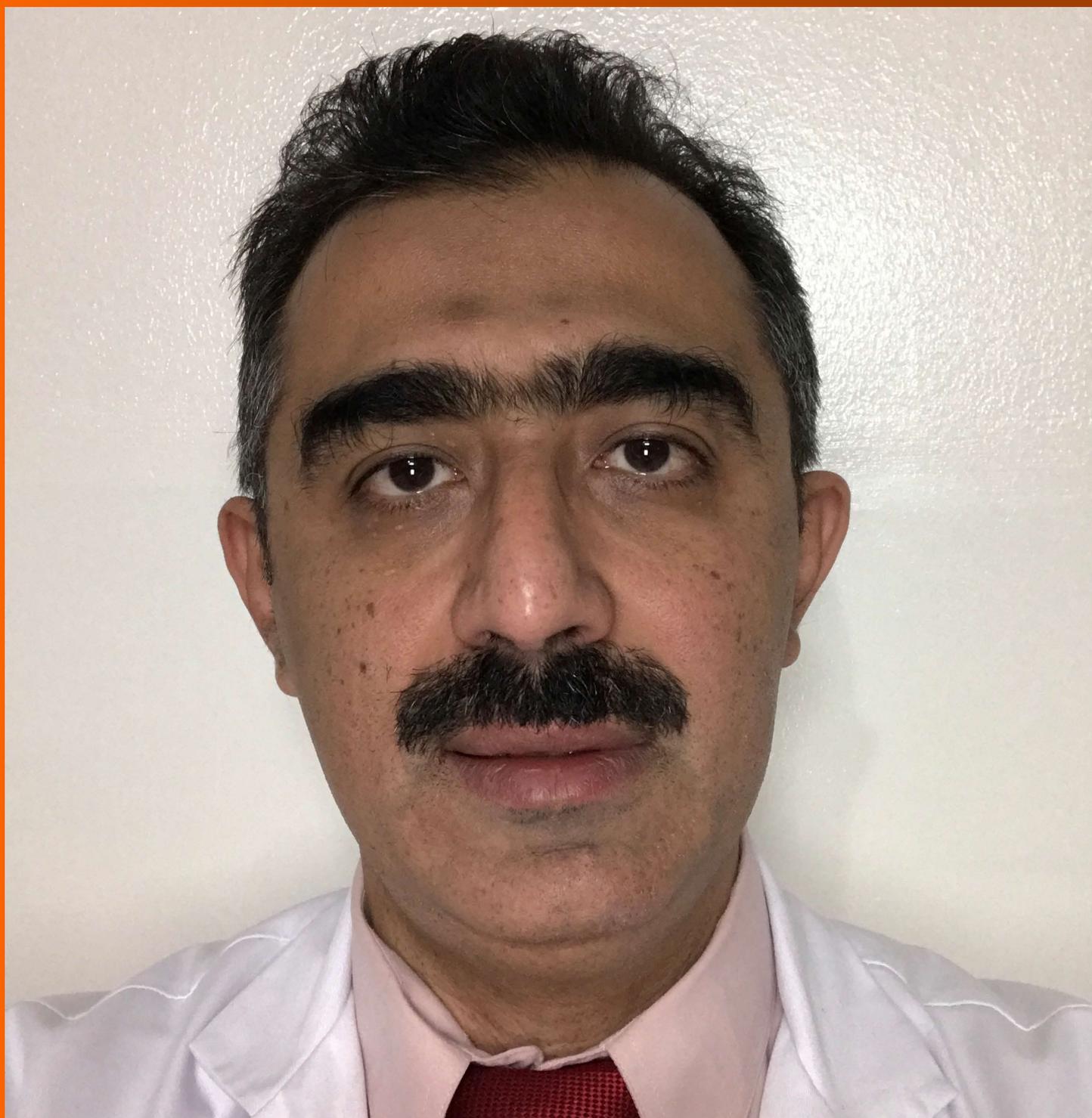
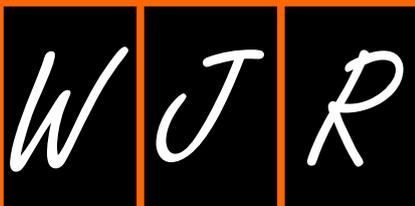


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Basic Study

Correlation of lumbar lateral recess stenosis in magnetic resonance imaging and clinical symptoms

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Institutional review board statement: The study inclusive of patient information and consent form was reviewed and approved by the ethics committee of the State Authorisation Association for Medical Issues of Hessen, Germany (FF 48/2014). Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to examination by written consent.

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Data sharing statement: Consent was not obtained but the presented data are anonymized and risk of identification is very low. No additional data are available.

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Abstract

AIM

To assess the correlation of lateral recess stenosis (LRS) of lumbar segments L4/5 and L5/S1 and the Oswestry Disability Index (ODI).

METHODS

Nine hundred and twenty-seven patients with history of low back pain were included in this uncontrolled study. On magnetic resonance images (MRI) the lateral recesses (LR) at lumbar levels L4/5 and L5/S1 were evaluated and each nerve root was classified into a 4-point grading scale (Grade 0-3) as normal, not deviated, deviated or compressed. Patient symptoms and disability were assessed using ODI. The Spearman's rank correlation coefficient was used for statistical analysis ($P < 0.05$).

RESULTS

Approximately half of the LR revealed stenosis (grade 1-3; 52% at level L4/5 and 42% at level L5/S1) with 2.2% and 1.9% respectively reveal a nerve root compression.

The ODI score ranged from 0%-91.11% with an arithmetic mean of 34.06% \pm 16.89%. We observed a very weak statistically significant positive correlation between ODI and LRS at lumbar levels L4/5 and L5/S1, each bilaterally (L4/5 left: $\rho < 0.105$, $P < 0.01$; L4/5 right: $\rho < 0.111$, $P < 0.01$; L5/S1 left: $\rho 0.128$, $P < 0.01$; L5/S1 right: $\rho < 0.157$, $P < 0.001$).

CONCLUSION

Although MRI is the standard imaging tool for diagnosing lumbar spinal stenosis, this study showed only a weak correlation of LRS on MRI and clinical findings. This can be attributed to a number of reasons outlined in this study, underlining that imaging findings alone are not sufficient to establish a reliable diagnosis for patients with LRS.

Key words: Low back pain; Lumbar spine; Magnetic resonance imaging; Lateral recess stenosis; Oswestry Disability Score; Lumbar spinal canal stenosis

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Core tip: In the presented study lateral recesses of nearly 1000 patients with low back pain were evaluated on magnetic resonance imaging (MRI) and correlated with patient symptoms. Though MRI is the method of choice for diagnosing lumbar spinal stenosis, we revealed only a very weak correlation of lateral recess stenosis (LRS) and patient symptoms. This can be attributed to numerous reasons outlined in this study, underlining that imaging findings alone are not sufficient for an adequate diagnostic approach of patients with LRS.

Splettstößer A, Khan MF, Zimmermann B, Vogl TJ, Ackermann H, Middendorp M, Maataoui A. Correlation of lumbar lateral recess stenosis in magnetic resonance imaging and clinical symptoms. *World J Radiol* 2017; 9(5): 223-229 Available from: URL: <http://www.wjgnet.com/1949-8470/full/v9/i5/223.htm> DOI: <http://dx.doi.org/10.4329/wj.v9.i5.223>

INTRODUCTION

After arthritis and rheumatism^[1] low back pain (LBP) is the second most cause of disability in United States adults, and thus is a major social and economic issue^[2]. With the aging population the prevalence is even drastically rising^[3]. Lumbar spinal stenosis (LSS) is one main cause of LBP. As a distinct syndrome LSS was already described by Verbiest *et al*^[4] in 1954. Most studies about LSS focus on the central LSS. Failure to recognize or adequately treat lateral recess stenosis (LRS) is considered to be the main reason for failed back surgery on the lumbar spine^[5]. On account of this we focused on the LRS in the presented study. Regarding imaging analyses LSS is defined by the reduced size of the spinal canal. Based on the anatomical regions,

LSS is generally subdivided in central spinal stenosis, LRS and foraminal stenosis. The LRS affects the lateral region of the lumbar spinal canal that is bordered laterally by the pedicle, posteriorly by the superior articular facet, and anteriorly by the vertebral body, endplate margin, and disc margin^[6] (Figure 1). LRS is most commonly caused by degenerative changes of the spine such as facet joint osteoarthritis, ligamentum flavum hypertrophy, intervertebral disc degeneration and endplate spur. Congenital abnormalities, bone diseases, tumors or trauma are rare causes of LRS^[7]. According to Bartynski *et al*^[8] two pathways for the development of degenerative LRS exist. On the one hand the congenital or acquired trefoil canal in which the nerve root remains in its position in the LR and the narrowing of the LR develops in an anteroposterior fashion. Regarding the acquired trefoil canal first of all facet joint osteoarthritis causes the trefoil-shape, subsequent following endplate and disc degeneration result in LRS. The second pathway is called acute angular pinch. The narrowing occurs simultaneously from all directions due to endplate, disc and facet joint degeneration. The nerve root is either deviated medially or compressed in the LR. Magnetic resonance imaging (MRI) is considered the standard imaging technique for evaluation of LSS^[9-11] due to the best soft tissue contrast^[7]. Although LSS as a distinct syndrome has already been described more than 60 years ago, the radiological classification systems remain inconsistent^[12,13]. In 2014 the "Consensus conference of core radiological parameters to describe lumbar stenosis" with 15 internationally renowned experts focused on this problem^[12]. Concerning the LRS they recommend the classification system of Bartynski *et al*^[8] which focuses on the compression and the localization of the nerve root in the LR. In short Bartynski *et al*^[8] divided the LRS in 4 grades: Normal (grade 0), small without root compression (grade 1), small with root compression (grade 2) and severe root compression (grade 3). LSS is usually diagnosed by clinical findings in correlation with imaging results. However in the daily routine we frequently experience a mismatch between LBP and MRI results. The aim of our study was to verify this mismatch regarding LBP and LRS. To the best of our knowledge there are no previous studies investigating the correlation of LBP and MRI findings of LRS in such a large group of patients.

MATERIALS AND METHODS

Study participants

The study was approved by the ethical committee. In total the study involved lumbar MR images of 927 patients (410 men and 517 women). The mean age of the patients included was 47.7 years (ranging from 13 to 92 years). All patients included in the study had suffered from LBP without any history of spinal surgery. Criteria for exclusion of patients were confirmed disc herniation, spinal stenosis, scoliosis and vertebral fractures. The MR images were gathered over a time of one year with

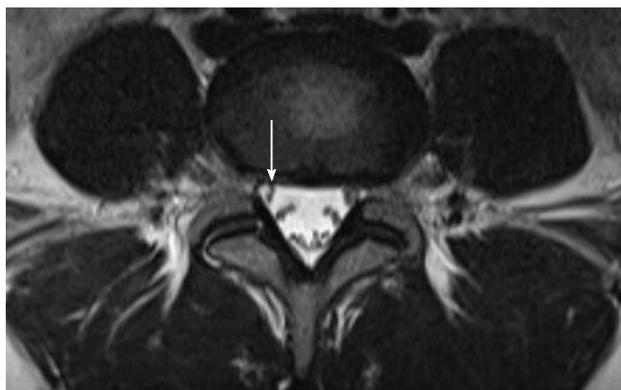


Figure 1 Axial T2-weighted magnetic resonance image of lumbar level L4/5 shows the lateral recess that is bordered laterally by the pedicle, posteriorly by the superior articular facet, and anteriorly by the vertebral body, endplate margin, and disc margin.

suspected disc herniation and facet joint degeneration being the main reasons for MRI.

Imaging technique

MRI of the lumbar spine was conducted with a 1.5 Tesla MRI system (Magnetom® Avanto, Siemens AG, Erlangen, Germany) and a dedicated receive only spine coil. For imaging analysis axial T2-weighted images were obtained using fast spin-echo sequences. The sequence parameters were: TR 3550; TE 90; matrix 448; field of view 210 mm; slice thickness 4 mm; interslice gap 10%, number of excitations.

Image analysis

All MR images were assessed in consensus by two blinded authors (Adel Maataoui, M Fawad Khan). Both authors are board certified radiologists with longstanding experience in imaging of the musculoskeletal system. Degeneration of lumbar spine concerns mostly segments L4/5 and L5/S1, for which reason the LR of these segments were graded on axial T2-weighted fast spin-echo images. All in all, an overall number of 3708 lateral recesses were rated.

Our grading system of LRS was based on Bartyński's classification. We defined grade 0 as a normal LR in which the nerve root is bathed in cerebrospinal fluid. There is no contact to the adjacent structures. Grade 1 represents a narrowing of the LR without root deviation. Grade 2 additionally reveals a root deviation. Grade 3 describes a compression of the nerve root (Table 1, Figure 2).

Oswestry Disability Index

By means of the Oswestry Disability Index (ODI) functional status was assessed. The ODI is one of the principle outcome measure questionnaires for LBP - it measures pain and disability, which are core items in patients with LBP^[14]. We used the german version of the ODI developed by Mannion *et al.*^[15]. This standardized, self-administered questionnaire contains ten sections: One section about pain intensity and nine sections

about limitations of various activities of daily life, namely personal care (washing, dressing, *etc.*), lifting, walking, sitting, standing, sleeping, sex life, social life and travelling^[16]. The question about sex life was excluded on grounds of ethical aspects. Each section is scored on a scale of 0-5 points with 0 representing no disability and 5 the greatest disability. Section 2 "personal care" for example contains the following statements and scores: I can look after myself normally without causing extra pain (0); I can look after myself normally but it is very painful (1); It is painful to look after myself and I am slow and careful (2); I need some help but manage most of my personal care (3); I need help every day in most aspects of self care (4); and I do not get dressed, wash with difficulty and stay in bed (5)^[16].

Finally the index is calculated by dividing the summed score by the total possible score (which has to be reduced by 5 for every question not answered). The result is then multiplied by 100 and expressed as a percentage. The result is interpreted as follows: Score of 0%-20%, minimal disability; 20%-40%, moderate disability; 40%-60%, severe disability; 60%-80%, crippled; 80%-100%, patients are bedbound.

Statistical analysis

Data were analysed with the use of the BIAS software package (Epsilon publisher, Frankfurt a.M., Germany). In order to evaluate the correlation of LRS and ODI Spearman's coefficient of rank correlation was determined. *P* value < 0.05 were considered statistically significant.

RESULTS

Grades of LRS in the patient cohort

Three thousand seven hundred and eight LR of 927 patients were assessed at lumbar level L4/5 and L5/S1. Table 2 presents the number of LR according to the relative grade of stenosis. The image evaluation revealed 430/461 grade 0 stenosis (48.1%), 357/349 grade 1 stenosis (38.1%), 113/103 grade 2 stenosis (11.7%) and 27/14 grade 3 stenosis (2.2%) for the left/right side of lumbar level L4/5 and 528/548 grade 0 stenosis (58%), 303/316 grade 1 stenosis (33.4%), 75/49 grade 2 stenosis (6.7%) and 21/14 grade 3 stenosis (1.9%) for the left/right side of lumbar level L5/S1, respectively.

Symptoms and disability

According to ODI scores patient symptoms and disability ranged from a minimal score of 0% to a maximal score of 91.11%. The mean value amounted to 34.06% ± 16.89%. Most patients (48.39%) showed a moderate functional disability (21%-40%). Regarding sex no statistical difference between the ODI scores could be revealed: Men 32.47% ± 16.55% and women 35.58% ± 16.55%.

The mean ODI scores for LRS grade 0, 1, 2, 3 of lumbar level L4/5 on the right side were 31.53% ± 15.46%, 31.53% ± 17.60%, 33.01% ± 17.17% and

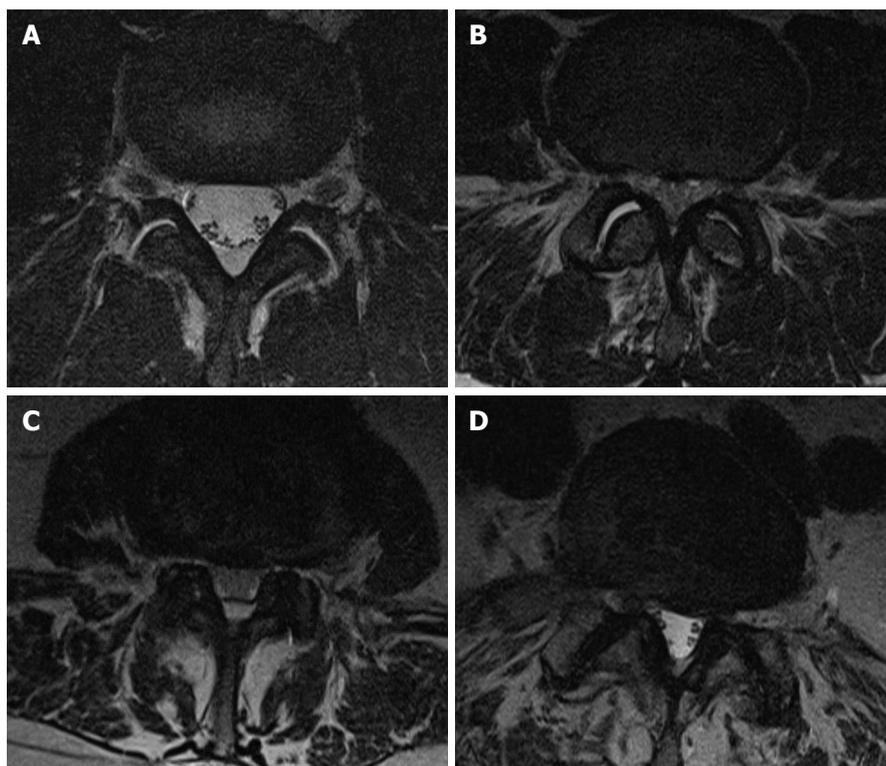


Figure 2 Axial T2-weighted magnetic resonance images illustrate the grading system of lateral recess stenosis. A: Grade 0 bilaterally; B: Grade 1 bilaterally; C: Grade 2 bilaterally; D: Grade 3 on the left, Grade 1 on the right.

Table 1 Grading system of lateral recess stenosis	
Grade	Nerve root in the lateral recess
0	Normal
1	No deviation
2	Deviation
3	Compression

Table 2 Number of grades of lateral recess stenosis for lumbar levels L4/5 and L5/S1				
Lumbar level	Grades			
	0	1	2	3
L4/5 left	430	357	113	27
L4/5 right	461	349	103	14
L5/S1 left	528	303	75	21
L5/S1 right	548	316	49	14

33.03% ± 16.89%. There was no statistical difference between the ODI score and the grade of LRS on lumbar level L4/5 on the right.

The mean ODI scores for LRS grade 0, 1, 2, 3 of lumbar level L4/5 on the left side were 30.75% ± 17.85%, 30.74% ± 17.03%, 32.39% ± 16.97% and 33.25% ± 16.90%. There was no statistical difference between the ODI score and the grade of LRS on lumbar level L4/5 on the left.

The mean ODI scores for LRS grade 0, 1, 2, 3 of lumbar level L5/S1 on the right side were 32.03% ± 16.58%, 32.03% ± 16.60%, 33.24% ± 16.41% and 33.88% ± 16.76%. There was no statistical difference between the ODI score and the grade of LRS on lumbar level L5/S1 on the right.

The mean ODI scores for LRS grade 0, 1, 2, 3 of lumbar level L5/S1 on the left side were 32.14% ± 16.90%, 33.15% ± 16.62%, 33.13% ± 16.60% and 33.46% ± 16.78%. There was no statistical difference between the ODI score and the grade of LRS on lumbar level L5/S1 on the left.

Correlation of ODI and LRS

We observed a very weak statistically significant positive correlation between ODI and LRS at lumbar levels L4/5 and L5/S1, each bilaterally.

L4/5 left and ODI: $\rho < 0.105, P < 0.01$; L4/5 right and ODI: $\rho < 0.111, P < 0.01$; L5/S1 left and ODI: $\rho 0.128, P < 0.01$; L5/S1 right and ODI: $\rho < 0.157, P < 0.001$.

DISCUSSION

Despite the high prevalence of LSS and that the combination of clinical and imaging findings are the standard diagnostic tools^[17] clinical and imaging findings often do not correlate. Haig *et al*^[9] and Geisser *et al*^[18] could not find any difference between symptomatic and asymptomatic patients based on the size of the lumbar spinal canal measured on MR images. Lohmann *et al*^[19] did also not detect a correlation between clinical findings and LSS on computed tomography (CT) images.

The aim of our study was to verify if the results of these studies which focused on central LSS, do also apply to LRS. In the presented study with a cohort of more than 900 patients we found only a very weak positive correlation between the severity of LBP and the severity of LRS. Our findings are supported by the results of Kuittinen *et al.*^[20]: By MR imaging and electromyography they evaluated 140 nerve roots of 14 patients, who were selected for surgical treatment of LRS. The findings were correlated with each other as well as with the clinical symptoms, measured by different tests including the ODI. In this little cohort they revealed a positive correlation between MR-findings and EMG and between EMG and patient symptoms. But they revealed no correlation between MR findings and patient symptoms. The study is limited by the very small cohort of patients and the fact that also neuroforaminal stenosis was included.

It is unclear why clinical and imaging findings do often not correlate. The compression of the nerve root is considered to be one of the main causes of symptoms in patients with LRS^[21-23]. In an experimental study Lacroix-Fralish *et al.*^[24] observed that a nerve root ligation in a rat model produced mechanical allodynia. Mechanical root compression in a dog model revealed intraradicular edema and Wallerian degeneration^[25]. Using a silicon tube Saal^[26] and Xue *et al.*^[27] produced lumbar nerve root compression in a rat model, which resulted in disappearing of the myelin sheath and activation of microglia, which is assumed to participate in the genesis and maintenance of pain^[24].

Thus, it must be considered that a possible reason for the discrepancy between MRI findings and patient symptoms could be that MRI does not sufficiently identify nerve compression. Bartynski *et al.*^[8] assessed the accuracy of MRI in 26 patients with symptomatic nerve root compression in the LR at lumbar levels L2/3 - L5/S1. Each patient underwent MRI, conventional myelography and CT myelography; the root compression was confirmed surgically and a post-operative pain improvement could be observed. In MRI the root compression was underestimated in nearly 30%.

LSS, in addition, has an important dynamic component. MRI was performed, as usual, with the patient lying in the supine position. Yet it is known and even a key feature for LSS that patient symptoms increase under axial loading and lumbar extension while they decrease under axial distraction and flexion^[17,28]. This can be explained by anatomic alterations: Flexion and extension can change the size of the central lumbar canal, the LR and the neural foramen and can consecutively result in changes of the cauda equina as well as in isolated nerve root compression in the LR^[29]. In experimental studies axial loading has caused alterations of the size of the lumbar canal and the neural foramen^[30]. In the upright position axial loading can cause displacement of peridiscal structures that lead to a nerve root compression which is not observable in the supine position^[31]. In addition the pressure in the lumbar canal can be altered by postural changes^[32,33].

Two other aspects should be considered as possible explanations for the weak correlation. On the one hand the nerve root can be compressed without clinical symptoms. On the other hand clinical symptoms can be evident without imaging findings of root compression. Although there are single studies which reveal nerve root compression in approximately 20% of asymptomatic individuals^[34], there is in total only a small number of asymptomatic individuals who reveal nerve root compression in MRI. In a study presented by Weishaupt *et al.*^[35] with 60 asymptomatic volunteers only one single root compression was observed in MRI by one of the readers. A study of nearly 100 asymptomatic elite junior tennis players revealed a nerve root compression in only 2%^[36]. Boos *et al.*^[37] reported a "major nerve deformation" in 4% of asymptomatic adults.

A possible explanation for clinical symptoms without evident nerve root compression in imaging is the inflammation of the nerve root caused by inflammatory mediators^[38,39], for example, Interleukin $\beta 1$ ^[40]. It is hypothesized, that these substances can diffuse in the spinal canal from the facet joints, the ligamentum flavum^[40] and from the intervertebral disc^[26,41].

Beside the nerve root nearly all lumbar structures are potential sources of LBP, such as the facet joints, the intervertebral discs, bones, fascial structures and muscles^[42]. Especially facet joint osteoarthritis is known for radiating pain without evidence of nerve root compression^[43,44]. Because of the fact that LRS is based on facet joint osteoarthritis, intervertebral disc degeneration, ligamentum flavum hypertrophy and endplate spur we have to consider that in our study each of these structures could be the crucial factor for patient symptoms.

LBP rarely causes objective endpoints so outcomes are best measured with patient-reported metrics^[45]. We assessed patient symptoms by means of the ODI. It is one of the most commonly used measures of disability in back pain^[46]. It has established psychometric properties, is easy to use and has a low administrative burden^[46]. Yet, based on self-reported symptoms, the ODI remains subjective. Furthermore it does not measure nerve root level specific symptoms. A limitation of the presented study is that results of clinical, more objective, examinations were not included and that we assessed no nerve root level specific symptoms. In addition the LRS were not proved surgically.

In conclusion, in our broad study population we only found a very weak statistically significant positive correlation between LBP and LRS on MR-images, thus confirming the well-known problem that in the context of diagnosing LBP clinical and imaging findings often do not correlate. Our results underline the necessity not to evaluate LRS isolated on imaging but in relation to clinical findings.

COMMENTS

Background

Low back pain (LBP) is an important issue for healthcare systems all over the

world. One reason of LBP is lumbar spinal stenosis (LSS), with lateral recess stenosis (LRS) not gaining as much attention as central spinal stenosis, a fact that is assumed to be the main reason for failed back surgery. Concerning imaging techniques magnetic resonance imaging (MRI) is the standard imaging tool for evaluating LSS. However in the daily routine people frequently experience a mismatch between LBP and MRI results. The aim of this study was to verify this mismatch regarding LBP and LRS.

Research frontiers

The problem that in the context of LBP clinical and imaging findings often do not correlate has been the objective of numerous studies in the past. Yet the LRS as one reason of LBP is underrepresented and most studies have a small study population.

Innovations and breakthroughs

The authors assessed the correlation between LBP and LRS in a very broad study population including nearly 1000 patients. Functional status was assessed by means of the Oswestry Disability Index (ODI), and LRS was assessed on axial magnetic resonance images of lumbar level L4/5 and L5/S1 by evaluating the nerve root in the lateral recess on a 4 point grading scale. The authors revealed a very weak statistically significant positive correlation between ODI and LRS at the L4/5 segment as well as the L5/S1 segment.

Applications

The presented findings underline the necessity not to evaluate LRS isolated on imaging but in relation with the clinical findings.

Terminology

Lateral recess stenosis: It describes the stenosis of the lateral part of the lumbar spinal canal that is bordered laterally by the pedicle, posteriorly by the superior articular facet, and anteriorly by the vertebral body, endplate margin, and disc margin. It is most commonly caused by degenerative changes; Oswestry Disability Index: The Oswestry Disability Index is one of the principle outcome measure questionnaires for low back pain focussing on disability and pain.

Peer-review

The authors studied the correlation of lumbar recess stenosis in MRI with clinical symptoms.

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