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Research Article

Comparative Analysis of Lateral Radiography and Magnetic Resonance Imaging in the Diagnosis of Lumbar Disc Herniation

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Abstract

Aim: This article investigates the use of X-ray as a cost-effective and feasible alternative to magnetic resonance imaging (MRI) for diagnosing lumbar disc herniation (LDH), a common condition with significant economic impact.
Material and Method: We assessed the diagnostic efficacy of lumbar lateral radiography (LLR) in identifying LDH. The study cohort formed from patients, presenting with lumbalgia or lumbosciatalgia. Participants who gave consent and had both MRI and LLR within a one-month period were included. Data normality was evaluated, employing the Kolmogorov-Smirnov test for nonparametric data. Variables were represented as means ± standard deviation, analyzed using the Wilcoxon test, with a p-value of less than 0.05 indicating statistical significance.
Results: The study involved 436 patients, 56.8% female and 43.2% male, ranging in age from 18 to 75 years. No significant gender, age, or Body Mass Index (BMI)-related differences were observed in the presence of LDH on radiographs. However, significant differences were noted at the L5-S1 and L4-L5 levels. The LLR showed a sensitivity of 94%, specificity of 95%, and a high agreement of 96.7% among evaluators.
Conclusion: Study concludes that LLR achieves a diagnostic success rate comparable to Lumbar MRI for most LDH cases. Notably, it is crucial to employ LLR even in patients presenting with "red flag" signs. LLR stands out as a cost-effective and rapid diagnostic alternative in the assessment of LDH. Nonetheless, it is important to acknowledge that MRI continues to be indispensable in more complex cases or for patients exhibiting specific clinical symptoms.

Keywords: Lumbar lateral radiography, lumbar disc herniation, lumbar magnetic resonance imaging, comparative analysis

INTRODUCTION

Lumbar disc herniation (LDH) is a prevalent condition, ranking as the second most common reason for medical consultations and hospitalizations (1,2). It accounts for 15% of all workforce losses and is the leading cause of disability in individuals under 45 years old (1). Given its impact, financial investments in diagnosing and treating LDH hold significant economic importance (3). In 2020, according to data from the Social Security Institution in our country, there were 86,386 new cases of LDH (3). The expenditure on surgical treatments for these cases was approximately 127 million Turkish Liras, representing only about 2% of the disease's total cost (3). This figure does not include investments in healthcare facilities or the indirect costs of workforce losses (3,4).

Currently, magnetic resonance imaging (MRI) is the most commonly utilized diagnostic tool for LDH, primarily due to its evidence-based effectiveness (5). Despite being the gold standard for etiological diagnosis, MRI has notable limitations, including long waiting times for appointments and high costs associated with installation, maintenance, and staffing (3). Additionally, MRI is not suitable for patients with certain medical devices or conditions such as pacemakers, stents, metallic fixators, or claustrophobia (6).

In contrast, X-ray, a simpler and less expensive imaging modality, is underutilized in neurosurgery training and practice, although it plays a crucial role in diagnosing bone pathologies (7,8). While not typically employed for diagnosing LDH, lumbar lateral radiography (LLR) is instrumental in surgical level determination, investigating

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muscle spasm etiology, assessing spinal alignment, and identifying various pathologies, including congenital/acquired anatomical disorders, tuberculosis or brucella spondylitis, and trauma-related injuries (7-9). Over the years, we have noticed during patient examinations that it is possible to observe disc traces in LLR. The advent of digital X-ray technology, with its adjustable dosing capabilities, has further facilitated this observation (9).

It is important to note that early diagnostic interventions using advanced technology do not necessarily contribute to the natural healing process of LDH (6). While a small subset of patients requires surgical intervention, a significant portion undergoes MRI due to legal and social reasons, despite the potential for diagnosis through X-ray (3,5,7-9). This overreliance on MRI has prompted a reevaluation of whether LLR could serve as a cost-effective alternative to alleviate the financial burden of more expensive imaging modalities.

This study aims to explore the feasibility of substituting lumbar MRI (LMRI) with LLR for diagnosing LDH. Given the financial burden of MRI on the health system and its widespread use (3,5), this research seeks to determine whether LLR, being cheaper, easier, and faster, could be a viable alternative under specific conditions.

MATERIAL AND METHOD

From March 2022 to August 2023, a research study was conducted at the Niğde Ömer Halisdemir University Faculty of Medicine Training and Research Hospital, Department of Neurosurgery. This study aimed to evaluate the effectiveness of LLR in diagnosing LDH. Eligible patients included those who visited the clinic with lumbalgia/lumbosciatalgia symptoms and met the following criteria:

- Aged between 18 and 85 years.
- Gave consent to participate in the study.
- Underwent both LMRI and LLR within a one-month interval.
  - Had both LMRI and LLR records available in the Hospital's PACS (Picture archiving and communication system) system.
  - Experienced persistent back pain unresponsive to treatment or developed neurological deficits, and subsequently underwent an LMRI.
  - Were new patients previously treated with an LMRI, unresponsive to pain treatment, scheduled for surgery, and had an LLR to determine the surgical level.

The study did not involve additional tests beyond those indicated for patients' existing conditions. Thus, existing LMRIs and LLRs were analyzed. Also, demographic data were collected and anonymized.

Patients were excluded from the study if they had contraindications for MRI (e.g., metal implants, claustrophobia, pacemakers) or X-ray (e.g., pregnancy), or if they had undergone previous lumbar surgeries, suffered from lumbar vertebral fractures, had congenital or acquired lumbar spinal stenosis, lumbar scoliosis greater than 10 degrees, lumbar spondylolisthesis, Paget's disease, were undergoing long-term steroid therapy, had renal colic, or presented with inadequate or inappropriate imaging.

For adequate LLR, criteria ensured:

- Comprehensive visibility of the lumbar spine from T12/L1 to L5/S1.
- Clear display of superimposed structures including the greater sciatic notches, superior articulating facets, and both superior and inferior endplates.
- Adequate image penetration and contrast, emphasizing trabecular and cortical bones of lumbar vertebral bodies.

Anonymized LLRs were independently evaluated by two authors, focusing on disc findings between L2-3 and L5-S1, due to their clinical importance (10). Patients were grouped into three age categories (18-40, 41-65, 66-85 years), and further divided based on Body Mass Index (BMI) into three subgroups (<24.9, 25-29.9, >30), creating nine evaluation groups. Disc herniations were classified into five types: natural, bulging, protrusion, extrusion, and sequestration. Disc findings on LMRI were analyzed and compared with disagreements considered inaccurate (Figure 1).

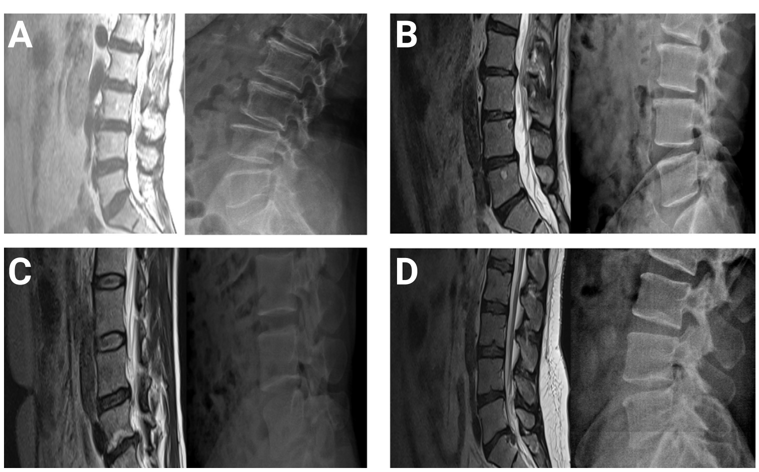

Figure 1. LMRI and LLR comparative examples of different types of disc herniation at various levels; although active digital dosing cannot be performed on the images following shows: **A.** LMRI and LLR showing bulging at L3-L4 and other natural levels; **B.** LMRI and LLR showing protrusion at L2-L3, bulging at L4-L5, and other natural levels; **C.** LMRI and LLR showing extrusion at L5-S1 and other natural levels; **D.** LMRI and LLR showing sequestration at L5-S1 and other natural levels

In LLRs, we classified and assessed slight bulging as "bulging", further protrusion as "protrusion", sagging without detachment from the disk space either superiorly or inferiorly as "extrusion", and the separation of the fragment as "sequestration" (Figure 1).

LMRIs were conducted using a 1.5-Tesla device (Magnetom Aera, Siemens, Germany), and LLRs with a digital X-ray device (Jumong, Sghealthcare, South Korea). Radiological measurements were utilized with the KarMed PACS. Data analysis was performed using SPSS (ver: 22.0) and Microsoft Excel (version 17), with Photoshop CS3 and Microsoft PowerPoint (version 17) for image editing.

Statistical Analysis

The study began with demographic data distribution analyses. LLRs effectiveness was evaluated through specificity, sensitivity, positive and negative predictive values, and test validity calculations. Data normality was assessed, and variables were presented as means±standard deviation. Nonparametric tests like the Kolmogorov–Smirnov and Wilcoxon tests were used. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

In this study, 436 patients were evaluated, consisting of 248 females (56.8%) and 188 males (43.2%). The analysis revealed no significant correlation between gender and the presence of disc findings in LLRs or across BMI groups (p>0.05).

The age distribution of the patients ranged from 18 to 75 years. The median age was 44, with an average age of 44.69 and a standard deviation of 13.44 (Figure 2). Statistical analysis showed no significant correlation between age and the presence of disc findings in LLRs or BMI groups (p>0.05).

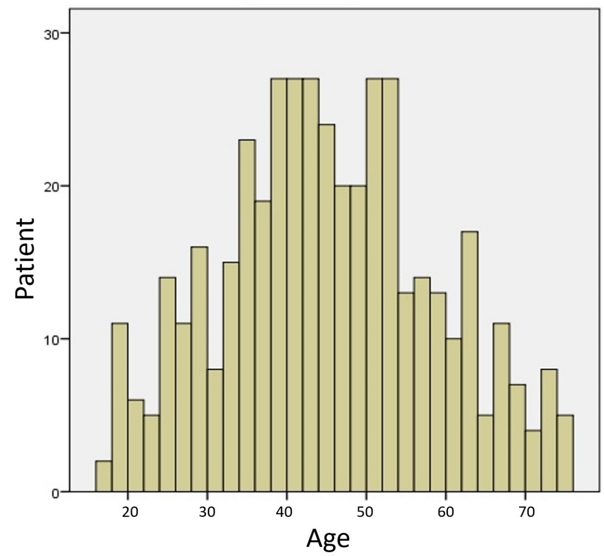

Figure 2. Age distribution histogram

The BMI of the patients varied from 14.69 to 48.89, with an average BMI of 27.77 and a median of 27.61. There was no significant correlation found between BMI and the presence of disc findings in LLRs (p>0.05).

In the cohort, a total of 1744 spinal levels were examined. The findings indicated that 1124 levels (70.18%) showed no pathologic disc involvement, while 520 levels (29.81%) exhibited pathologic disc findings. The breakdown of these findings was as follows: 40 levels (2.29%) at L2-L3, 96 levels (5.50%) at L3-L4, 214 levels (12.21%) at L4-L5, and 171 levels (9.80%) at L5-S1. Of these, 45 cases (2.58%) were identified as requiring surgical intervention for LDH (Table 1). Notably, a significant correlation was observed at the L5-S1 level and a lesser correlation at the L4-L5 level for inaccurate or inadequate disc findings in LLRs (p<0.05) (Table 2).

Table 1. Table showing the distribution of the examined levels according to the investigated factors.

	BMI* ≤24.9		BMI 25-29.9		BMI ≥30		Overall	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Pathological discs with L2-L3 level**	7	1.39%	19	2.81%	14	2.47%	40	2.29%
Pathological discs with L3-L4 level**	24	4.77%	37	5.47%	35	6.19%	96	5.50%
Pathological discs with L4-L5 level**	58	11.53%	83	12.27%	72	12.74%	214	12.21%
Pathological discs with L5-S1 level**	53	10.53%	68	10.05%	50	8.84%	171	9.80%
Levels requiring surgery***	16	3.18%	13	1.92%	16	2.83%	45	2.58%
All levels observed with LDH****	142	28.23%	207	30.62%	171	30.26%	520	29.81%
All levels without LDH	361	71.76%	469	69.38%	394	69.73%	1224	70.18%
All levels examined	503	28.84%	676	38.76%	565	32.39%	1744	100%

*Body mass index; ** Disk herniations at this level include bulging, protrusion, extrusion, and sequestration; *** Disk herniations at every level including extrusions and sequestrations require surgery; **** Disk herniations at every level include bulging, protrusion, extrusion, and sequestration; LDH: lumbar disc herniation

Table 2. Statistics results*

BMI**	L2-L3 level	L3-L4 level	L4-L5 level	L5-S1 level
≤24.9	0.157	1.000	0.751	0.105
25-29.9	0.141	0.785	0.050	0.009
≥30	1.000	0.180	0.129	0.176
Overall	0.071	0.476	0.021	0.002

* Samples related to the study were analyzed using the Wilcoxon signed-rank test, one of the nonparametric tests; the significance level for the test values was set at p<0.05, with a confidence interval of 95%; ** Body mass index

Among the levels assessed, 70.18% showed no pathologic disc changes, 14.63% exhibited bulging, 11.75% exhibited protrusion, 2.52% exhibited extrusion, and 0.91% exhibited sequestration. Accuracy rates in identifying these conditions were 97.78% in levels with no pathologic disc findings, 94.34% in bulging, 89.76% in protrusion, 79.1% in extrusion, and 76.25% in sequestration.

The overall diagnostic performance of LLR was evaluated, revealing a sensitivity of 94%, specificity of 95%, a positive predictive value of 88%, a negative predictive value of 97%, and an overall test validity of 94% (Table 3).

Table 3. Evaluation of LLR* in the diagnosis of LDH**

	BMI*** ≤24.9	BMI 25-29.9	BMI ≥30	Overall
Sensitivity	93%	94%	94%	94%
Specificity	95%	94%	95%	95%
Positive predictive value	88%	86%	90%	88%
Negative predictive value	97%	97%	97%	97%
Test validity	95%	94%	95%	94%

* Lumbar lateral radiography, ** Lumbar disc herniation, *** Body mass index

Additionally, there was a high degree of agreement between evaluators in analyzing LLRs, with a concordance rate of 96.7% across 1687 spinal levels from a total of 1744.

DISCUSSION

LDH is a multifactorial condition influenced by genetic, inflammatory, traumatic, and nutritional factors (6). Affecting primarily the 20-40 age group worldwide, it is increasingly observed in younger individuals due to paravertebral muscle weakness and weight gain as a result of a sedentary lifestyle brought about by technological advancements (11,12). In fact, LDH accounts for two-thirds of all general practitioner consultations for ambulatory patients (8). These conditions pose significant economic challenges due to lost work hours and the costs associated with diagnosis and treatment (3,13). In this study we conducted a comparative analysis to determine the extent to which LLR could fulfill a significant portion of the needs typically addressed by the more costly LMRIs. Apart from three articles that did not directly investigate this specific issue, there is no other study in the literature addressing this comparison (7-9).

Our findings indicated that the gender distribution in our study mirrors the general population (14), with a slight female predominance. This aligned with previous researches (15-18) suggesting that women may experience low back pain more intensely. However, gender did not significantly influence the need for surgical intervention (p>0.05).

The age distribution of our study population aligned with general epidemiological data (Figure 2) (11,12). The absence of a significant correlation between age, and disc findings in LLRs, or BMI groups may be attributed to our selection criteria, which excluded many age-related conditions like previous lumbar surgeries, lumbar vertebral fractures, acquired lumbar spinal stenosis, lumbar scoliosis more than >10 degrees, lumbar spondylolisthesis, long-term steroid therapy. Yet, these exclusions should not substantially affect our findings, as these conditions represent a small portion of the general population requiring more detailed investigations than X-ray.

One notable finding was the minimal impact of BMI on the diagnosis of LDH from LLRs. Despite X-ray imaging quality typically decreasing with increased tissue thickness, modern X-ray devices with automatic dosing and digital enhancements allowed for successful imaging across all BMI groups.

On the contrary, a drop in LLR accuracy rate was observed at certain spinal levels, particularly at the L5-S1 and, to a lesser extent, L4-L5 levels. This was mainly due to the overlapping shadow of the iliac wings. Hence physicians must be alert to artifacts from superimposed tissues and spinal axis disorders, which result from the two-dimensional structure of X-rays.

When we shift our focus to the types of LDH, we found that the distribution of herniation types were consistent with that in the general population (19). Although detecting sequestered and extruded herniations on LLR was more challenging, most of these cases were located at the L4-L5 and L5-S1 levels, where the iliac wings often obscure imaging. Even so, the rate of detecting these herniations on LLRs was not less than 76.25%. When the factor of level is excluded, the predictive accuracy of LLR was in the 90th percentile (Table 3). Given the relatively low prevalence of these types of LDH, their presence did not significantly diminish the utility of LLR (Table 3). Additionally, the clinical severity and high likelihood of neurological deficits in these patients generally necessitate more advanced diagnostic tools. Therefore, greater caution should be exercised in complex cases.

In our comparative analysis between LLRs and LMRI, we observed high success rates. reliability of the study was further enhanced by the fact that both evaluators provided highly similar results, and the mismatched results were scrutinized among the inaccurate levels.

According to the literature and our data, although LDH is a financially burdensome disease that diminishes quality of life (1,2,13), it is inherently prone to spontaneous regression (6), rarely leads to morbidity, and seldom requires surgery (3,6,13). As demonstrated in our study, LLRs are capable of diagnosing the vast majority of patients. In their detailed analysis, Jarvik and Deyo revealed that 95% of lower back pain originates from benign processes (20). They stated that only 0.7% of patients presenting to primary healthcare with a diagnosis of lumbago had undiagnosed metastatic neoplasms, 0.01% had pyogenic and granulomatous discitis, epidural abscess, or viral processes including spinal infections, and 0.3% suffered from non-infectious inflammatory spondyloarthropathies such as ankylosing spondylitis (20). They also found that osteoporotic compression fractures were identified as the most common etiological factor in only 4% of cases (20). The authors emphasized that the vast majority of these patients indeed recovered, many had musculoskeletal injuries or sprains, and up to 85% of patients had nonspecific degenerative phenomena for which no definitive diagnosis can be made (20).

At this stage, we need to mention the usage habits of advanced imaging techniques. Even when patients are examined using advanced imaging techniques, there is no evidence that these results lead to improved outcomes (21). Most spinal imaging is generally unnecessary and does not contribute to patient assessment, as our data also proved (21). Gilbert and colleagues' research highlighted the importance of using advanced imaging techniques such as Computed tomography (CT) or MRI in patients presenting with back pain only when there is a clear clinical indication (21). Similarly, Chou and his team concluded that LMRI does not improve clinical outcomes unless there are symptoms of a serious underlying condition for back pain (22). Carragee and colleagues conducted LMRI tests on asymptomatic individuals engaged in physically demanding jobs with a risk of back and leg pain and followed these patients periodically for five years (23). During this period, a second LMRI was performed when a subgroup of these subjects presented to the clinic with complaints of acute back or leg pain (23). However, less than 5% of the LMRIs performed for acute back or leg pain revealed clinically significant new findings (23). The authors emphasized that the degree of functional disability resulting from back and/or leg pain is a better indicator than morphological imaging results (23). For clinicians and patients, the value of advanced imaging techniques like MRI and CT emerges only when they facilitate the diagnostic process, rule out certain malignant conditions, or provide opportunities for evidence-based therapeutic interventions (24). These techniques can play a critical role in elucidating complex medical conditions and in developing treatment plans for specific diseases (23). Especially in cases where diagnosis is challenging and specific treatment strategies need to be determined, the use of these techniques is particularly valuable (23). These findings underscore the importance of preventing unnecessary imaging in the treatment of back pain.

Finally, in today's digital X-ray technology, radiation exposure has been significantly reduced (25). Even its contraindications have become relative (25). Moreover, X-ray imaging cost is incomparably lower than any other medical imaging technique (8). Through the use of advanced digital X-ray devices and appropriate techniques, we have achieved comparable results in our clinical practice, as evidenced by our data.

During our studies, we have gained significant experience related to the topic, which also we would like to share. X-ray imaging offers a broader perspective than MRI, enabling us to quickly and economically make accurate decisions. There are important cases on the subject. Firstly, although it does not provide information about disc spaces because of angles, it is indispensable in diagnosing and monitoring scoliosis. X-ray images are also extremely useful in demonstrating degeneration. Similarly, they are essential in the follow-up of ankylosing spondylitis. Also evaluating metallic implants, X-ray images are the most important modality. Even though LLR does not directly provide side information about LDH, it is possible to infer the side based on the bending caused by muscle spasms observed in anterior-posterior radiographs and through physical examination.

In light of all this information, our paper concludes that, except for patients with contraindications, an LLR should first be performed in every case. For patients without red flag signs (6) (Table 4) and no additional pathology found in the LLR, we recommend management with appropriate muscle relaxant medical therapy, rest, and psychosocial support. For patients without red flag signs (6) (Table 4) and pathology found in the LLR, we recommend continuing follow-up and treatment according to the pathology and physical examination findings. In patients with red flag signs (6) (Table 4), advancement to further investigation is recommended based on LLR and physical examination findings. For those managed with muscle relaxant medical therapy, rest, and psychosocial support who do not respond to treatment, it is advised first to check treatment compliance and then, if compliance is confirmed, proceed to further investigation if not ensure treatment compliance. In those who have contraindications to X-ray imaging, if there are red flag signs (6) (Table 4) according to the current follow-up and treatment protocol (6), further investigation and treatment is required according to physical examination findings if not appropriate muscle relaxant medical therapy, rest, and psychosocial support should be provided. For those managed with muscle relaxant medical therapy, rest, and psychosocial support who do not respond to treatment, it is advised first to check treatment compliance and then, if compliance is confirmed, proceed to further investigation if not ensure treatment compliance. Current practice suggests monitoring patients without red flag signs (6) (Table 4), for about a month (Figure 3) (6). Although sources indicate that this does not lead to significant time loss (8), diagnosing many pathologies without delay using an inexpensive imaging method like LLR is not only cost-effective but also undeniably beneficial for patients.

Table 4. Table showing "Red flags" (5) for patients with low back problems

Condition	Red flags
Cancer or infection	Age>50 or <20 years
	History of cancer
	Unexplained weight loss
	Immunosuppression
	Urinary tract infection, intravenous drug abuse, fever, or chills
	Back pain has not been improved with rest
Spinal fracture	History of significant trauma
	Prolonged use of steroids
	Age>70 years
Cauda equina syndrome or severe neurologic compromise	Acute onset of urinary retention or overflow incontinence
	Fecal incontinence or loss of anal sphincter tone
	Saddle anesthesia
	Global or progressive weakness in the lower extremities

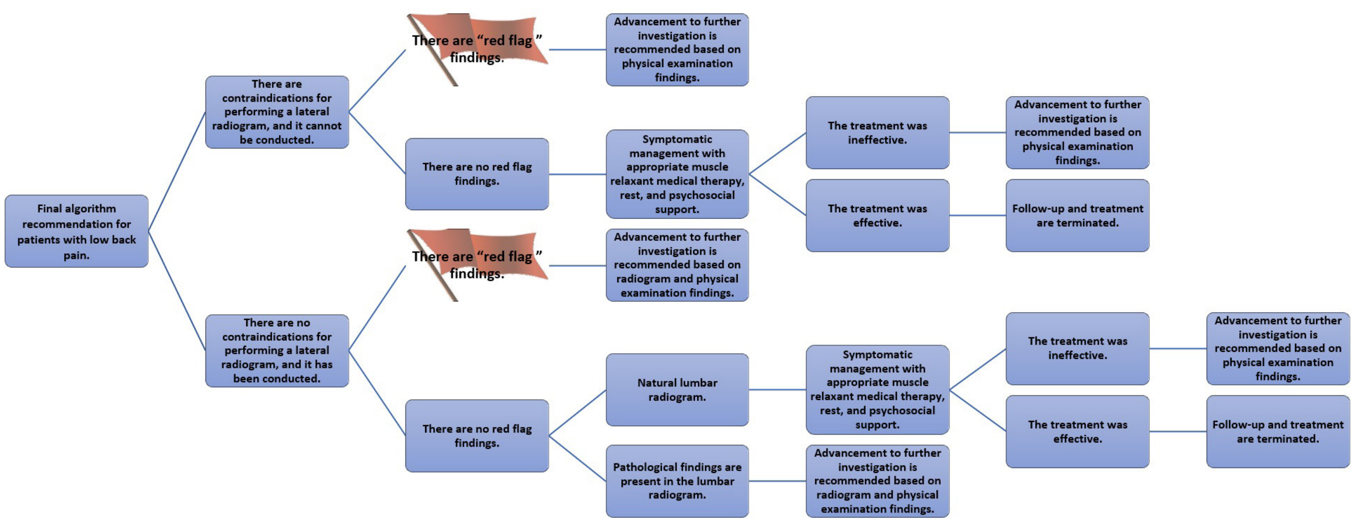

Figure 3. Final algorithm

CONCLUSION

Overall, our study concludes that LLR achieves a diagnostic success rate comparable to LMRI for most LDH cases. Notably, it is crucial to employ LLR even in patients presenting with "red flag" signs. This practice enables a prompt transition to more comprehensive investigations if needed. LLR stands out as a cost-effective and rapid diagnostic alternative in the assessment of LDH. Nonetheless, it is important to acknowledge that MRI continues to be indispensable in more complex cases or for patients exhibiting specific clinical symptoms.

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Conflict of interest: *The authors have no conflicts of interest to declare.*

Ethical approval: *Study was conducted in accordance with the Helsinki Declaration of 1975 (as revised in 2004 and 2008). Patient consent forms were archived at Niğde Ömer Halisdemir University Hospital. The study received approval from the institutional non-interventional clinical research ethics committee (2022-21).*

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