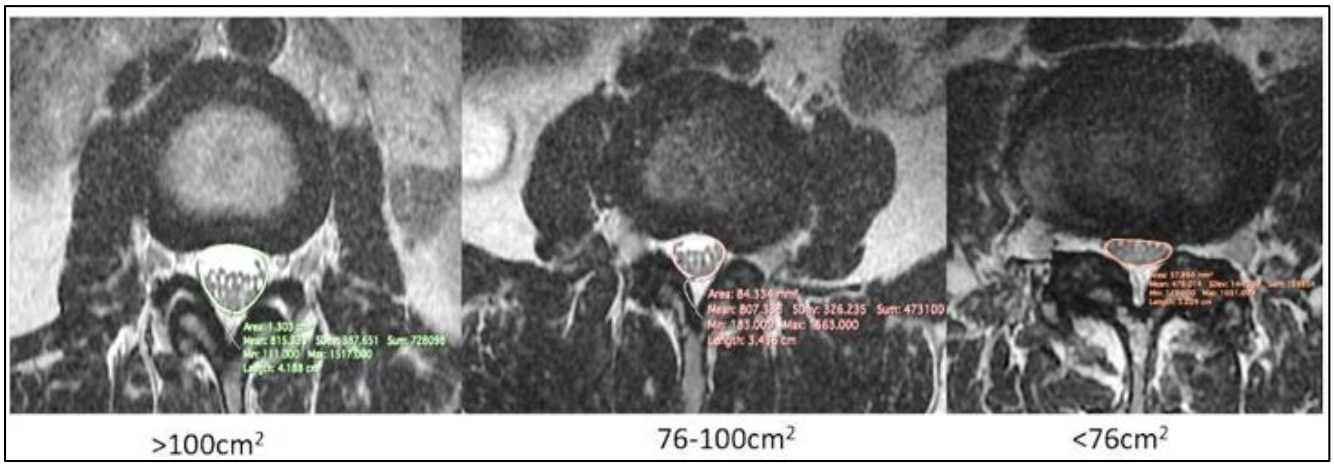

Fig 1: Central canal stenosis grading on the basis of Dural sac surface area

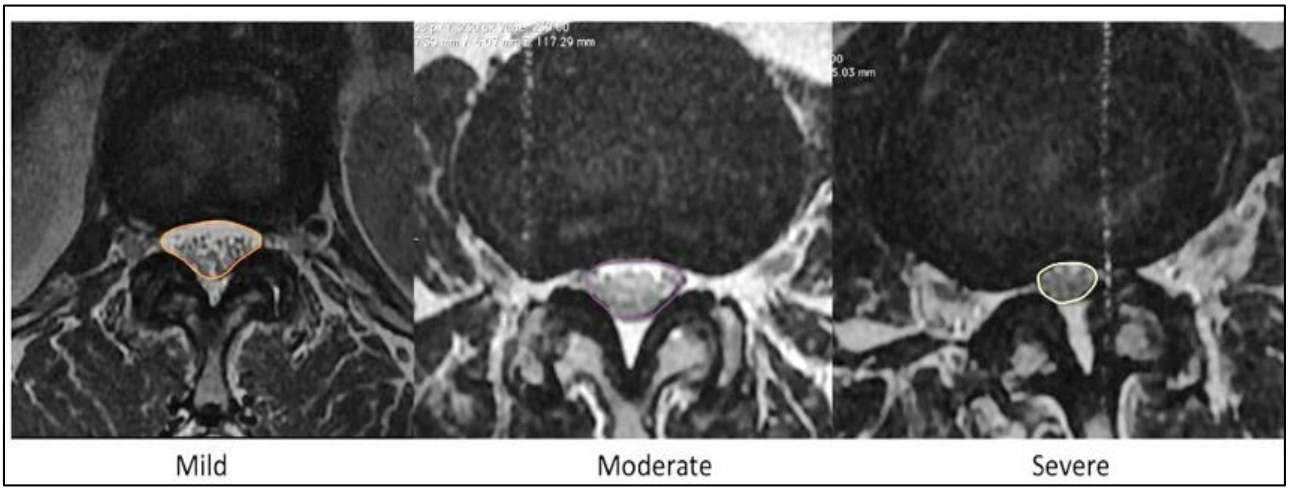

Fig 2: Central canal stenosis grading on the basis of separation of cauda equina

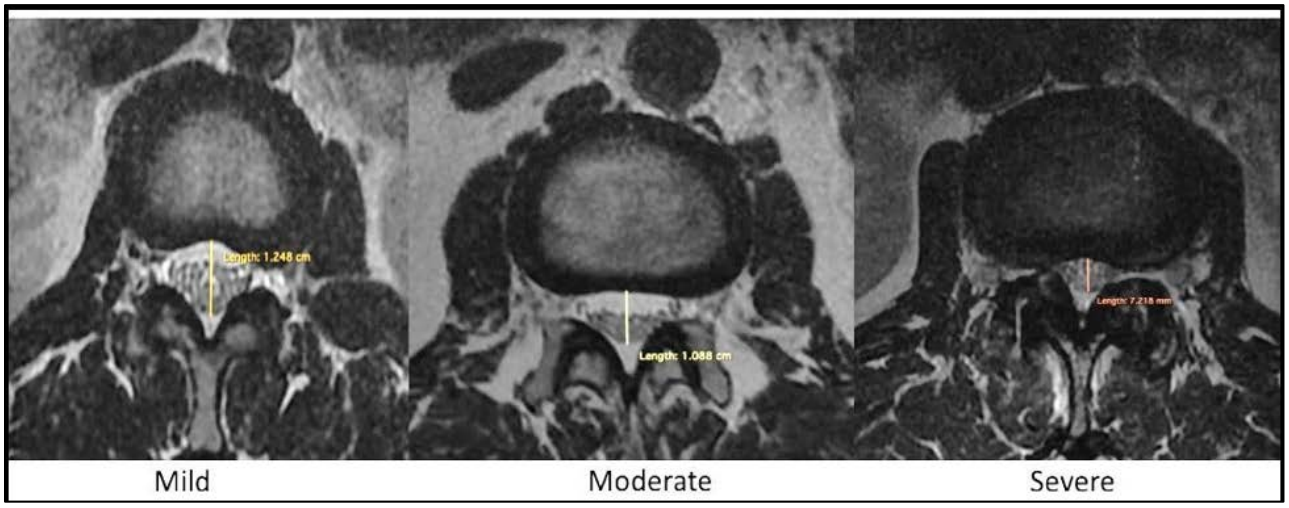

Fig 3: Central canal stenosis grading on the basis of MSD

Statistical analysis of the data was performed to correlate radiological stenosis of central canal and percentage disability by means of ODI using software package SPSSv22.0 and represented as absolute values, frequency distribution and mean ranks. The non-parametric mean score comparison was done using Kruskal Wallis test. Chi square analysis was done to compare nominal data. The p-value <0.05 was taken as significant and p-value > 0.05 was considered statistically not significant.

Result

Of the patients included in the study showing slight male predominance. The mean age was 56.9 ranging from 26-81 yrs. All 121 patients completed ODI questionnaire. On the basis of the percentage disability score of the ODI - Out of the 121 patients, 2 patients(1.7%) demonstrated mild disability, 49 patients(40.5%) moderate disability, 57 patients(47.1%) severe disability, 10 patients (8.3%) were crippled and 3 patients (2.5%) were bedridden. On imaging however in our study, the maximum affected level was L4-L5 as recorded by mid sagittal diameter, separation of cauda equina and dural sac surface area was present in almost all patients included in study. Following the above mentioned classification of central canal stenosis on the basis of dural sac surface area- no stenosis, moderate and severe stenosis was evaluated for each IVD level in which 171 levels (28.2%) revealed moderate grade stenosis and 216 levels (35.7%) showed severe grade stenosis [table 1][chart 1]. On the basis of separation of cauda equina mild stenosis was noted at 182 levels (30.08%), moderate stenosis at 190 levels (31.4%) and severe at 7 levels (1%) [table 2] [chart 2]. On the basis of mid sagittal diameter mild stenosis was noted at 159 levels (26.2%), moderate stenosis at 179 levels (29.5%) and severe at 177 levels (29.2%) [table 3] [chart 3]. ODI percentage scores were compared of DSCSA, separation of cauda equina, mid sagittal diameter between the subdivisions of the degree of central canal stenosis by calculating mean rank at each level for mild, moderate and severe stenosis and was compared by Kruskal Wallis test analysis. p value was found to be >0.05 which showed that there was no significant

statistical correlation for the parameters assessed with the ODI. In conclusion, data collected and analysed in the current study demonstrate no significant correlation between imaging appearances and levels of disability in patients with LSS.

Table 1: Association of Dural sac cross sectional area with ODI score

	DSCA	N	Mean Rank	Chi square value	p-value
L1-2	No	88	62.28	.599	.741
	Moderate	29	57.00		
	Severe	4	61.88		
	Total	121			
L2-3	No	63	62.47	4.167	.125
	Moderate	38	53.41		
	Severe	20	70.80		
	Total	121			
L3-4	No	30	61.93	2.600	.273
	Moderate	37	54.22		
	Severe	54	65.13		
	Total	121			
L4-5	No	9	56.44	1.613	.447
	Moderate	27	55.00		
	Severe	85	63.39		
	Total	121			
L5-S1	No	28	63.98	2.337	.311
	Moderate	40	54.69		
	Severe	53	64.19		
	Total	121			

Table 2: Association of degree of separation of cauda equina with ODI score

	Degree of SCE	N	Mean Rank	Chi square value	p-value
L1-2	No stenosis	90	62.08	0.562	0.755
	Mild	24	56.63		
	Moderate	7	62.07		
	Severe	0	0		
	Total	121			
L2-3	No stenosis	65	62.12	3.278	0.351
	Mild	39	57.42		
	Moderate	16	61.41		
	Severe	1	113.5		
	Total	120			
L3-4	No stenosis	30	61.83	3.642	0.303
	Mild	41	56.73		
	Moderate	49	62.84		
	Severe	1	113.5		
	Total	120			
L4-5	No stenosis	9	55.39	2.699	0.440
	Mild	35	53.61		
	Moderate	74	62.78		
	Severe	3	73.50		
	Total	118			
L5-S1	No stenosis	32	62.25	6.638	0.084
	Mild	43	52.47		
	Moderate	44	65.73		
	Severe	2	96.75		
	Total	119			

Table 3: Association of MSD with ODI score

	Mid sagittal diameter	N	Mean Rank	Chi square value	p-value
L1-2	No stenosis	44	55.78	3.364	0.339
	Mild	50	66.94		
	Moderate	25	57.56		
	Severe	2	70.25		
	Total	121			

L2-3	No stenosis	28	59.45	4.750	0.191
	Mild	42	61.89		
	Moderate	40	56.06		
	Severe	11	79.50		
	Total	121			
L3-4	No stenosis	5	37.60	4.077	0.253
	Mild	31	63.60		
	Moderate	41	57.55		
	Severe	44	65.05		
	Total	121			
L4-5	No stenosis	2	53.50	2.239	0.524
	Mild	12	60.71		
	Moderate	30	53.97		
	Severe	77	63.98		
	Total	121			
L5-S1	No stenosis	11	63.77	4.462	0.216
	Mild	24	63.52		
	Moderate	43	52.94		
	Severe	43	66.94		
	Total	121			

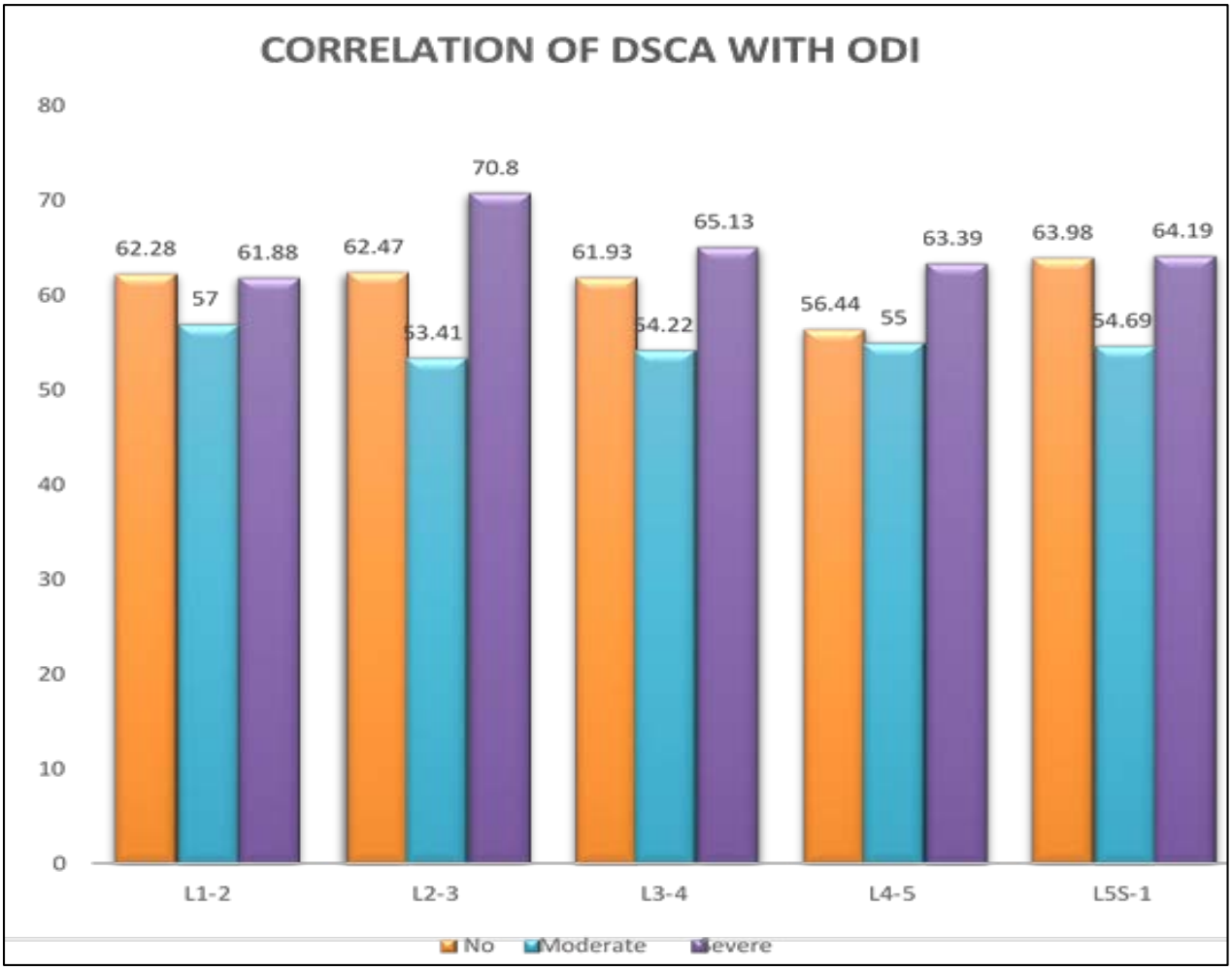

Chart 1: Bar diagram showing Association of Dural sac cross sectional area with ODI score

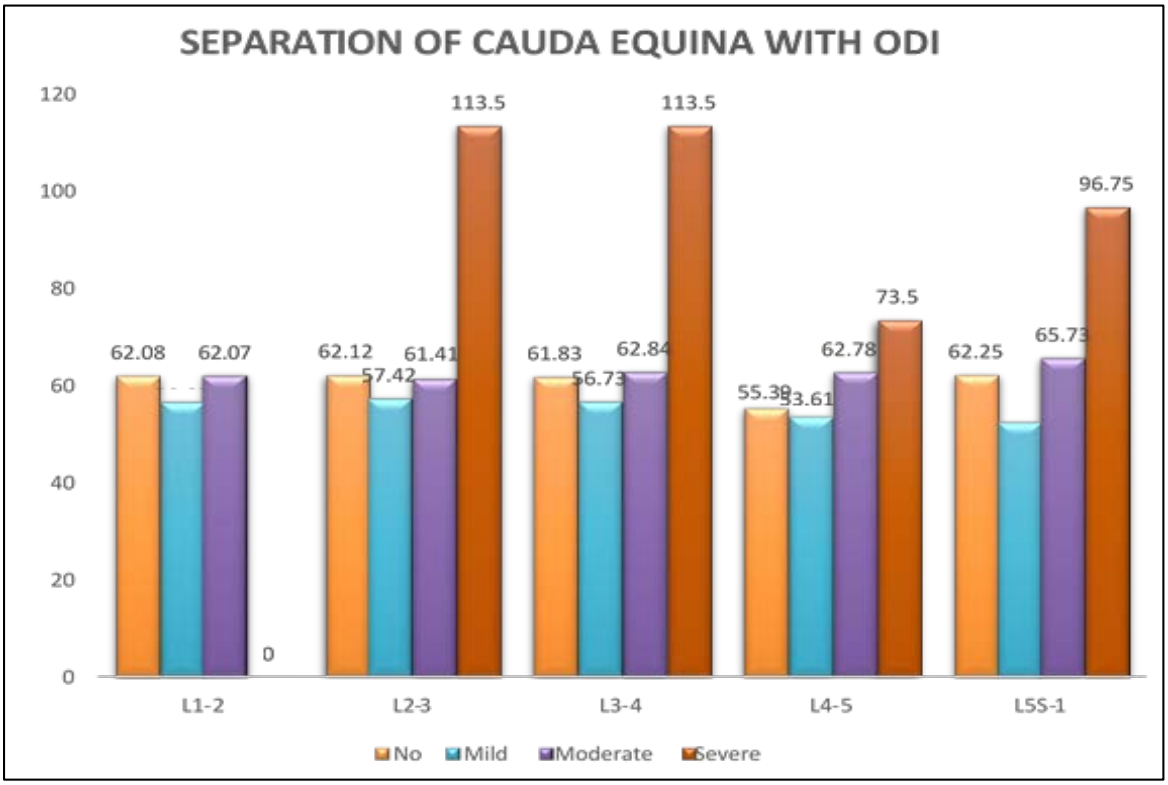

Chart 2: Bar diagram showing association of degree of SCE with ODI score

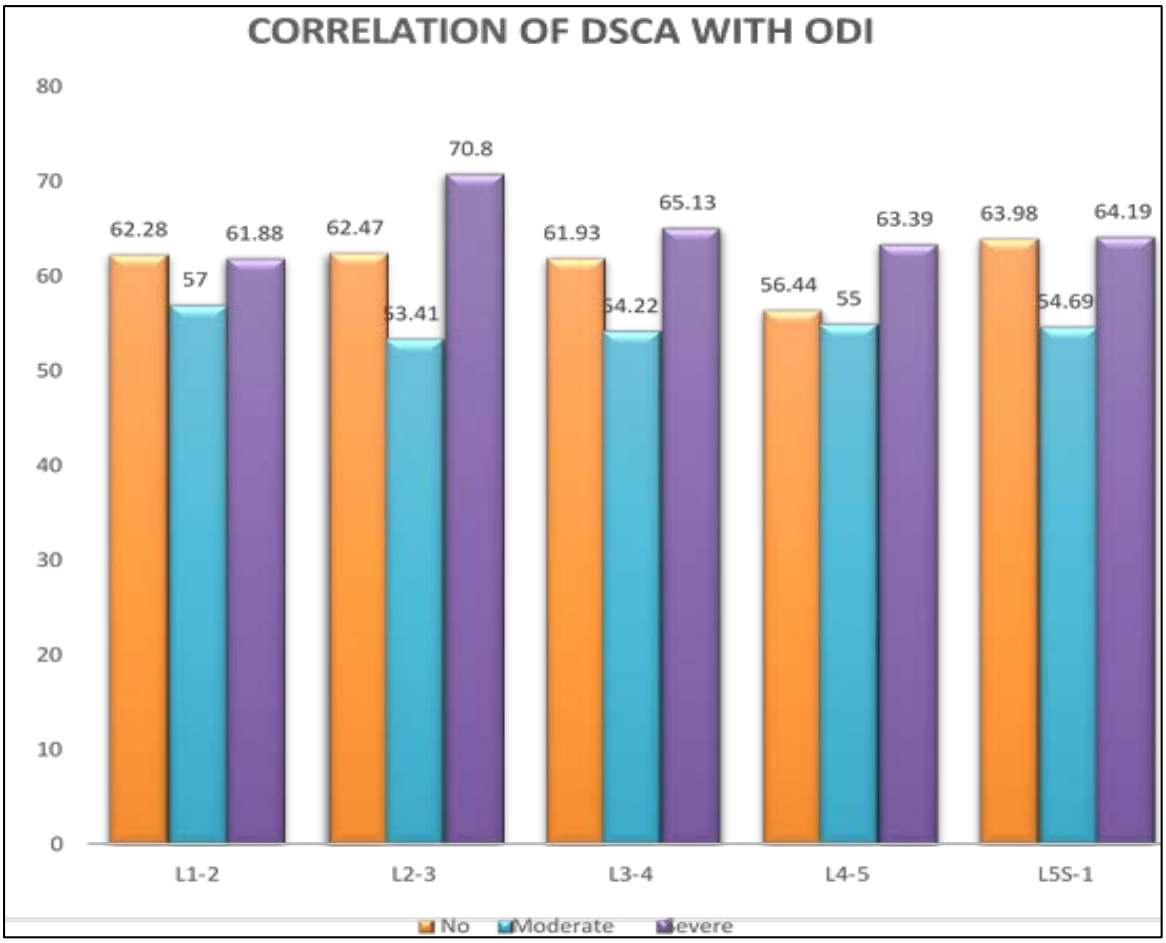

Chart 3: Bar diagram showing Association of MSD with ODI score

Discussion

Lumbar spinal stenosis is the most common degenerative spine disease in middle-aged and elderly patients [7, 8, 9, 10]. Back and leg pain, intermittent neurological claudication, and urinary retention occur as symptoms for central canal stenosis.

The prevalence and associated clinical disability related to degenerative lumbar spinal stenosis is on the rise with increasing longevity of life and aging populations. The most frequently a consequence of severe spinal degeneration is stenosis. Since the degree of constriction of the spinal canal considered to be symptomatic for LSS is not clear, diagnostic accuracy of imaging techniques, findings from clinical examination and appropriate outcome measures need to be identified to ensure careful patient and treatment selection for successful and lasting results.

For LSS, some studies reveal the relationship between symptoms and signs and morphological parameters in MRI [11, 12, 13, 14]. These studies focus on the dura cross-sectional area (DSA), spinal canal cross-sectional area (SCA), mid sagittal diameter [15]. The most common diagnosis of radiological CSS is assessed by DSA measurement [16, 17, 18]. Clinical diagnosis is based on patient history, examination, and supportive imaging methods showing spinal canal narrowing.

Various authors have also noted a lack of correlation between Radiographically detected stenosis and clinical findings, and the presence and/or absence and intensity of symptoms and signs [20, 21]. Although patients with narrower spinal canals are more likely to develop some symptoms of spinal stenosis, the radiographic changes were more extensive than expected from the clinical picture. Difficulties associated with finding such correlations include the presence of a large number of patients with spinal narrowing and a complete lack of symptoms [22, 23] variations in canal size throughout the population and a lack of an accepted system for quantifying the degree of narrowing. Obviously, patients can have changes on MR imaging compatible with the morphological diagnosis of spinal stenosis but be asymptomatic. The present study was undertaken to assess the lumbar canal stenosis for the patients who were referred to our department with chronic back symptoms consistent with neurogenic claudication and a clinical suspicion of spinal stenosis, as well as for evaluation of their work ability. The strength of this study was its prospective study design for both radiological and clinical methods.

In our study the mean age of patients was 56.9 +/- 1.2 years with the range of 26 to 81 years near similar to that in Parisa Azimi *et al* [24] with mean age of 58.1+/-10.6. Although the mean age was younger compared to most studies, the maximum number of patients were in the above 50-years group similar to the study done by Prasetya *et al* [25] indicating that radiographic spinal stenosis is quite common among the elderly. There was a slight male preponderance, 66 being male and 55 being female patients, as in study done by Pawar *et al* [26].

We proposed in this study to correlate between the DSA, SCE, MSD measurement with clinical impairment in patients with ODI. Few studies have identified any significant correlation between the severity of stenosis on MRI and clinical disability. [27, 28, 29] The relationship between spinal canal stenosis and ODI is essential. Although many articles show the relationship between the degree of stenosis and ODI, some authors reported that there was no correlation between MRI results and ODI. [11, 13, 27, 30] In our study, it observed that the results of ODI in patients with stenosis were affected from minimal neurological dysfunction to severe disability.

In our study, the ODI questionnaire (translated to both Hindi and English) was easily comprehended and had a response rate of 90.9%. On the basis of the percentage disability score of the ODI, prevalence of severe disability was seen in 57 patients (47.1%) followed by moderate disability in 49 patients (40.5%). Various studies have reported that this short, self- administered questionnaire was reproducible, reliable, internally consistent and valid and was an adequately useful instrument for the assessment of disability in patients with lower back pain as reported by Goni *et al*, [27] Adamova *et al* [31] and many more. Geisser *et al* [11] in their study have suggested that the perception of pain limits activity or that the expected level of pain in performing an activity was more highly predictive of functional limitation in patients and suggested ODI to be better predictor of perceived disability. Since the degree of constriction of the spinal canal considered to be symptomatic for LCS was not clear, the diagnostic accuracy of imaging techniques, findings from clinical examination and appropriate outcome measures need to be identified to ensure careful patient and treatment selection for successful and lasting results.

The sensitivity and specificity of MRI to assess LCS were reported to be higher than CT scan and myelography, so MRI was considered more effective in diagnosing lumbar canal stenosis as mentioned by Ambade and Mane *et al* [32]. We used MRI as the imaging modality for the evaluation of clinically suspected central canal stenosis in our study. Various authors including Lohman *et al* [21], Jonsson *et al* [20] have also noted a lack of correlation between radiographically detected stenosis and clinical findings, and the presence and/or absence and intensity of symptoms and signs. Zeifang *et al* [33] have concluded that the MRI findings seem to have less clinical relevance on the walking distance in patients with symptomatic lumbar spinal stenosis than previously assumed.

In our study the maximum affected level was L4- L5 as recorded by all the parameters and was present in almost all patients included in study. Similar prevalence was noted in the study done by Ishimoto *et al* [3] were severe central canal stenosis was noted at L4-5 level followed by L3- 4 level.

We have evaluated all lumbar IVD summing up to total of 605 levels and classified into mild, moderate and severe grade stenosis on the basis of DSCA, SCE and MSD of lumbar spinal, at the level of intervertebral disc. Haig *et al* [34], Goni *et al* [27], Sirvanci *et al* [4] and many more authors have evaluated central canal by measuring the area of minimal Dural sac cross sectional area as performed in our study and found no significant correlation with comparison on ODI. On evaluation of SCE verses ODI percentage score, again no significant correlation was established as seen in the study done by Prasetya *et al* [25] in his study of 25 patients and Lee *et al* [9] on 133 patients. Goni *et al* [27] in their study made comparison between subdivisions of the degree of central canal stenosis based on AP diameter and ODI outcome presented in five categories based on severity, showed no correlation. Jonsson *et al* [20] found a weak positive correlation between the central spinal canal AP diameter and reduction of the patient's estimated walking ability; however, that correlation was not statistically significant. The studies by Verbiest [35],

Schönström and Hansson [36] and Olmarker *et al* [37] support the fact that a narrower canal should lead to more severe clinical symptoms. But studies by Amundsen *et al* [7] and Lohman *et al* [21] published results based on myelography and computed tomography, stated that the correlation of clinical symptoms in lumbar spinal stenosis and DSCA was not significant. Sirvanci *et al* [4] found no correlation between the severity of spinal stenosis and ODI.

The fact that in some patients the radiological changes were more extensive than expected from the clinical picture and the degree of narrowing did not correspond to the severity of ODI percentage disability further establishes that degenerative LCS is a clinico-radiological syndrome. Many other factors may play a role in determining the onset and progression of clinical impairment in patients with spinal stenosis. In this regard, studies should be handled with a multidisciplinary approach.

Conclusion

This study demonstrated the no significant relationship between central canal measurement and clinical disability in patients by ODI score as each symptom of disease plays its own role in the clinical picture. Although MRI is an important diagnostic method and is needed to establish the level and severity of stenosis for selection of proper treatment options. This problem requires future research directed in tailoring a dynamic assessment modality to quantify spinal canal stenosis and to better elucidate correlation between radiographic findings and clinical outcome in LCS.

Conflict of Interest

None declared.

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