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Relationship Between Magnetic Resonance Imaging Findings and Clinical Symptoms in Patients with Suspected Lumbar Spinal Canal Stenosis: a Case-control Study

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ABSTRACT

Introduction: Despite the availability of many imaging and clinical criteria for diagnosis of lumbar spinal stenosis (LSS), its correct diagnosis is a challenge for clinicians and radiologists. **Aim**: The aim of this study was to examine the relationship between magnetic resonance imaging (MRI) findings and clinical symptoms in symptomatic and asymptomatic patients with suspected LSS in MRI. **Methods**: This study is a case-control study. Two groups of 100 symptomatic and asymptomatic individuals (aged 20 to 84 years) with suspected lumbar spinal canal stenosis who referred to the imaging unit for lumbosacral MRI were included. The clinical symptoms and radiological parameters in MRI for all patients were recorded and relationship between them were evaluated. **Results**: Among the quantitative imaging findings, only the anterior-posterior diameter of the canal at the level of the intervertebral disc, the central spinal canal cross-section area and lateral recesses cross-sectional area were valuable. Coefficient of stenosis was calculated for the case and control groups which had statistically significant difference ($p<0.001$). The difference between qualitative findings such as disc protrusion, extrusion, sequestration and Cauda Equine serpain or redundant was significant between the two groups. **Conclusion**: According to the results, among the quantitative criteria of MRI imaging findings, central spinal canal cross-section (less than 77.5 mm2 for central stenosis) and lateral recesses cross-section (less than 22.5 mm2 for lateral stenosis) had the highest sensitivity and specificity for LSS diagnosis in symptomatic and asymptomatic patients with suspected LSS. Strongest observed correlation was between neurogenic claudication and LSS diagnostic radiological markers.

Keywords: Magnetic Resonance Imaging, Spinal Stenosis, Signs and Symptoms, Lumbar Vertebrae.

1. INTRODUCTION

Lumbar spinal stenosis (LSS) is the most common indication for spinal surgery in patients over 65 years of age. Most LSSs are secondary to degenerative changes. Despite the relatively high prevalence of LSS, its correct diagnosis is still a challenge for physicians and radiologists (1–2).

LSS is a condition that ends in a decrease in the space available for the neural and vascular components of the lumbar spinal cord. In clinical practice, when LSS becomes symptomatic, it results in a variety of symptoms, including buttock pain, unilateral or bilateral neurological disorder, and lower extremity pain, or fatigue with or without back pain may be the only symptom of the disease (3). Symptomatic LSS has specific stimulating or mitigating properties. Stimulating properties include neurogenic claudication during walking or posture and its exacerbation by standing up, and mitigating properties include improving symptoms by bending forward, sitting, or lying down. The manifestations of LSS are usually cause by reduced space available for neural and vascular structures of the lumbar spine (4–5). This definition includes two aspects: structural abnormalities and clinical manifestations, resulting from physical abnormalities (6).

Studies have indicated that clinical symptoms with mild to moderate lumbar LSS may exist in less than half of patients. Therefore, in defining destructive LSS, it is necessary to match clinical symptoms

with imaging results. Thus, radiological evaluation using magnetic resonance imaging (MRI) along with their matching with clinical findings is the gold standard in LSS diagnosis (7-8). Moreover, in LSS it should quantitatively specified that narrowing which part of the spinal canal is intended, including the posterior anterior diameter or transverse diameter of the spinal canal, and the distance between the inner surface of the ligamentum flavum, or the depth and lateral recess angle (9). On the other hand, qualitative indices such as protrusion, bulging, extrusion, perineural intraforaminal fat, hypertrophy of facet joint (FJH), hypertrophy of ligamentum flavum (HLF), lack of fluid around coquina aquila, spiral or nerve root elongation, epidural lipomatosis, and so on have always been used to describe the severity of stenosis (10). There are also remarkable differences between the ability of various radiologic qualitative features in LSS diagnosis according to many radiologists (11).

Although there are many clinical signs and symptoms for LSS that contribute to clinical diagnosis, the relationship between these symptoms and signs and the quantitative and qualitative indices of the canal is still unclear; whether quantitative or qualitative radiological indices of LSS lead to any clinical signs or symptoms has not yet been determined, as well (12-13). Several studies have found contradictory results between signs and symptoms of LSS and radiological findings by MRI and CT scan. Thus, vague and varied symptoms as well as unknown radiological features have led to many problems for physicians, researchers and patients with LSS (14-15). In other words, the operational definition of LSS is still unclear, and the conducted studies are sometimes outdated and non-functional. Previous studies have not accurately quantified which section of the spinal canal should be measure and whether the measured index is in line with clinical symptoms.

2. AIM

The aim of the current study was to examine the relationship between MRI findings and clinical symptoms in symptomatic and asymptomatic patients with suspected lumbar spinal canal stenosis in MRI.

3. METHODS

In this case-control study all patients with symptoms such as neurogenic claudication, gluteal pain, paresthesia, lower extremity weakness, low back pain, and radicular pain, who have been admitted to Neurosurgery, Rheumatology and Orthopedic Surgery Clinics of Imam Khomeini Hospital in Sari and referred the imaging unit for lumbosacral MRI were evaluated as case group. Moreover, patients without these symptoms but in need of lumbar MRI for some reasons (such as the patients with spinal cord infections, deformities, tumors, metastasis, or spinal trauma, and so on) were examine as the control group. Exclusion criteria were a history of spine surgery or those who had MRI contraindications (such as having a cardiac pacemaker, metal implants, metallic foreign body or aneurysm clip, or claustrophobia).

After approval of the study by institutional ethics committee and obtaining informed consent from the patients, before undergoing MRI, patients' clinical symptoms such as presence or absence of neurogenic claudication, mechanical low back pain, gluteal pain, radicular pain, paresthesia or lower extremity weakness were recorded. Then, all patients undergo lumbar MRI using 1.5T GE MRI machine. For lumbar spine MRI, the sagittal T1W and T2W sections and T2W axial sections were taken using cervical thoracic lumbar (CTL) coil. In each patient, the vertebral surface was examined for clinical findings, and if it had not been possible to determine this relationship for any reason, this level would have been evaluated given the high prevalence of LSS at L4-L5.

All MRI images and radiological parameters (posterior-anterior and transverse diameter at the levels of the vertebral body and intervertebral disc, cross-sectional area of dural sac and left and right lateral canals and recess, as well as the diameter of spinal canal on the left and right side) were reviewed by two board-certified radiologists with sufficient expertise in spinal degenerative disorders. Moreover, radiologists qualitatively reported radiological manifestations of patients in both groups. Additionally, LSS coefficient of stenosis which defined as the ratio of total lateral recess cross-section area to dural sac cross-sectional area (DCSA) or the ratio of all lateral canal areas to dural sac area, was calculated for the intervention and control groups. Finally, the researchers evaluated the relationship between MRI findings and clinical symptoms.

4. RESULTS

In this case-control study, 100 patients with sign and symptoms suggesting LSS (case group) and 100 patients in control group, who underwent lumbar MRI were evaluated during the study period. The age range in the case group was 21 to 84 years with the mean age of 53.03 and standard deviation of 15.12 years. In control group, the age range was 20 to 84 years and the mean age was 51.92 with standard deviation of 14.44 years ($P > 0.05$).

The incidence of clinical symptoms in patients with and without LSS symptoms is shown in Table 1.

Clinical symptoms		Symptoms associated with LSS (case)	No symptoms associated with LSS (control)	P-value
Low Back Pain	Yes	94	92	0.3
	No	6	8	
Neurogenic claudication	Yes	46	8	<0.001
	No	54	92	
Gluteal pain	Yes	52	32	0.04
	No	48	68	
Paresthesia	Yes	42	16	<0.001
	No	58	84	
Weakness and idleness	Yes	19	7	0.019
	No	81	93	
Radicular pain	Yes	89	69	0.01
	No	11	31	

Table 1. Frequency of clinical symptoms in patients with and without LSS

Radiological manifestations	Case group	Control group	P value
Mean posterior diameter of spinal canal at vertebral body surface	14.05±2.13	15.4±2.27	<0.001
Mean posterior diameter of the spinal canal at the level of the intervertebral disc	9.58±3.49	12.71±3.18	<0.001
Mean spinal canal transverse diameter at vertebral body surface	23.18±4.07	24.5±3.69	<0.017
Mean transverse diameter of the spinal canal at the level of the intervertebral disc	14.82±4.77	17.87±4.43	<0.001
Mean cross-sectional area of the spinal canal at the level of the vertebral body	114.29±58	171.47±65	<0.001
Mean right lateral recess cross-section	14.98±14	29.61±18	<0.001
Mean left lateral recess cross-section	14.52±13	31.58±20	<0.001
Mean posterior anterior diameter of right spinal cord	8.93±1.52	9.41±1.37	0.023
Mean posterior anterior diameter of left spinal cord	8.94±1.58	9.41±1.33	0.025
Disc bulging (n)	59	66	0.07
Disc extrusion (n)	25	11	0.025
Disc protrusion (n)	48	19	<0.001
Disc sequestration (n)	4	0	0.045
Cauda Equine serpain or redundant	39	18	<0.001

Table 2. Quantitative and qualitative radiological features in case and control groups

In both case and control groups, the highest level of stenosis was related to L4-L5 intervertebral disc level (79 subjects in case and 85 subjects in control groups), L5-S1 levels (10 subjects in case and 11 subjects in control groups) and L3-L 4 levels (8 subjects in case and 3 subjects in control groups), respectively. There were no significant differences between the two groups in this regard (P> 0.05). The mean and standard deviation of radiological indices of the patients in both case and control groups are shown in Table 2.

The optimal cut-off level for radiological indices in diagnosis of LSS were evaluated using receiver operating characteristic (ROC) curve. The cut-point for anterior-posterior diameter of the spinal canal at the level of the vertebral body and intervertebral disc were 14.5 mm and less than 10.5 mm, respectively. In addition, the cut-off levels for spinal canal transverse diameter at vertebral body surface and intervertebral disc were 22.5 and 17.5 mm, respectively. Moreover, the cut-off levels for cross-sectional area of the central spinal canal, right and left lowest lateral cross-sectional area, and diameter of spinal cord on the left and right side were less than 99.5 mm^2, less than 22.5 mm^2, less than 22.5 mm^2 and 8.5 mm, respectively. Qualitative radiological features in case and control groups has been shown in Table 2.

Perineural fat obliteration was present in 44 patients unilaterally (28 in the case group on the right and 16 on the left) and bilaterally in 30 in the case group. There were no cases of perineural fat obliteration in the control group (P<0.001). Forty-five, 11, 11 and 33 of patients in case groups had LSS coefficient ≤0.19, between 0.2 to 0.24, 0.25 to 0.29 and ≥0.3, respectively (p<0.001).

The results showed a significant relationship between claudication with disc bulging (p=0.01), disc extrusion (p=0.009), disc protrusion (p=0.008), FJH (p=0.001), posterior anterior diameter (p<0.001) and transverse canal (p=0.015) at disc level, central spinal canal cross section (p=0.001), and redundant nerve root (p=0.001). There was a significant relationship between mechanical back pain with FJH (p=0.002), left lateral recess cross-section (p=0.03) and transverse canal diameter at disc surface (p=0.046). In addition, there was a statistically significant relationship between radicular pain with disc protrusion (p=0.009), posterior anterior diameter (p=0.019), and channel transverse (p=0.01) at the disc surface, right lateral recess cross-section (p=0.01), perineural intraforaminal fat obliteration (p=0.02) and redundant nerve root (p=0.003). There was a significant relationship between gluteal pain and disc extrusion (p=0.02). There was a significant relationship between paresthesia and cross-section of the central spinal cord (p=0.006) and redundant nerve root (p=0.001). In addition, there was a significant relationship between paralysis with disc sequestration (p=0.02) and HLF (p=0.003). In other cases, there were no significant relationships between clinical and imaging results.

5. DISCUSSION

To our knowledge, present study is the first evaluation of radiologic and clinical manifestations of lumbar LSS in asymptomatic and asymptomatic patients with suspected lumbar spinal canal stenosis in Iran. Steurer et al. (16) stated the need for specific, unambiguous radiologic criteria for evaluation of LSS, to improve the quality of diagnosis and to develop robust and definitive features in clinical studies.

In the present study, the most common clinical manifestations of patients in both case and control groups were mechanical low back pain, radicular pain, and gluteal pain, respectively. Also, there were no significant relationships between most clinical symptoms with each of the radiological indices separately and the highest significant correlation was observed between neurogenic claudication and radiological indices. The results of a study by Sirvanci et al. on patients with LSS, who were candidates for surgery, showed no correlation between the clinical symptoms of patients with quantitative and qualitative radiologic indices of anatomical stenosis and degree of stenosis. Moreover, the duration of neurogenic claudication had no relationship with the severity of radiological symptoms (17). The study by Eun et al. on patients with severe L4-L5 stenosis candidates for bilateral decompression surgery showed no significant relationship between the severity of clinical symptoms and the radiologic signs of LSS (9). The results of Pawer et al. showed that intra-ligamentous diameter and lateral recess depths were significantly different in asymptomatic and asymptomatic patients with LSS (18). In Hughes et al. study, 37 patients with

L5-S1 stenosis and 37 volunteers without any clinical symptoms of LSS were examined. The results showed a statistically significant relationship between severity of clinical symptoms and the characteristic of stenosis coefficient in patients (7). What these studies emphasized with consensus was the comparison of different imaging methods in the diagnosis of severity of LSS and correlation of imaging findings with clinical criteria was not evaluated, as well. The mean age of participants in all of these studies was more than a decade older than the current study. Although this may be accidental, it suggests the possibility of an earlier incidence of LSS in our studied population. Future studies should be done to examine this issue.

In the study by Cheung et al. mean posterior anterior diameter at L4-L5 level at T1 was 14.1 and at T2 level, it was 14.2, which was similar to the current study (19). In Pawer et al., mean posterior diameter of the canal at L4-L5 level in the symptomatic group was 9.05 mm and in the control group, it was11.13 mm, which had significant differences (18). In this study, the posterior anterior diameter of the canal was lower than the current study in both the case and control groups. This finding may be due to the racial differences in the current study with those of Pawer's study (18). The study also showed a significant difference between the symptomatic and asymptomatic groups in relation to the anterior posterior diameter of the spinal canal, which was similar to the current study. In Hughes et al. the critical limit was 10-15mm, which was not significantly different from our study. It has been suggested that the posterior-anterior diameter of the bony canal has little diagnostic importance and that what is important in this parameter, is the examination of the same area in the myelogram to examine the dural sac (7). In the present study, 48 patients in the case group and 13 patients in the control group had anterior-posterior diameter at the intervertebral disc level less than 10mm, which was similar to that of Pawer et al. and Cheung et al. studies (18-19). In the study by Cheung et al. the mean interpanedular distance was 30 mm at T1 and was 29.8 at T2, which was slightly more than the current study`s result (19). Moreover, in the study by Pawer et al., this distance mean between the patient and healthy group was 30mm (18), which was higher than the mean of current study. These findings were likely to be due to racial differences in these communities.

Concerning the lateral stenosis of the spinal canal, it has been suggested that the depth and height of lateral recesses are highly dependent on the operator and thus is not a suitable predictor for the evaluation of the severity of lateral spinal stenosis. Thus, in recent studies lateral recesses cross-section suggested as a more appropriate predictor (20-21). According to the current study, cross-sectional values less than 22.5 to 20.5 mm^2 had the highest sensitivity and specificity for the diagnosis of lateral recess stenosis. In the study by Hughes et al. to evaluate lateral and foraminal stenosis, first older parameters like the depth and height of lateral recesses were used and then to facilitate the process, the sum of these two cross-sections of right and left lateral recesses and finally the concept of stenosis coefficient were used (7). In the study by Mamisch et al. extrusion, protrusion and perineural intraforaminal fat, among the qualitative criteria of LSS, were the most important ones in the diagnosis of stenosis. In the second degree of significance were FJH and HLF (22).

6. CONCLUSION

According to the results, among the quantitative criteria of MRI imaging findings, central spinal canal cross-section (less than 77.5 mm^2 for central stenosis) and lateral recesses cross-section (less than 22.5 mm^2 for lateral stenosis) had the highest sensitivity and specificity for LSS diagnosis in symptomatic and asymptomatic patients with suspected LSS. Strongest observed correlation was between neurogenic claudication and LSS diagnostic radiological markers.

- **Author's contributions:** Study conception and design: HM, MSh, and MP. Acquisition of data: HM, MSh, FN, MM, SE, MP and ZM. Statistical analysis and interpretation of data: MSh and MP. Drafting of the manuscript: HM, MSh, FN, MM, SE, MP and ZM. Critical revision of the manuscript for important intellectual content: HM, MSh, FN, MM, SE, MP and ZM.
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