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Magnetic Resonance Imaging Features in Patients with Acquired Lumbar Spinal Stenosis

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Abstract— Background: Lumbar spinal stenosis often associated with chronic pain describes the abnormal narrowing of the lumbar spinal canal, likely resulting in compression of neural elements within the central spinal canal or the lateral recesses or the root canals or coordinate with each other. The purpose of this study was to describe the plain X-ray and magnetic resonance imaging features of lumbar canal stenosis and to finding MRI addition value when patients with clinical symptom expression but not diagnosed on X-ray. Materials and method: This was a cross-sectional study of 78 patients with a lumbar spinal canal between October 2017 and May 2018. All Plain X-ray and MRI findings were collected for each patient in a pre-designed structured data collection sheet. Results: Out of 78 patients with a lumbar spinal canal, mean age was 52.37 ± 13.58 years. There were more males (57.7%) than females (42.3%). The clinic has 47.4% showed lumbar syndrome and 100% showed redundant nerve root syndrome. The X-rays confirmed osteophytes in 92.3%, endplate sclerosis in 88.5% and disc space narrowing 62.8%. A pattern of lumbar MRI findings was as follows, disc herniation (97.4%), ligamentum flavum hypertrophy (75.6%), facet hypertrophy (59%), kyphosis and scoliosis (48.7%), spondylolisthesis (24.4%), vertebral degenerative changes (73.1%), spinal mass (7.7%). On MRI, 224 lumbar levels were lumbar spinal canal stenosis, 181 lumbar levels were evaluated for the grade of central spinal canal stenosis. Conclusion: Lumbar spinal stenosis is mainly diagnosed by history taking, physical examination and imaging features. Traditional X-ray examination has great limitations in a diagnosis of lumbar spinal stenosis. MRI has advantages of multi-directional imaging and the high resolution. MRI has become "gold standard" in diagnostic of the lumbar spinal stenosis, due to its possibility to visualize Roentgen-negative soft tissues.

Keywords— Lumbar spinal stenosis (LSS), Magnetic resonance imaging (MRI), X-RAY, Grading

1 INTRODUCTION

ERECTED vertically, the spine is the mast of our body and has three major functions: to provide structural support, enable trunk movement and protect the neural elements [12], [17]. Spinal canal stenosis is unisegmental or polysegmental narrowing of the central spinal canal and/or of the lateral recesses and/or of the root canals [16]. This condition is very common in the lumbar tract. Lumbar spinal stenosis is commonly used to describe patients with symptoms related to an anatomical reduction of the lumbar spinal size [6]. This finally leads to a reduction of the spinal canal dimensions and compression of the neural elements (nerve roots or spinal cord) [15]. Since patients with anatomic LSS can range from asymptomatic to severely disabled, the clinical diagnosis focuses on symptoms and examination findings associated with LSS. Imaging findings are helpful for patients with persistent, bothersome symptoms in whom invasive treatments are being considered [6]. The diagnosis and resulting conservative or operative treatment is based on the patient's medical history and concerns, physical examination and radiographic imaging, especially X-rays and MRI scans. Imaging of the lumbar spinal stenosis is a frequent challenge in radiology. Magnetic resonance imaging is a noninvasive and good method for evaluation of lumbar stenosis [15].

Interpreting and comparing the results of available research is limited by a lack of consensus about the definition of LSS. Plain X-ray is the most commonly ordered spinal imaging test because of ready availability and low cost and can be very helpful in its ability to demonstrate bony abnormalities. Most often, an X-ray of the spine will be the first diagnostic tool used in evaluating back pain, and it is usually done before consideration of an MRI or a CT scan. Good quality X-rays will permit not only an analysis of the individual bones of the spine but also the overall contour of the spinal column [13]. Nowadays, MRI of lumbosacral spine is considered as a gold standard imaging modality for evaluation of nerve root compression and spinal stenosis [19].

This study seeks to determine the proportion of cases of lumbar canal stenosis among adult patients presenting with chronic low back pain and the pattern of findings seen on MRI of the lumbosacral spine at Hue University Of Medicine and Pharmacy Hospital for Radiology.

The purpose of this study was to describe the X-ray and magnetic resonance imaging features of lumbar canal stenosis and to finding MRI addition value when patients with symptoms which not diagnosis X-ray. Finding MRI addition value when patients with symptoms which not diagnosis on X-ray. Its value to replace X-ray and computed tomography (CT) when radiation exposure or iodinated contrast material is contra-indicated is well acknowledged.

The purpose of this study was to evaluate the reproducibility of this new grading system for lumbar foraminal stenosis and to discuss its clinical relevance.

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2 Materials and method

To investigate the value of X-ray and MRI for the diagnosis of lumbar spinal stenosis. This was a cross-sectional study of 78 patients with a lumbar spinal canal between October 2017 and May 2018 in the department of Radiology and imaging of Hue University Of Medicine and Pharmacy Hospital. All Plain X-ray and MRI findings were collected for each patient in a pre-designed structured data collection sheet. All subjects underwent lumbar AP and lateral standing radiographs of the lumbosacral spine (view of the thoracolumbar region to sacrum) extracted to measure parameters including sagittal vertebral body width (SBW), pedicle width (PW) on lateral views, and SBW: PW ratio was calculated.

The MRI scans were obtained using a 1.5 Tesla scanner (Siemens Magnetom Amira) and phased array spine coil with the imaging protocol of sagittal T1-weighted (TR/TE 400/20 ms), sagittal T2-weighted (TR/TE 3000/120 ms), and axial T2-weighted (TR/TE 3000/120 ms), sagittal STIR of the entire lumbar spine. The image matrix was 320 x 320 for T1-weighted sagittal images, 384 x 384 for T2-weighted sagittal images, 256 x 256 for STIR sagittal images, and 384 x 384 for T2-weighted axial images. The field of view was 26 x 26 cm for sagittal images and 22 x 22 cm for axial images. The slice thickness was 4 mm with 0.8 mm interslice gap. We defined LCCS as the obliteration of the CSF space in front of the cauda equina in the dural sac on T2-weighted axial images. LCCS was divided into four grades according to degree of separation of the cauda equina on T2-weighted axial images: grade 0: defined as no LCCS as the anterior CSF space was not obliterated; grade 1: defined as mild LCCS, in which the anterior CSF space was mildly obliterated, but all cauda equina could be clearly separated from each other; grade 2: defined as moderate LCCS, in which the anterior CSF space was moderately obliterated and some of the cauda equina were aggregated, making it impossible to visually separate them; and grade 3: defined as severe LCCS, in which the anterior CSF space was obliterated so severely as to show marked compression of the dural sac, and none of the cauda equina could be visually separated from each other, appearing instead as one bundle [14].

3 Results

The data of 78 patients with clinical diagnosis and typical imaging signs of lumbar spinal stenosis were analyzed. The present study included 45 males and 33 females with an average age of 52.37 years (range from 24 to 91 years). The clinic has 47.4% showed lumbar syndrome and 100% showed redundant nerve root syndrome.

In 25 patients (32.1%) the pain radiated to the right extremity and in 25 cases (32.1%) the pain radiated to the left extremity. In 28 cases (35.9%), the pain radiated to both legs equally.

The X-rays confirmed that 98.7% of cases of lumbar developmental spinal stenosis and other characteristics are presented in Table 1. The magnetic resonance imaging characteristics associated with lumbar spinal stenosis are shown in Table 2. Some of the causes of lumbar spine stenosis are shown in Figures 1 & 2.

Table 1. Radiological findings of the lumbar spine

Radiological findings	n	%
Normal	4	5.1
Osteophytes	72	92.3
End plate sclerosis	69	88.5
Disc space narrowing	49	62.8
Abnormal curves of the spine	38	48.7
Spondylolisthesis	20	25.6
Spina bifida occulta, sacralization	13	16.7
Vertebral Collapse, traumatic collapse	12	15.4
Other *	20	25.6

* e. g., junctional vertebrae, osteoporosis, spondylolysis, Schmorl's hernia, mass

Table 2. A pattern of lumbar MRI findings

MRI features	n	%
Degenerative disc	76	97.4
Disc herniation	74	94.9
Ligamentum flavum hypertrophy	59	75.6
Vertebral degenerative changes	57	73.1
Facet hypertrophy	46	59
Kyphosis and scoliosis	38	48.7
Spondylolisthesis	19	24.4
Ligamentum posterior longitudinal hypertrophy	6	7.7
Spinal mass	6	7.7

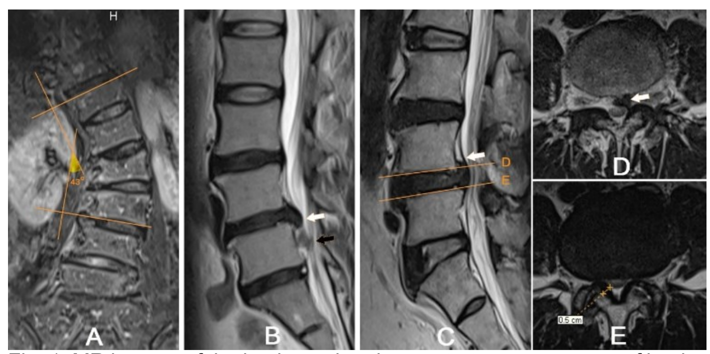

Fig. 1. MR images of the lumbar spine demonstrate some causes of lumbar spinal stenosis. (a) - The coronal STIR-image in a 63-year-old female show scoliosis measured by Cobb method, Cobb = 43 degrees. (b) - Sagittal T2-weighted MR images of the lumbar spine in a 34-year-old female patient. A disk extrusion with an inferior migration of the intervertebral disk beyond the confines of the superior endplate of L5 (white arrow). A disk fragment (sequestered disk fragment) is also seen as inferior to the disk extrusion (black arrow). (c, d & e) - Sagittal T2-weighted MR images and axial T2-weighted MR image corresponding in the same patient as a 64-year-old man. Disk extrusion originating from the L4-L5 level and extending superiorly to be positioned in an infrapedicular location (white arrow in c & d), and accompanied by ligamentum flavum thickening causing severe spinal canal stenosis (e).

Table 3. The grades of the lumbar central canal stenosis with regard to the vertebral levels

Level / Grade	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1	Total
	n	n	n	n	n	n
Grade 0	67	48	35	15	44	209
Grade 1	6	21	29	15	25	96
Grade 2	3	7	12	24	5	51
Grade 3	2	2	2	24	4	34
Total	78	78	78	78	78	390

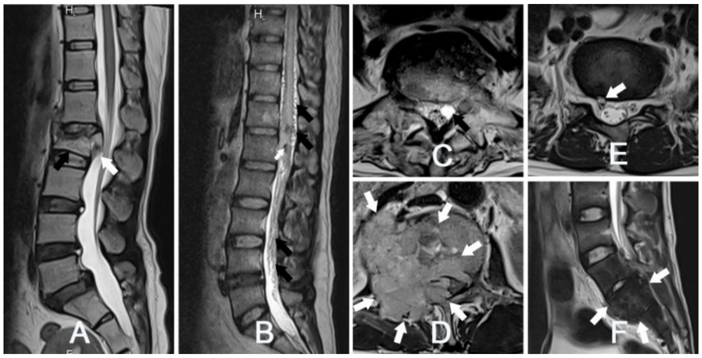

Fig. 2. Some common causes of spinal stenosis are uncommon. (a) - Trauma compression fracture at L2 (black arrow) in a 43-year-old female with fragmentation into the spinal canal (white arrow) on a sagittal T2-weighted image. (b) - A 40-year-old man with perimedullary AVF. A sagittal T2-weighted image showed an ill-defined high SI lesion in the T8-10 cord and the tortuous and dilated perimedullary vessels from T8 to L4, suggesting spinal AVF. A ventral dominance of the engorged perimedullary vessels favoured perimedullary AVF and the fistula was suspected to be located near T12-L1, where the flow voids were most crowded (arrowhead). The L1 lumber arteriography (not demonstrated) revealed the anterior spinal artery being the feeder of a perimedullary AVF and the fistula formation at the level of a lower portion of the T12 vertebral body. (c) - An axial T2-weighted image in 74-year-old female showed an arachnoid cyst in position lateral recess at L5 level. (d) - An axial T2-weighted image 54-year-old man showed a tumour at an L1-L2 level that causes spinal stenosis (arrows). (e) An axial T2-weighted image in 52-year-old man showed a Tarlov of S1 capsule root (arrow). (f) A sagittal T2-weighted image in 24-year-old man showed a tumour in the lumbosacral spine region (pathology diagnosis is osteosarcoma).

Table 4. Lumbar spinal stenosis location

Lumbar spinal stenosis	n	%
No	177	45.4
Central canal	24	6.2
Lateral recess	3	0.8
Foraminal	21	5.4
Central canal & Lateral recess	53	13.6
Central canal & Foraminal	8	2.1
Lateral recess & Foraminal	8	2.1
All	96	24.6
Total	390	100

Table 5. Relation of the number levels lumbar canal stenosis and the narrowest level of severity central canal stenosis

The narrowest / The number of	Grade 1	Grade 2	Grade 3	Total
	n	n	n	n
1	4	6	2	12
2	12	2	9	23
3	0	11	11	22
4	3	4	9	16
5	2	1	2	5
Total	21	24	33	78

Suitability almost perfect between plain X-ray and MRI for assessing spondylolisthesis, abnormal curves of the spine ($p<0.05$, Kappa > 0.9).

Table 6. Suitability between plain X-ray and MRI for assessing spondylolisthesis

Spondylolisthesis		MRI		Total
		Yes	No	
X-rays	Yes	19	1	20
	No	0 (0%)	58	58
Total		19	59	78
p<0.01, Kappa = 0.966				

Suitability almost perfect between plain X-ray and MRI for assessing spondylolisthesis.

Table 7. Suitability between plain X-ray and MRI for assessing curves of the spine

Abnormal curves of the spine		MRI		Total
		Yes	No	
X-rays	Yes	38	0	38
	No	0	40	40
Total		38	40	78
p<0.01, Kappa = 1				

Suitability almost perfect between plain X-ray and MRI for assessing abnormal curves of the spine.

Table 8. The relation between plain X-ray and MRI for assessing lumbar spinal stenosis

Lumbar spinal stenosis (390 lumbar disk levels)		MRI		Total
		Yes	No	
X-rays	Yes	204	163	367
	No	20	3	23
Total		224	166	390
p<0.05				

There is an relation between X-ray and MRI for assessing lumbar spinal stenosis.

4 Discussion

Lumbar spinal stenosis was first described by Verbiest in 1954 as a clinical condition with symptoms of nerve root compression on standing or walking but not at rest [21]. Lumbar spinal stenosis is a clinical syndrome with many symptoms including leg weakness or numbness, back pain, and neurogenic claudication. Radiological narrowing of the lumbar central canal may be present in asymptomatic elderly people and its degree may not be proportional to the severity of symptoms [11], [21], [22].

Many authors have studied the relationship between radiologic parameters and clinical manifestations or outcomes, but radiologic findings alone cannot be a major factor in predicting clinical severity and outcome or in determining a treatment plan [2-5], [7], [9]. Upright plain radiographs in two planes are the initial screening imaging of choice for low back pain. They aid in ruling out pathologies such as deformity, fracture, and metastatic tumors as underlying causes of back pain. It is supplemented by other imaging modalities for evaluation of signs of degeneration [4].

In our study, osteophytes were the most common x-rays features in patients with lumbar spinal stenosis (92.3%), followed by signs of end plate sclerosis (88.5%) and disc space narrowing (62.8%). To our knowledge, no structured and systematic review collecting radiological criteria applied for defining lumbar spinal stenosis has been published to date [18].

Lumbar spinal stenosis is defined as a pathologic condition in which the neural elements are compressed by bone, soft tissue, or both, resulting in ischemia of nerve roots, and is secondary to the growth of osteophytes, redundancy of the ligamentum flavum, and posterior, bulging of the intervertebral discs [20]. It results in central stenosis, which is an abnormal narrowing of the spinal canal, and lateral stenosis, which may be lateral recess (subarticular) or foraminal narrowing. MRI is used to classify lumbar stenosis into central canal, foramina, or subarticular (lateral recess) location, or combination of these locations [16], [20].

All 78 patients in our study had spinal stenosis, belong to the three categories as on narrow. Of the 390 lumbar spine levels, 224 were narrow (57.4%) and 116 were not narrow (42.6%). There are 181 vertebral levels narrow lumbar central canal, 209 vertebral levels non-narrow. In 181 levels lumbar central canal stenosis, the narrowest level was mild with 53%, narrowing to the moderate level of 28.2%, the narrow level was the least severe with 18.1%. Studies on spinal stenosis of Parizi Azimi el al have standard spinal stenosis similar to our standard (according to the standards of the Lee GY), 272 cases for spinal cord stenosis in 357 cases, 37.9% were mild stenosis, 46.7% moderate stenosis, and 15.4% severe stenosis [1]. The results were mild stenosis in 21 cases (26.9%), moderate stenosis in 24 cases (30.8%) and severe stenosis in 33 cases (42.3%). Although there is a difference in rates, the difference is due to disease selection criteria and methodology.

With further improvements in imaging techniques that allow detailed visualisation of spinal structures, radiographic findings are increasingly considered to be solid evidence, similar to laboratory test results or histopathological findings. This anticipated confidence might dispose surgeons to largely base their recommendations for treatment strategies on such imaging [10]. The correlation between radiological and clinical findings to distinguish between symptomatic and asymptomatic patients is, however, limited and unreliable for all common modalities such as X-ray, computed tomography, MRI scan or single-photon emission computed tomography (SPECT) scan [8]. This applies to general spinal cord disease and spinal stenosis in particular, independent of whether quantitative or qualitative stenosis classifications are used. Clear correlations are usually described only for different parameters of the same technique.

5 Conclusions

Traditional X-ray examination has great limitations in a diagnosis of lumbar spinal stenosis. MRI has advantages of multi-directional imaging and the high resolution. MRI has become "gold standard" in diagnostic of the lumbar spinal stenosis, due to its possibility to visualize Roentgen-negative soft tissues. Although imaging results are frequently considered as hallmarks of disease by specialists to plan their future treatment strategy, a clear correlation of symptoms and imaging results is not yet possible with current techniques. In view of the trend in evidence-based medicine to provide medical algorithms, our findings underline the continuing need for individualised spine medicine that, along with imaging techniques or targeted infiltrations, includes diagnostic dimensions such as good patient history and clinical examination.

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