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Comparison between plain X-ray and MRI in lumbar spinal stenosis

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Abstract
Objective: To analyze lumbar spinal stenosis among patients in our city.
Design: To compare between plain X-ray and MRI in diagnosis of lumbar spinal stenosis.
Setting: The study was conducted in radiological department in AL-Salam Teaching Hospital between November 2005 to May 2006.
Subjects: Seventy patients having lumbar spinal stenosis covering age group between (20-80) years.
Methods: All patients were examined by plain X-ray and MRI scan.
Main results:
1. 36 cases (51.4%) male and 34 (48.6%) female.
2. The more peak incidence of spinal stenosis in lumbar region is between (41-50) years's age (30%).
3. The most common type of stenosis is central stenosis 45 cases (64.28%).
4. 44 cases (62.85%) show normal spinal canal and 26 cases (37.13%) show stenosis in plain radiograph.
5. 45 cases (64.3%) show one level and 25 cases (35.7%) show more than one level stenosis.
6. 25 cases (35.71%) have spinal stenosis at level L4-L5.

Conclusion: MRI is more accurate than plain radiograph in assessment of patients with spinal stenosis because MRI scan has the ability to diagnose various etiologies of spinal stenosis prior to surgical interference.

Keywords: spinal stenosis, MRI scan

Introduction

Lumbar spinal stenosis

It is defined as any narrowing of spinal canal or the various tunnels through which nerves and other structures communicate with that canal. Narrowing of spinal canal can be the result of [1] alteration in the shape of canal, [2] degenerative changes that decrease the canal size, or [3] movement of one anatomic segment in relation to another [1].

Normal anatomy of the vertebra

The typical vertebra has vertebral body anteriorly and a neural arch posteriorly. The neural arch consists of pedicles lateraly and of laminae posteriorly. The pedicles are notched superiorly and inferiorly so that adjoining pedicles are separated by an intervertebral foramin, which transmit the segmental nerves. A transverse process arises at the junction of the pedicle and the lamina and extend laterally on each side. The lamina fuse posteriorly forming a spinous process. The articular processes project superiorly and inferiorly from each lamina. Articular facet faces posteriorly on superior facet and anteriorly on the inferior facet. The part of lamina between superior and inferior articular facets on each side called pars interarticularis.

The lumbar vertebrae are five in number, having bigger vertebral bodies and strong, square, horizontal spinous processes.

The transverse processes of the upper four vertebra are spatulated and increase in size from above downward. The transverse process of fifth vertebra is short but strong and pyramidal in shape and arise from the lateral aspect of pedicle and the vertebal body itself [2].

The vertebral canal

Is bounded anteriorly by posterior edge of vertebral body including posterior longitudinal ligament which is adherent to the posterior surface of vertebral body, laterally by the pedicles, postero laterally by the facet joints and articular capsule, and posteriorly by the lamina and ligamenta flava [4].

The lateral recess

Is the space between posterior margin of the vertebral body and the anterior margin of the superior facet. Its anatomic boundery includes thecal sac medialy and the pedicle laterally. It is normally larger than 5 mm in diameter [5].

The ligamentum flavum

It is paired, thick, fibroelastic band which connects the lamina of adjacent verebral bodies and situated postero laterally in the canal. Antero laterally is contiguous with the capsule of facet joint. The normal thickness is 3 mm in lumbar spine [5].

Transitional vertebra

Transitional vertebrae are common at lumbo sacral junction occurring in 4% to 8% of population. The last lumbar vertebra articulates partially or completely with sacrum known as sacralization. The articulation may be unilateral or bilateral. The first sacral vertebra may be separated from the reminder of sacrum known as lumbarization [2, 5].

Radiological features of lumbar spine

Each vertebra consists of body, pedicles, laminae, transverse, articular and spinous processes. Oblique view used to visualize the inter vertebral foramina and pars inter articularis

[2]. The anterior posterior (AP) width of spinal canal is measured on a lateral film from posterior cortex of the vertebral body to the base of the spinous process [2]. The normal saggital diameter of lumbar canal is 15 to 25 mm and below is regarded and suggested to be abnormal; a diameter less than 12 mm confirms the presence of stenosis [3].

MRI features of lumbar spine

On T1 weighted spine echo imaging

- The vertebral body marrow appears as high signal intensity.
- Normally hydrated discs are slightly hypointense to vertebral marrow.
- The ligamentum flavum has intermediate signal intensity.
- Cerebro spinal fluid has low signal intensity.
- The spinal cord has intermediate signal intensity [5].

On T2 weighted spine echo imaging

- CSF and hydrated disc show high signal intensity.
- The cord and soft tissues have intermediate signal intensity.
- Fat including vertebral body have intermediate signal intensity [5].

Pathophysiology: Lumbar spinal stenosis is clinical condition and not radiological finding or diagnosis. It refers to pathological condition causing compression of the content of the canal, particularly the neural and vascular structures. The classical symptom is neurogenic claudication and it have been attributed to arterial obstruction of lumbar nerve roots resulting in ischemia and there is venous pooling induced by impairment of venous drainage at root level and will occure only if stenosis is present at a minimum of two adjacent levels [1, 6].

Classification of lumbar spinal stenosis

1. **Congenital-developmental stenosis**

1. Idiopathic reduction in the normal spinal canal dimension [13].
2. Developmental stenosis of the entire spinal canal is a well-known feature of achondoplastic dwarfism [13].

In congenital spinal stenosis the antero posterior diameter of lumbar spinal canal decreases. The pedicles are short and thick. The spinal canal tapers in the lumbar region. This is apposite of normal, in which the canal is usually equal in size to or greater in antero posterior dimension than that in the thoracic region. The lateral recesses and neural foramina may also be narrowed. The L4-L5 level is the most common site for canal stenosis and congenital stenosis which predispose the patient to early degenerative disc disease [5].

2. Acquired stenosis

There is compression of neural elements due to one or more of the following conditions:

1. Degenerative changes of vertebral bodies, facet joints, discs [2].
2. Spondylolisthesis forward slipping of one lumbar vertebral body relative to the adjacent lower vertebral body. Spondylolisthesis causes narrowing of neural foramen, which may cause nerve root impingment. The fractures in the pars interarticularis are commonly visible on the lateral film of lumbar spine but better demonstrated on oblique projections. The degree of slipping and neural compromise is also shown on MRI. On axial MRI the discontinuity of bone may be difficult to visualize and to diagnose it by the presence of continues facet sign from disc space above to the disc space below. The bony defect is often clearly seen on saggital MRI. Degenerative spondylolisthesis most frequently seen at L4-L5 level, may result in stenotic condition, with degenerative spondylolisthesis, the midline saggital image demonstrate narrowing of the spinal canal [5, 7].
3. Post traumatic as burst fracture of the spine.
4. Combined stenosis in which secondary narrowing of canal occurs in patients with preexisting stenosis [8].
5. Post-operative [13]
   - Laminectomy.
   - Fusion.

6. Metabolic and endocrine abnormalities [13]
   - Epidural lipomatosis is seen predominantly in patients with endogenous obesity who are taking steroid or have Cushing's syndrome.
   - Acromegaly.
   - Renal osteodystrophy.
   - Hypoparathyroidism.

7. Miscellaneous [7]
   - Paget's disease where there is enlarged vertebral body and pedicle, which shows condense thickened end plate and involvement of posterior element. Vertebral collapse is common and may cause spinal nerve compression, these changes shown on a plain film while on MRI the complications of paget's disease and subsequent relations to compromised soft tissues are noted, example: nerves, malignant degeneration and expansion into a soft tissues are well demonstrated.
   - Ankylosing spondylitis, rheumatoid arthritis and diffuse idiopathic skeletal hyperstosis [13].

Classification according to location of stenosis

There are three types of spinal stenosis: central, lateral recess and foraminal.

1. Central stenosis

Disc degeneration and collapse of disc result in uniform bulging of posterior annulus which encroaches upon the neural canal. With degenerative spinal disease the liagamentum flavum becomes fibrotic, visible thick and buckled. It causes narrowing of postero lateral and thus lateral recess. It may also narrow the central canal and/or neural foramina [5].

The process of annular bulging, bone spur formation, facet joint enlargement and ligamentous hypertrophy result in narrowing of central spinal canal [9].

2. Lateral recess stenosis

Facet joint hypertrophy is another cause of degenerative spinal stenosis. Hypertrophy of superior articular facet is a primary cause of lateral recess stenosis [5].

3. Neural foraminal stenosis

It is most common at L4-L5 and L5-S1. Degenerative disease of the disc, end plate and posterior element (facets) contribute to foraminal stenosis. The most common cause is hypertrophy of superior facet. The stenosis is accentuated if

the disc is narrow [5].

Clinical presentation of lumbar spinal stenosis

The complaint with symptomatic spinal stenosis includes claudication, an intense pain and it is felt in one or both lower extremities. The pain is often sufficiently intense to force patients to stop walking or sit in order to seek relieve. Claudication is either vascular which brought up by ischemia or neurogenic, due to pain associated with impingement of neural structures caused by lumbar stenosis [1]. Cauda equina syndrome usually occurs as result of compression of nerve roots in lumbosacral spine distal to conus medullaris. Features of cauda equina include low back pain, unilateral or bilateral sciatica, and bowl and bladder disturbances [4].

Investigations with spinal stenosis

1. Plain AP and lateral radiographs of lumbar spine

They are often the initial investigation of choice. These simple X- ray are valuable in ascertaining the severity of lumbar spondylosis, as patients with significant spinal stenosis who often demonstrate radiological changes of decrease disc height, osteophyte and facet hypertrophy, also lateral X-ray of lumbar spine will demonstrate spinal instability inform of spondylolisthesis, and the most reliable method in assessing spinal stability is flexion and extension lateral spine radiograph**.** Also X-ray is helpfull in excluding isthmic spondylolisthesis, a condition in which there is a break in the pars interarticularis, and in assessing whether there is concomitant degenerative scoliosis [8, 9, 11].

2. MRI

It is a modern neuro imaging technique which is required to confirm the diagnosis of spinal stenosis, and assess the severity of canal compromise. MRIs are expensive and very sensitive methods which give more specific and complete information about the anatomy and pathology of lumbar spine. MRI with its multi plannar imaging capability depicts soft tissues, including the cauda equina, ligaments, epidural fat subarchnoid space and inter vertebral discs. This modality allows visualization of neural elements. It also shows stenosis and defines which structures cause the stenotic process and permit the evaluation of true saggital dimensions and cross sectional area of the thecal sac. It can delineate patho anatomic and chemical changes of degenerating disc before disc herniation. It also delineates small tears in annular fibers. It gives information about spinal cord, para vertebral soft tissue and detect the presence of any inflammatory process involving the disc. It also detect the primary and metastatic neoplasm in spinal column, spinal cord or para verebral soft tissue figure (8). MRI remains the main stay of screening in the evaluation of central, lateral recess or foraminal stenosis [4, 8, 9, 12].

Patients and Methods

The study consists of (70) patients (34 females and 36 males), their age between (20-80) years with mean of (50). All are referred patients to Al-Salam Teaching Hospital in Mosul City between November 2005 and May 2006, they are examined by plain (X-ray) to lumbo sacral spine in AP and lateral views using machine schimadzu 1000 mA. We measure the saggital diameter of spinal canal in lumbar region, then the patients are examined.

By MRI machine, the apparatus – Philips - Gyroscan ACS-NT 1.5 Tesla. Power trak 3000 using synergic spinal coil.

Standard sequences used for every patient, with total examination time (15-30) minutes are:

1. Tlw sequence (spin echo – turbo spin echo) for anatomical details and performed at saggital and selected axial orientation. TR= 677 milisecond, TE= 12 milisecond, time= 3.18 minutes. T1 selected TR= 500, TE= 17, time= 3.27.
2. T2w sequence (turbo spin echo) for detection of pathological changes and to give myelographic effect and performed with saggital orientation. TR= 2757 milisecond, TE= 120 milisecond, time= 4.44 minutes T2 selected TR= 450, TE= 9, time= 6.11.
3. Myelographic like images (MR Myelography) of thecal sac and obtained with heavily T2 sequence. TR= 6000 milisecond, TE= 200 milisecond, with suppression of back ground signal.
4. Technique for motion suppression includes: rest slap, pulse and respiratory trigger. The pulse trigger is used to decrease vascular pulsation.

The MRI results are assessed by two senior radiologists in MRI department and the final result put down, is included in my study.

Results

Samples of this study consist of (70) patients, there were (36) of them (51.4 %) male and (34) of them (48.6 %) are female as shown in table (1).

Table 1: Shows sex distribution

Sex	No. of patients	Percentage
Male	36	51.4
female	34	48.6
Total	70	100

The age of our patients ranged between (20-80) years a shown in histogram.

Table 2: Shows age distribution

Sex	20-30	31-40	41-50	51-60	61-70	71-80	Total
Male	3	13	8	6	4	2	36
female	2	4	13	8	6	1	34
Total	5	17	21	14	10	3	70
Percentage	7.14	24.3	30	20	14.3	4.3	100

The most common type of stenosis is central stenosis which observed in (45) patients (64.28 %) as shown in table (3).

Table 3: Shows the type of the stenosis

Type of stenosis	Male	Female	Total	Percentage
Central stenosis	21	24	45	64.28
Foraminal stenosis	14	8	22	31.42
Combined stenosis	1	2	3	4.28
Total	36	34	70	100

The two most common causes of spinal stenosis are stenosis due to multiple causes seen in (36) patients (51.42 %) and the second is due to degenerative disc herniation seen in (24) patients (34.28 %) as shown in table (4).

Table 4: Shows causes of stenosis

Causes	Male	Female	Total	Percentage
Degenerative disc herniation	18	6	24	34.28
Ligamentum flavum hypertrophy	-	-	-	-
Spondylosis	2	4	6	8.57
Spondylolisthesis	-	2	2	2.85
Facet arthropathy	1	-	1	1.42
Compression fracture	-	1	1	1.42
Stenosis due to multiple causes	15	21	36	51.42
Total	36	34	70	100

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The use of plain film in examination of spinal canal in lumbar region is normal in (44) patients (62.85 %) while it shows spinal stenosis in (26) patients (37.13 %) as shown in table (5).

Table 5: Shows state of spinal canal by plain X-ray in all patients examined

State of spinal canal	Male	Female	Total	Percentage
Normal	24	20	44	62.85
Suggestive stenosis	8	9	17	24.28
Confirm stenosis	4	5	9	12.85
Total	36	34	70	100

MRI shows some of spinal stenosis were found to be at one level while other appear at multiple level as shown in table (6).

Table 6: Shows the no. of stenosis level

No. of stenosis level	Male	Female	Total	Percentage
One level	27	18	45	64.3
More than one level	9	16	25	35.7
Total	36	34	70	100

Detailed MRI finding shows the stenosis involving most of the disc spaces as shown in table (7).

Table 7: Shows the level of spinal stenosis

level of stenosis	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
No. of the patients	1	-	3	25	16
Percentage	1.42	-	4.28	35.71	22.85

Discussion

Choosing the best imaging technique for spinal stenosis is important but understanding the capabilities and limitations of the available modalities is essential for deciding the optimal test used. In our patients the highest age incidence in the fifth decade of life (41-50) years observed in (21) patients (30%) mostly due to hard work the patient do in their life and due to aging process. The most common type of stenosis is central stenosis observed in (45) patients (64.28%) which is due to multiple causes including degenerative disc herniation, ligamentum flavum hypertrophy and osteoarthritic changes in which by time leading to progressive narrowing of the spinal canal. The use of plain radiograph in lumbar spinal stenosis is normal in (44) patients (62.85%) while it shows spinal stenosis in (26) patients (37.13%). The low specificity of plain radiograph in diagnosis of spinal stenosis are due to:

1. Radiographic technical errors KV, MAs, position of the patient, quality of the film and experience of the radiographer.
2. The plain film only shows bony changes and unable to show soft tissue details like state of the disc, ligament, epidural fatty tissue, cauda equina and nerve root.
3. The limitation of the X-ray view because it takes the image on standard view (AP and lat.) and not having multi planner capability like coronal, saggital and transvers sections. Nevertheless, the use of plain radiograph of the spine by themselves are not diagnostic but helpful in assessing spinal stability and shows allignement of the spine also they are almost be positive for bony spurs, decrease disc height and facet arthropathy [4, 9]. The diagnosis of lumbar spinal stenosis can't be made on the basis of the plain film alone [13]. Plain film radiograph was the primary radiological examination used to evaluate the patients with lumbar spine dysfunction [12]. MRI is noninvasive method, risk and pain free and required no special preparation for the patients [12]. MRI when available it is useful in radiographic diagnosis of spinal stenosis, its advantage includes lack of radiation, the avoidance of invasive intrathecal contrast administration and capability of direct multi planar image construction. It has greater sensitivity in detecting disc disease and provide better soft tissue details but it doesn't provide the detail of bony structure [13]. Replacing lumbar spine radiograph with MRI in primary care patients results in increasing the cost of care because of increasing number of spine operations among patients undergoing MRI scan and overall cost may be high as well but the use of MRI scan instead of radiograph as initial imaging of lumbar spine has become more common [14]. There was excellent agreement between MRI imaging and clinical findings for the level and side and the purpose of using diagnostic to provide information about the patient's condition and influence the physician's plan for care [15]. MRI imaging decreases the need for contrast myelography and it is only performed on patients with contra indication to MRI like cardiac pace maker, metallic foreign body in orbit or spinal canal [16]. MR myelography is an imaging technique which utilizes heavily T2 weighted sequence to produce high signal similar in appearance to conventional myelography, it has been applied for demonstration of lumbar thecal sac and dural sleeves [17]. The most common level of spinal stenosis occurs at (L4-L5) and it is observed in (25) patients (35.71%) is due to most of the body weight occure at this level and the centre of spinal movement pass through (L4- L5) and (L5-S1). MRI was found to be of great value in detecting the causes and level of spinal stenosis in which the central stenosis is (64.28%). The results were compared to those of Jeffrey *et al*. 2003, central stenosis 20% while Michael *et al.* 1995 show central stenosis 12%. Central stenosis in my series is different from that of Jeffrey and Michael probably because their patients seek advice for their back pain more earlier than our patients.

Conclusions and Recommendations

1. MRI is more sensitive than other modalities in diagnosing of spinal stenosis.
2. The plain radiograph is the initial investigation in diagnosing patients with spinal stenosis because it is cheap and widely available.
3. Every patient complaining of backache should be exposed to this investigation to detect the stenosis early.
4. I recommend to increase the number of MRI unit in this country.
5. In this study spinal stenosis occurs in male patients more

than females and this is in agreement with other possibility is due to type of work the male does.

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