ОРИГИНАЛЬНАЯ СТАТЬЯ

ROLE OF MRI IN THE DIAGNOSIS OF CAUSES OF SPINAL STENOSIS AT LUMBOSACRAL REGION

Alyaa Hussein Jawad, Osamah Ayad Abdulsattar, Amani Alaa Saeed Mashtah

Department of Radiology, College of Medicine, University of Babylon. Babylon, Iraq.

Purpose. Spinal stenosis is an abnormal narrowing of the spinal canal or neural foramen that results in pressure on the spinal cord or nerve roots. MRI has become the most frequently used study to diagnose spinal stenosis. Aim of the study was to assess the beneficial role of MRI in evaluate and differentiation causes of spinal stenosis at lumbosacral spine.

Materials and methods. A cross-sectional study was recruited patient lower back pain, it's launched in 1st August 2021 to 1st September 2022, in Department of Radiology. Collection of data based on well-defined questionnaire contain three parts. MRI was perform with a 1.5 Tesla systems (Achieva; Philips Medical Systems, the Netherlands) using a SENSE body coil. Data was collected and analyzed using SPSS 23.

Result. The mean age of patients was 49.1±8.3 years, 55% of them in age group 40-60 years and 45% in age group 20-39 years. Male to female ratio was 1.3:1. The MRI findings, the stenosis was presented in 83.3% of patients of them 13.3% was mild stenosis and 70% was moderate stenosis. The spinal level of L4-L5 was the major region of stenosis in 50% of sample whereas the L2-L3 level 16% and L3-L4 26% of patients.

Conclusion. MRI modality is a useful diagnostic option in evaluation of lumbosacral spinal stenosis, as it can describe appropriate variable pathological changes, such as disc degeneration.

Keywords: spinal stenosis, lumbosacral lesion, spondylolisthesis, disc prolapse, MRI.

Corresponding author: Alyaa Hussein Jawad, e-mail: Medicalresearch82@yahoo.com

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РОЛЬ МРТ В ДИАГНОСТИКЕ ПРИЧИН СТЕНОЗА ПОЯСНИЧНО-КРЕСТЦОВОЙ ОБЛАСТИ

Алия Хусейн Джавад, Осама Аяд Абдулсаттар, Амани Алаа Саид Маштах

Кафедра радиологии, Медицинский колледж, Вавилонский университет. Вавилон, Ирак.

Стеноз спинномозгового канала – это аномальное сужение позвоночного канала или нервного отверстия, которое приводит к давлению на спинной мозг или нервные корешки. Магнитно-резонансная томография (МРТ) стала наиболее часто используемым исследованием для диагностики стеноза спинномозгового канала.

Цель. Оценить роль МРТ в оценке и дифференциации причин стеноза спинномозгового канала пояснично-крестцового отдела позвоночника.

Материалы и методы. В кросс-секционном исследовании, которое проводилось с 1 августа 2021 года по 1 сентября 2022 года в отделении лучевой диагностики, приняли участие па-

циенты с болью в пояснице. Сбор данных осуществлялся на основе четко определенной анкеты, состоящей из трех частей. МРТ выполняли на аппарате 1,5 Тесла (Achieva; Philips Medical Systems, Нидерланды) с использованием катушки для тела SENSE. Данные были собраны и проанализированы с использованием программы SPSS 23.

Результат. Средний возраст больных составил 49,1±8,3 года, из них 55% – в возрастной группе 40-60 лет и 45% – в возрастной группе 20-39 лет. Соотношение мужчин и женщин было 1,3:1. По данным МРТ стеноз был представлен у 83,3% пациентов, из них у 13,3% был выявлен стеноз легкой степени и в 70% – умеренный стеноз. Уровень L4-L5 был основным участком стеноза в 50%, уровень L2-L3 – у 16% и L3-L4 – у 26% больных.

Вывод. МРТ является полезным диагностическим исследованием при оценке стеноза пояснично-крестцового отдела позвоночника, поскольку данный метод позволяет получить информацию о соответствующих патологических изменениях таких, как дегенерация диска.

Ключевые слова: стеноз позвоночника, поражение пояснично-крестцового отдела, спондилолистез, пролапс диска, МРТ.

Контактный автор: Алия Хусейн Джавад, e-mail: Medicalresearch82@yahoo.com

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The unusual narrowing of spinal canal or neural foramens called spinal stenosis. This pathological stat may cause increase compression on the spinal cord and sometime nerve pathway root [1]. Result in various symptoms and signs such as pain, weakness in arm or leg and numbness in limbs. These clinical features actually grow slowly to intense presentation and its can be improved by bending of trunk ahead. With increase severity results in loss of bladder con troll, loss of bowel control and sexual dysfunction [2]. Many causes are reported and investigated for example osteoarthritis, rheumatoid arthritis, tumor in spine, trauma, bone Paget's disease, scoliosis, spondylolisthesis and genetic disorder [3].

These lesion could categories by region of spine was affected it subdivided into cervical, thoracic and lumbar stenosis. The most common part affected was lumbar spinal stenosis at lumbar, secondly cervical stenosis, thoracic spine stenosis are less common [4]. Pressure on nerve root at lumbar spine in lower back, might be causes features of sciatica include tingling, weakness and numbness, it radiating from back to buttock and leg [5]. Lumbar spinal stenosis almost the stenosis with severely intense are absent. Cauda equine a nerve root continue down when spinal cord end at lumbar spine [6]. Causes of spinal stenosis are aging, arthritis, congenital, instability of the spine, trauma, and tumor [7, 8].

The most common modalities to investigation the spinal stenosis are MRI, it become popular in diagnosis, by produce electromagnetic signal to show image of spine. It can appear soft tissue clearly such as nerve, muscle and ligament than they show by CT scan or X-ray. It aims in find the accurate causes of spinal nerve obstacle [8]. MRI have a good reliability criteria according to literature review public in this item, it have high sensitivity but questionable specificity in investigation of lumbar spine disorder, in disc herniation sensitivity range from 80-100% and low specificity range from 45- 90% are described in prior studies. These low values are due to large number of asymptomatic disc degenerative which produce high false positive result [9].

Aim of study are to assess the beneficial role of MRI in evaluate and differentiation causes of spinal stenosis at lumbosacral spine.

Patients and methods.

Study designs and siting

A study of cross sectional design was recruited patient lower back pain, it's launched in 1st August 2021 to 1st September 2022.

Inclusion criteria

1 - patients had lower back pain or leg pain

2 - age 18 - 60 years

3-symptoms last for more than 4 weeks

4- no cancer or inflammation suspicion

Exclusion criteria

1 - patients had history of spinal surgery.

2 - patients with lack of lumbar MRI

3 - disease that produce intervertebral disk herniation.

4 - laboratories results suggestive of presence of coagulopathy, infections, or inflammatory diseases

5 - patient whose have not finished questionnaire.

Data collection.

Collection of data based on well-defined questionnaire contain three parts, demographics criteria, detail of present illness and results of procedures. First of all, an oral agreement was obtained from patient to enrolled in the study. Patient's demography contains age, sex and occupation.

Patients enrolled in study with clinical features of claudication, pain in leg and back pain, numbness lower limb in both or one and radiological study of spine.

Recruited patients give appointment for MRI investigation, short and brief clarification about examination and summary of contraindication, general advisement to noise and time of examination and cloth they wear, some patients afraid from narrow space we tell him about communication with examiner through intercom tool.

MRI examination technique.

MRI was performed with a 1.5 Tesla systems (Achieva; Philips Medical System, the Netherland) by use a SENSE body coils.

Assessment procedure through measurement of dural sac cross sectional area (DSCSA), level of stenosis and if seen of spondylolesthesis. Cutoff point in DSCSA 100 mm2 as diagnostic value for lumbar spinal stenosis. Region of interest (ROI) was used to measure of DSCSA, calculation was done by measure the center portion of disk level by axial T1 image.

Stenosis was classification according to multi level of narrowing spine when see stenosis at least two level and over. If patients have multi level stenosis we measure the narrowest site of stenosis while if one level calculate this single level lumbar stenosis. Other measurement to diagnosis severity of stenosis by calculate stenosis ratio (SR), which are define it the ratio of the cross sectional area of spinal canal at intervertebral disk to the cross sectional area of next middle vertebra levels above.

When the ratio was between 0.7 to 1, there was no stenosis. Ratio between 0.5-0.7 this mean mild stenosis, if value between 0.25-0.5 mean moderate stenosis and lastly if ratio range from 0- 0.25 there severe stenosis.

The grading is based on the CSF/rootlet ratio as seen axial T2 images and was conceived following observation of the different patterns according which the rootlets were disposed within the dural sac while the patient rested supine during MRI acquisition.

Description of the grading is as follows (Schizas grading system):

Grade A stenosis: there is clearly CSF visible inside the dural sac, but its distribution is inhomogeneous:

A1: the rootlets lie dorsally and occupy less than half of the dural sac area.

A2: the rootlets lie dorsally, in contact with the dura but in a horseshoe configuration.

A3: the rootlets lie dorsally and occupy more than half of the dural sac area.

A4: the rootlets lie centrally and occupy the majority of the dural sac area.

Grade B stenosis: the rootlets occupy the whole of the dural sac, but they can still be individualized. Some CSF is still present giving a grainy appearance to the sac.

Grade C stenosis: no rootlets can be recognized, the dural sac demonstrating a homogeneous gray signal with no CSF signal visible. There is epidural fat present posteriorly.

Grade D stenosis: in addition to no rootlets being recognizable there is no epidural fat posteriorly.

We defined grade A as no or minor stenosis, B as moderate stenosis, C as severe stenosis, and D as extreme stenosis. Schizas grades of lumbar spinal stenosis (Supplementary 2).

The level of spondylolisthesis were also identified.

Image analysis.

After calculation of DSCSA then the level from L1-L2 to reach L5-S1 was assess to search about the stenosis and other pathology as follow,

1 - circumference annular bulging, this seen when there is extension in intervertebral disk outside the edge of neighboring bone in range more than 50% of its outer border.

2 - thin annular bulging it same the circumference annular bulging but with saving concavity of posterior disc.

3 - annular tears, the external layer of intervertebral disc show focal region of high signal intensity.

4 - foramian disc herniated when external border of intervertebral disc emerge less than fifty percent outside the boundary of neighboring bone, these may occur unilateral or some time bilateral. Focused in two or one foramina

5 - center or para-central disc herniated when external border of intervertebral disc

Table №1. Demographic characters of sample.

		No.	%
Age group	20-39 years	27	45
	40-60 years	33	55
Gender	Male	34	56.7
	Female	26	43.3

Table №2. The presenting clinical feature of patients.

Clinical features	No.	%
Lower back pain	32	53.3
Leg pain	15	25
Both	10	16.7
Numbness and tingling	5	8.3
Intermittent claudication	3	5

Table №3. Spinal findings in MRI.

Spinal finding		No.	%
Stenosis	Mild stenosis	8	13.3
	Moderate stenosis	38	63.4
	Severe stenosis	4	6.6
No stenosis		10	16.7
Total		60	

emerge less than fifty percent outside the boundary of neighboring bone, bulging in center or sub articular inside of spinal canal.

6- spondylolisthises, displaced of vertebral body in anterior or posterior side more than or equivalent to one mm above the vertebral body down it.

7- pars defects in unilateral or bilateral.

8- disc herniated in anterior side.

9-Posterior vertebral element show increase signal intensity called stress reaction.

Ethical approval.

The study was approved by our institutional ethics committees and a verbal consent was obtained from each patient before participating in the study.

Statistical analysis.

Data was collected and included in a data based system and analyzed by statistical package of social sciences (SPSS, Inc., Chicago, IL, USA) version 23. Parametric data were expressed as mean ± standard deviation (SD). While non-parametric data were expressed as percentages.

Result.

The mean age of patients was 49.1±8.3, 55% of them in belong groups of 40-60 year and 45% of patients in group of 20-39 year. Ratio of males to females was 1.3: 1 the male constituent 56.7% of sample, (table №1).

About the clinical features 53.3% of patients presented with lower back pain while 25% show leg pain and 16.7% reveal both lower back pain and leg pain. Other manifestation was numbness in 8.3% and intermittent claudication in 5% (table №2).

Regarding the MRI findings, the stenosis was presented in 83.3% of patients of them 13.3% was mild stenosis, 63.4% was moderate stenosis and 6.6% with severe stenosis (fig. 1) (Table 3).

The spinal level of L4-L5 was the major region of stenosis in 50% of sample whereas L3-L4 26% of patients and the L2-L3 level 16% (fig. 2; table №4).

Other results, 34% of patients presented with disc degeneration 20% spondylolisthesis, 12% facet degeneration, 10% scoliosis, 16% annular fissure and 8% disc contour (fig. 3; table №5).

The Dural sac cross sectional area value to diagnosis of spinal stenosis in our study was100 mm2 these give sensitivity 84%, specificity was 92% area under curve 0.89 (0.81-0.94) and p values 0.002 (table №6).

More over the signs of root compression illustrated by MRI co-exist with spinal stenosis, 64% of patients had nerve root compression, 30% loss of CSF, 6% show loss of epidural fat surrounding the dura, decrease thickness of spinal cord was seen in 12% and 14% presented with decrease signal intensity (fig. 4, 5; table №7).

Discussion.

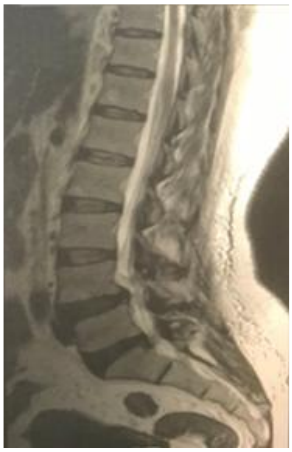


Fig. 1 a (Рис. 1 а)

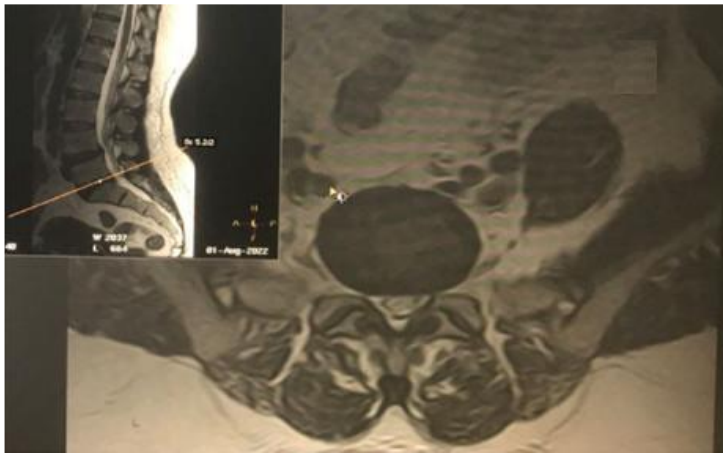


Fig. 1 b (Рис. 1 б)

Fig. 1. MRI, T2-WI, a – sagittal view, b – axial view.

MRI depicting moderate spinal stenosis at L4/L5 and L5/S1 level.

Рис. 1. МРТ, Т2-ВИ, поясничный отдел позвоночника, а – сагиттальная плоскость, б – аксиальная плоскость.

Умеренный стеноз позвоночника на уровне L4/L5 и L5/S1.

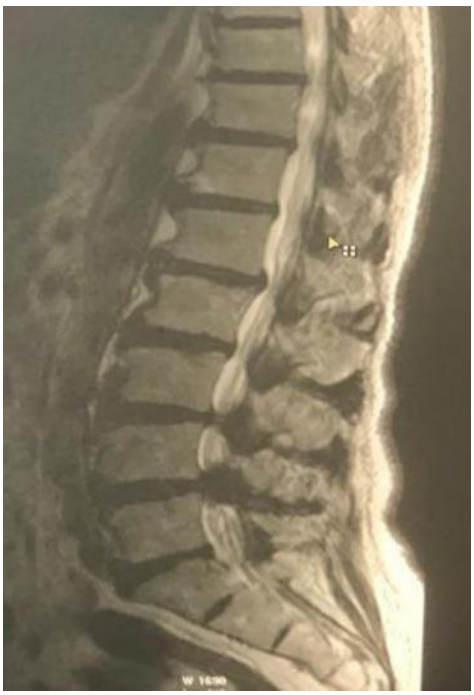


Fig. 2 (Рис. 2)

Fig. 2. MRI, T2-WI, lumbar spine, sagittal plane.

MRI depict multiple spinal stenosis at LSS.

Рис. 2. МРТ, Т2-ВИ, поясничный отдел позвоночника, сагиттальная плоскость.

Множественные стенозы в поясничном отделе позвоночника.

Magnetic resonance imaging becomes the top most important in evaluation of spinal stenosis. More over these modalities in spite of beneficial in diagnosis of lumbar spine stenosis but repeatability in evaluation of intervertebral disc abnormality and stenosis is questionable. In addition, it cost in over use, and cost efficiency are high, so if use in every case of suspected of stenosis give great of financial burden. But it still of much importance in preoperative planning and monitor of treatment, when the sign and symptoms correlated with image finding [8].

Our study found the mean age of patients was 49.1±8.3, 55% of them belong group 40-60 year and 45% belong group 20-39 year. Ratio of Males to females was 1.3: 1 the male constituent 56.7% of sample in accordance with previous studies and in contrast to other studies recruited older age group [10-12].

Hong et al. investigated 74 patients with central lumbar stenosis, they reported the mean age was 56 year of sample and age range 25-80 year. Gender composition, female was 41 and male 33 in contrast to our study [13].

Al-Jaberi et al, study enrolled fourteen men and 26 women, with average age 52.1±10.3, it has sample age range from 30-75 year [14].

Other study had the average age of study population was 62.3±8.4 and comprised 58 (45.7%) males and 69 (54.3%) females [15].

A cohort study by Hwang et al, show the

Table №4. Level of stenosis by MRI.

Level of stenosis	No.	%
L 2-L3	8	16
L 3-L4	13	26
L 4-L5	25	50
L 5 – S1	4	8
Total	50	

Table №5. MRI pathology of spine.

Pathologies of stenosis by MRI	No.	%
Spondylolisthesis	10	20
Disc degeneration	17	34
Facet degeneration	6	12
Scoliosis	5	10
Annular Fissure	8	16
Disc contour	4	8
Total	50	

Table №6. Cut off value for diagnosis of spinal stenosis.

Variables case	Cutoff	Sensitivity	Specificity	AUC(95%CI)	p-value
Dural sac cross section-al area	100 mm^2	84%	92%	0.89(0.81-0.94)	0.002

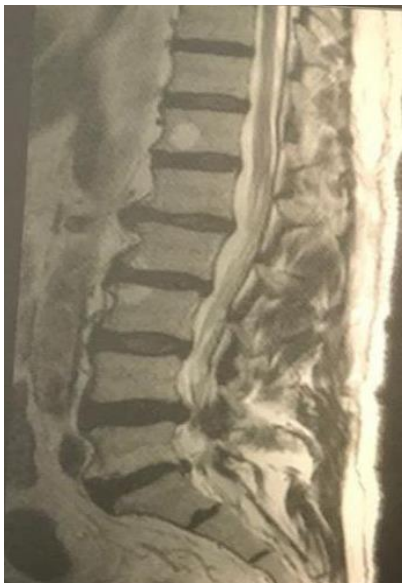


Fig. 3 (Рис. 3)

Fig. 3. MRI, sagittal T2-WI, lumbar spine.

MRI showing degeneratve changes, including disc bulging, loss of disc height, facet and ligament hypertrophy producing spinal stenosis at L4/L5 level.

Рис. 3. МРТ, Т2-ВИ, поясничный отдел позвоночника, сагитальная плоскость.

Определяются дегенеративные изменения, включая пролабированием межпозвонкового диска, снижение высоты диска, гипертрофию фасеточных суставов и связок, приводящую к стенозу на уровне L4/L5.

mean age is 68 year, this cohort had older age group which is presented with greater number of patients suffering from disc degeneration in compared to our study [16].

The difference between study in gender and mean age depend on site of study in which population under review such as in Swedish study recorded mean age was 70 year and Nordsten study had mean age was 66 year [17].

Age consider a risk factors in evolution of lumbar spinal stenosis, variable study show various value of DSCA between participants depend on differences in age composition of studies, in Swedish study reported low cutoff value of DSCA which might also influence the result and most of study across section that study patients with complain in specific time period [17].

The clinical features of our patients, 53.3% of presented with lower back pain while 25% show leg pain and 16.7% reveal both lower back pain and leg pain. Other manifestation numbness in 8.3% and intermittent claudication in 5% it in consist with study of Hong et al [13]. they reported more common presentation of patients lower back pain and leg pain, in same line of finding by Al-Jaberi et al, the similar findings because of root compression that give mostly the same presentation in patients [14].

Regarding the MRI findings, the stenosis was presented in 83.3% of patients of them 13.3% was mild stenosis, 63.4% was moderate

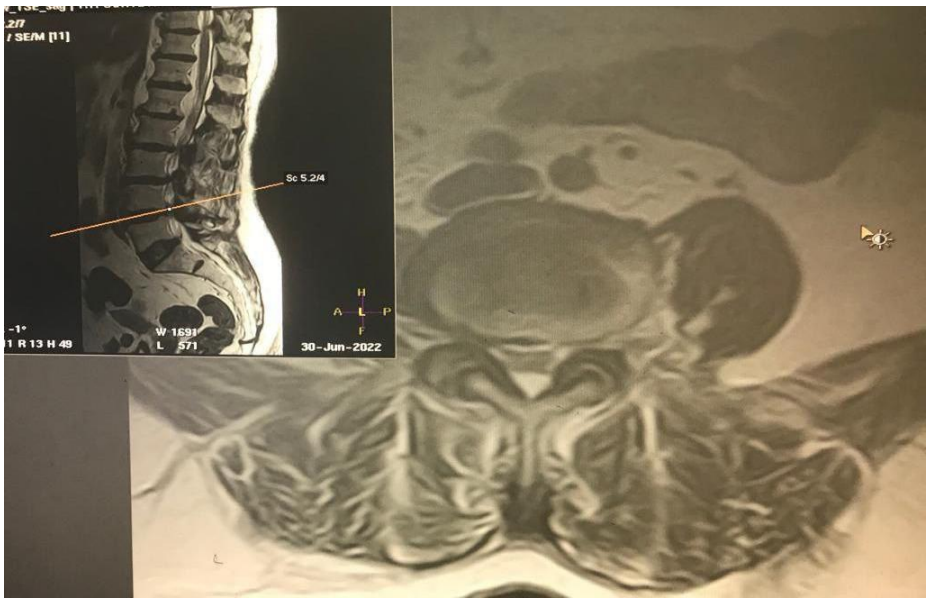


Fig. 4 (Рис. 4)

Fig. 4. MRI, lumbar spine.

Depicting CSF effacement and epidural fat posteriorly at L4/L5 level.

Рис. 4. МРТ, поясничный отдел позвоночника.

Потеря сигнала от спинномозговой жидкости и наличие эпидурального жира в задних отделах позвоночного канала на уровне L4/L5.

Table №7. Signs appear in MRI.

Signs in MRI	No.	%
Nerve root clumping	23	46
Loss of CSF	11	22
Loss of epidural fat	3	6
Decrease thickness of spinal cord	6	12
change signal intensity	7	14
Total	50	

stenosis and 6.6% with severe stenosis, these result close to Hong result [13].

On other hand a study was evaluated spinal stenosis level, there were 59.4% illustrated no stenosis while 34.6% had mild stenosis and only 5% had moderate stenosis, none of participant's image had severe stenosis [14].

In addition, Bhalla thesis enrolled patients from two different center with MRI finding prepared for surgical treatment, first group from Trondheim Norway had 78% of them had moderate stenosis and second group from Boston USA show 68% of patients with moderate stenosis [18].

Moojen et al. assessed the 154 patients with lumbar spinal stenosis they found 76% of sample are categories as mild and moderate stenosis [19].

Sigmundsson et al. evaluated a group of patients with 100 presented with lumbar spinal stenosis, prepared for spinal surgical treatment, 90% of them had mild to moderated finding, this is considerably higher than the findings of NORDSTEN study which is show 87%, which are close to our study [20].

This minor difference in presentation of intensity of stenosis between studies might be due to variable sample composition and various score and grade uses for measurement of stenosis [14].

Our study reported the spinal level of L4-L5 was the major region of stenosis in 50% of sample whereas the L2-L3 level 16% and L3-L4 26% of patients. In line of H-J PARK study show the incidence of the lumbar spinal stenosis, 15% in L3-L4, 66% in level of L4-L5 and

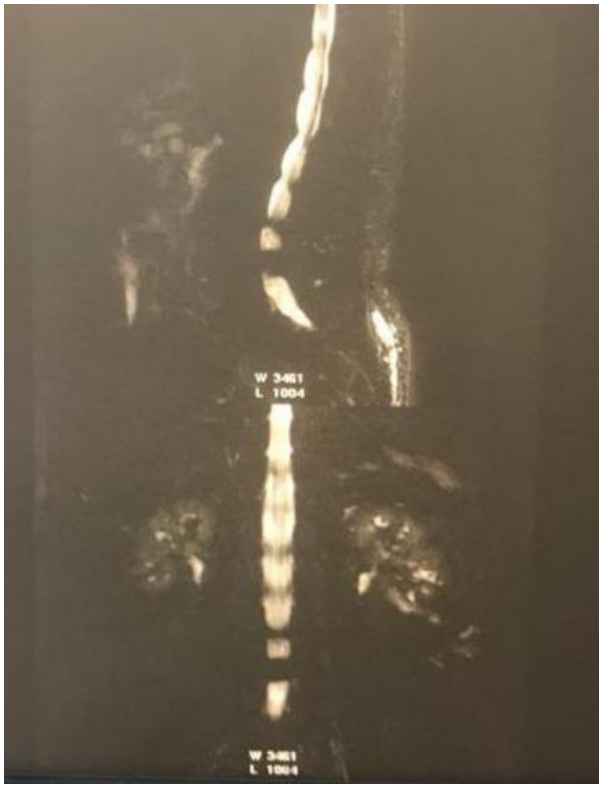


Fig. 5 (Рис. 5)

Fig. 5. MR-myelography of lumbar spine showing severe L3/4, L4/L5 lumbar canal stenosis.

Рис. 5. МР-миелография поясничного отдела позвоночника с выраженным стенозом поясничного канала на уровнях L3/4, L4/L5.

19% in L5-S1 [21].

In agreement with our study Hong et al, reported 10.9% of patients with stenosis level of L2-3, 16.4% in level L3-4, 76.7% in level L4-5 and 32.8% in level L5-S1 [13].

Authors evaluated subjects with congenital lumbar spinal stenosis in compared with normal individual by used of MRI images, they described patients with LSS group had single and multilevel affected with L3, L4 and L5 intervertebral disc segment more common than other level, and severe stenosis rarely happened [22]. These studies finding give strongest evidence to our study because resemble of common presentation of L4-L5 level of stenosis.

Other results in our study, there were 34% of patients presented with disc degeneration, 20% spondylolisthesis, 12% facet degeneration, 10% scoliosis, 16% annular fissure and 8% disc contour it in consistent with study by Hong et al, whose reported disc degeneration common pathology followed by spondylolisthesis which seen nine patients in one level had associated spondylolisthises and two patient had spondylolistheses at further than one level. Spondylolistheses was great often establish at the L4-L5 level [13].

Doktor et al. study reveal the common pathology show in MRI image were disc degeneration spondylolistheses, scoliosis, annular fissure, facet joints degeneration and disc contours [10].

Carrino et al. study more than 100 participants to examine the agreement between investigator to assess variable MRI pathology he found the disc degeneration, spondylolisthesis, endplate change, annular fissure and facet degeneration [23].

Moreover, Hwang et. al cohort of 45 subjects underwent spinal stenosis surgery categories 80% of subjects in study with worse disc degeneration on MRIs at baseline, other study reported 58% compare to our study 34% of patients with disc degeneration [17].

Akar et al study reported the presence of sever facet degeneration in group of 100 patients with lumbar spinal stenosis planning for surgery, they stated 14 % had facet degeneration these finding in same line of NORDSTEN study which are reported the facet happened in 11% and it close to our study 12% [24].

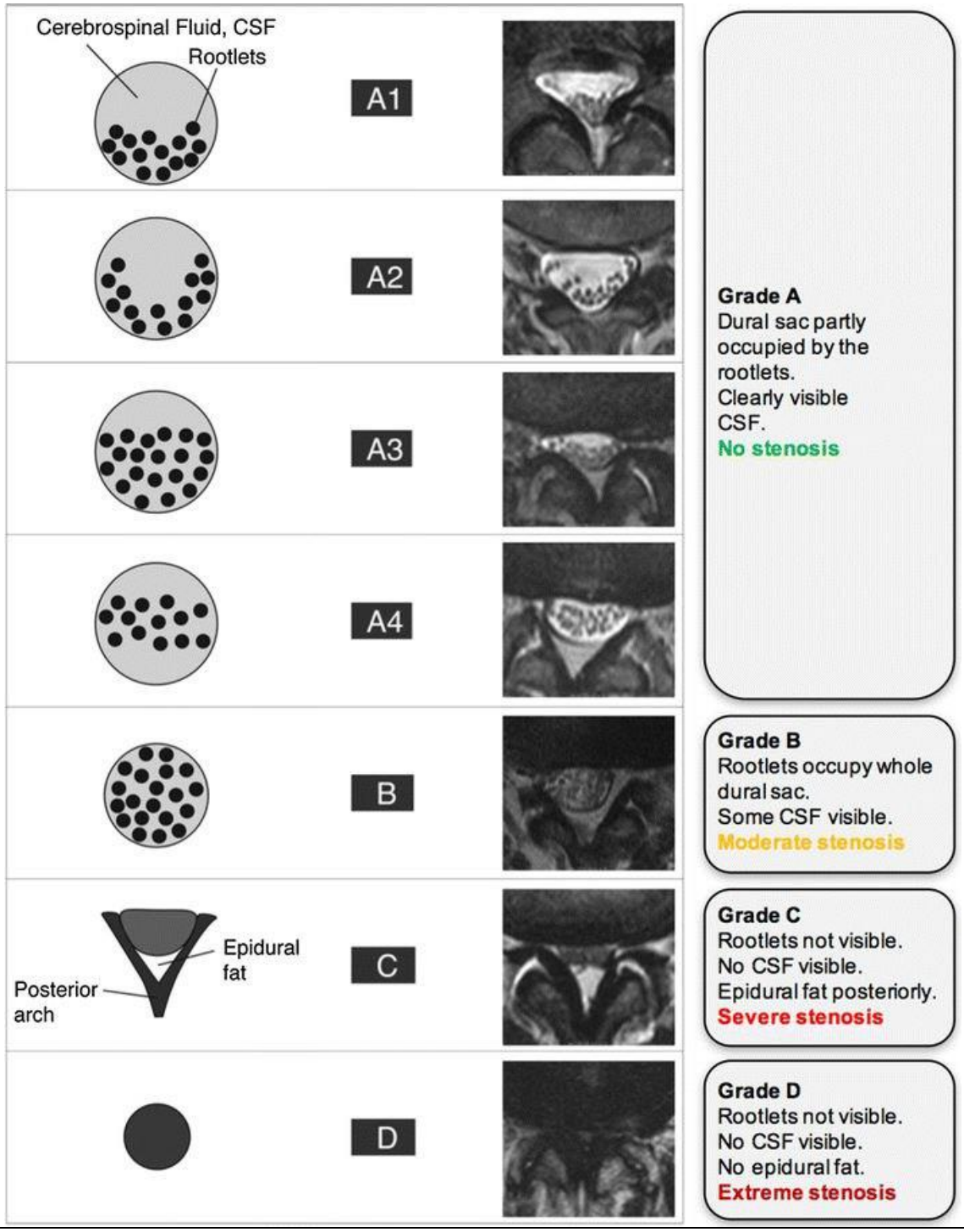
The variables presentation between studies regarding the pathological causes of spinal stenosis, these may be due to studies carried out in cross sectional design and enrolled patients admitted to hospital with signs and symptoms of spinal stenosis not necessitated representative to all causes of lumbosacral spine and cannot be generalized, because limiting to patients and time of studies [23].

Table six in our result show the Dural sac cross sectional area value to diagnosis of spinal stenosis in our study was (100 mm2), these give sensitivity 84%, specificity was 92% area under curve 0.89 (0.81-0.94) and p-value 0.002, it in consist to result of Hong et al some authors use lower cut off value of sac cross section area, the difference in cut off value between study due recruited older age group and variable gender enrollment in study [13, 25].

The signs of root compression in our study that illustrated by MRI co exist with spinal stenosis, there were 64% of patients had nerve root compression, 30% loss of CSF, 6% show loss of epidural fat surrounding the dura, decrease thickness of spinal cord was seen in 12% and 14% presented with Decrease signal intensity, it agrees with Yusof et al [26] study but disagree with Hwang et al. The cause might be due to difference in types of pathology found by variable studies [16, 27].

Conclusion.

Supplementary.



MRI modalities a useful diagnostic option in evaluation of lumbosacral spinal stenosis, as it can describe appropriate variable pathological changes, such as disc degeneration. Magnetic resonance images measurement of spinal canal associated to the level of disabilities. We recommend to use the MRI good confirmatory diagnostic modalities to investigate the spinal stenosis. MRI study could be a first step to put a plan for management of lumbar spinal stenosis.

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The Author(s) declare(s) that there is no conflict of interest.

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