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Diagnostic Accuracy of Magnetic Resonance Imaging versus Computed Tomography for Lumbar Spondylolysis in Patients with Chronic Low Back Pain: A Single-Center Retrospective Study

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Abstract

Purpose

The objective of this study is to compare the diagnostic efficacy of Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) in detecting lumbar spondylolysis among patients presenting with chronic low back pain, and to determine the rate of missed diagnoses when MRI is reported as "normal".

Methods

Radiological images of 2,104 patients who presented with chronic low back pain between December 2024 and December 2025 and underwent simultaneous lumbar CT and MRI were retrospectively reviewed. The study group comprised 67 patients diagnosed with spondylolysis based on CT findings, which served as the gold standard. Demographic characteristics, affected spinal levels, presence of degeneration, and MRI findings (classified as no findings, suspicious findings, or definitive findings) were analyzed.

Results

The prevalence of spondylolysis in the screened population was 3.18%. The mean age of the study cohort was 46.7 ± 11.2 years, with a female predominance (71.6%). The most frequently affected level was L5-S1 (82.1%). In the retrospective MRI evaluation of patients with a definitive CT diagnosis, 41.8% exhibited no pathological signal alterations (such as edema or fracture lines) in the pars interarticularis. Furthermore, an analysis of the hospital registry revealed that the diagnosis of spondylolysis was completely missed (100%) in all routine MRI reports. The rate of missed diagnosis on MRI was significantly higher in younger patients without degenerative changes (51%) compared to those with concomitant degeneration (31%).

Conclusion

Routine MRI evaluations yield a high rate of false-negative results in the diagnosis of lumbar spondylolysis. A "normal" MRI report is insufficient to rule out spondylolysis, particularly in younger patients lacking degenerative changes. In cases where clinical suspicion persists, CT imaging must be incorporated into the diagnostic algorithm.

INTRODUCTION

Spondylolysis is defined as a unilateral or bilateral bony defect in the pars interarticularis of the vertebra. Anatomically, the pars interarticularis represents the junction point of the pedicle, articular facets, and lamina [1].

With an estimated prevalence ranging from 3% to 6% in the general population, spondylolysis is recognized as a leading cause of low back pain among pediatric and adolescent athletes [2]. Although the majority of cases remain asymptomatic, defects in the pars interarticularis can progressively lead to spondylolisthesis, eventually causing radicular symptoms and severe functional impairment [3].

While there is no universally established single imaging gold standard for the diagnosis of spondylolysis, the diagnostic approach should aim to maximize clinical yield while minimizing radiation exposure, carefully weighing the risks and benefits of plain radiography, computed tomography (CT), single-photon emission computed tomography (SPECT), and magnetic resonance imaging (MRI) [4]. Radiographic diagnosis is frequently achieved using lateral and oblique spinal radiographs or CT. Nuclear medicine modalities, particularly SPECT scans, can be utilized to differentiate between acute and chronic spondylolytic lesions [5].

MRI is frequently requested by clinicians for the evaluation of individuals with low back pain and has largely replaced plain radiographs as the "first-line" imaging modality in many settings [6]. However, literature indicates that up to 30% of spondylolysis cases diagnosed via CT may be missed on MRI [7]. Conversely, although CT is regarded as the "gold standard" for imaging the bony anatomy of the neural arch and demonstrating the presence of complete or incomplete lysis, MRI exhibits higher sensitivity in detecting early-stage stress or overload-induced alterations at the pars level [8].

Therefore, a comparative evaluation of the recognizability of spondylolysis on MRI and CT in patients with chronic low back pain is of clinical significance to determine the diagnostic adequacy of MRI and to establish the most appropriate imaging paradigm [9].

MATERIALS AND METHODS

Study Design and Ethical Approval:

This single-center, retrospective cohort analysis reviewed the medical records and radiological images of patients who presented to the Physical Medicine and Rehabilitation outpatient clinic of Karabuk Training and Research Hospital with complaints of chronic low back pain between December 2024 and December 2025. The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of Karabuk University Faculty of Medicine (Approval No: 2568), with all procedures complying with the Declaration of Helsinki guidelines. The primary inclusion criterion was the availability of concurrent (or closely dated) lumbar Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scans in the hospital's database.

Data Collection and Evaluation Parameters:

Out of the 2,104 patients screened during the study period, 67 (3.1%) with a radiologically confirmed diagnosis of lumbar spondylolysis were included in the study cohort. Patient data were retrieved via the hospital information system and the Picture Archiving and Communication System (PACS).

All MRI examinations included in the study were performed using a 1.5-Tesla scanner utilizing standard lumbar spine protocols (T1-weighted, T2-weighted, STIR, and fat-suppressed sequences).

The retrospective analysis of the radiological images was conducted by a single specialist radiologist with 10 years of experience in musculoskeletal imaging. To minimize diagnostic bias, a stepwise evaluation protocol was employed. In the initial phase, the radiologist evaluated the MRI scans of the 2,104 patients while blinded to the CT results, specifically noting any signal alterations at the pars interarticularis . In the subsequent phase, the CT images of all patients were reviewed to establish the definitive diagnosis and determine the anatomical level of spondylolysis.

For each patient, demographic characteristics (age, gender) and the following radiological parameters were documented:

1. **Level and Laterality:** The vertebral level of the defect and its localization (unilateral or bilateral).
2. **Classification of MRI Findings:** MRI signs indicative of spondylolysis were categorized into three groups:
    - **No Findings:** Absence of pathological signal changes in the pars interarticularis.
    - **Suspicious Findings:** Signal alterations consistent with bone marrow edema and stress reaction at the corresponding level.
    - **Definitive Findings:** Clear visualization of a fracture line at the affected pars interarticularis.
3. **Degenerative Changes:** The presence of lumbar degeneration was dichotomously classified as 'present' or 'absent' based on findings such as vertebral body irregularities, osteophyte formation, and narrowing of the intervertebral disc space.

Pars interarticularis lesions observed on MRI were graded according to the classification system proposed by Hollenberg et al. [10], which is based on the presence of bone marrow edema and fracture lines. The staging was defined as follows:

- **Stage 0 (Normal):** Normal pars interarticularis with no signal alterations on MRI.
- **Stage 1 (Stress Reaction):** Presence of bone marrow edema with intact cortical integrity.
- **Stage 2 (Incomplete Stress Fracture):** Bone marrow edema accompanied by an incomplete cortical fracture or fissure.
- **Stage 3 (Acute Complete Fracture):** Full-thickness cortical fracture extending across the pars interarticularis, associated with bone marrow edema.
- **Stage 4 (Chronic Fracture):** Full-thickness fracture line across the pars interarticularis without accompanying bone marrow edema (no signal change).

For the purposes of statistical analysis and clinical correlation, these stages were collapsed into three main categories: Stage 0 cases were classified as the "Normal group with no spondylolysis findings,"

Stage 1 and 2 cases as "Suspicious spondylolysis findings," and Stage 3 and 4 cases as "Definitive spondylolysis findings."

During the study period, a retrospective screening was conducted on 2,104 patients who presented to our outpatient clinic with chronic low back pain and met the inclusion criteria (availability of concurrent lumbar CT and MRI scans). Based on the CT imaging, which served as the gold standard, lumbar spondylolysis was identified in 67 out of the 2,104 patients, yielding a prevalence of 3.18%.

The cohort of 67 patients diagnosed with spondylolysis consisted of 48 females (71.6%) and 19 males (28.4%). The mean age of the participants was 46.7 ± 11.2 years (range: 20–74 years).

Radiological assessments indicated that the vast majority of pars interarticularis defects were bilateral and most frequently affected the L5-S1 level. Single-level involvement was observed in 91.0% (n=61) of the cases, whereas multi-level involvement was present in 9.0% (n=6).

Evaluation of vertebral alignment in the affected patients demonstrated that 18 cases (26.9%) had concomitant Grade 1 spondylolisthesis accompanying the pars defect. The remaining 49 patients (73.1%) showed no evidence of listhesis. A detailed summary of the anatomical distribution and demographic characteristics is provided in Table 1.

Table 1. Demographic and Radiological Characteristics of the Patients with Spondylolysis

Characteristic	Count (n=67)	Percentage (%)
Gender		
Female	48	71,6
Male	19	28,4
Defect Laterality		
Bilateral	63	94,0
Unilateral	4	6,0
Level of Involvement		
Single-Level Involvement	**61**	**91,0**
L5-S1	55	82,1
L4-L5	4	6,0
L3-L4	2	3,0
Multi-Level Involvement	**6**	**9,0**
L4-L5 and L5-S1	4	6,0
L3-L4 and L5-S1	1	1,5
L3-L4, L4-L5 and L5-S1	1	1,5

Comparison of Imaging Modalities The MRI findings of the 67 patients with a definitive CT-confirmed diagnosis of spondylolysis were further analyzed. Retrospective clinical evaluation of the MRI slices revealed "suspicious findings" indicative of edema and stress reaction in 44.8% (n=30) of the patients, and a "definitive fracture line" in 13.4% (n=9). Notably, in 41.8% of the cases (n=28), no pathological signal alterations were detected in the pars interarticularis region on MRI.

However, a review of the routine institutional radiology reports demonstrated a 100% miss rate, as the diagnosis of spondylolysis was overlooked in all MRI reports. Strikingly, 94.0% (n=63) of the corresponding CT reports were also finalized as normal in the routine workflow.

A statistically significant association was observed between patient age and the presence of degenerative changes ($p < 0.001$). The mean age of the group exhibiting degenerative findings (54.0 ± 8.6 years) was significantly higher compared to the cohort without degeneration (40.1 ± 10.5 years) (Table 2).

Table 2. Age Distribution According to the Presence of Degeneration

Degeneration Status	Count (n)	Mean Age (Year)	Standart Deviation	Min - Max	p value*
Absent	35	40,1	10,5	20 - 64	**< 0,001**
Present	32	54,0	8,6	40 - 74	

Conversely, no statistically significant correlations were found between gender and the presence of degenerative changes (p=0.755), nor between gender and the laterality (unilateral vs. bilateral) of the defect (p=1.000).

DISCUSSION

The primary objective of this study was to comparatively evaluate the diagnostic reliability of MRI in detecting lumbar spondylolysis against CT, the established gold standard, in patients presenting with chronic low back pain. The most salient finding of our research is that MRI findings were evaluated as completely "normal" in nearly half (41.8%) of the patients who had a definitive pars defect confirmed by CT. Despite the superior soft-tissue resolution of MRI and its high efficacy in detecting bone marrow edema, it was found to be inadequate in visualizing "silent" fracture lines where cortical bone integrity is compromised without an accompanying active stress reaction [11]. Consequently, diagnostic processes relying solely on MRI lead to a high rate of false-negative results and missed diagnoses [12].

Beyond its comparative diagnostic scope, our study also serves as a comprehensive prevalence investigation, screening the imaging modalities of 2,104 patients. Within this extensive cohort of patients presenting with chronic low back pain, the prevalence of CT-confirmed spondylolysis was determined to be 3.18%. This figure is consistent with the 3-6% range reported in the literature for the general population [13]. However, a striking observation in our study was that despite analyzing a symptomatic group, 100% of these cases were overlooked in routine MRI reporting. Had these patients not been retrospectively verified via CT, the actual prevalence of 3.18% would have been erroneously reported as significantly lower. This finding suggests that the true incidence of spondylolysis might be underestimated in MRI-only screening protocols. Recent literature indicating MRI false-negative rates of up to 41% further corroborates the data obtained in the current study [9].

Although pathological signals (edema or fracture lines) were detectable on MRI in 58.2% of the cases during our retrospective evaluation, it is remarkable that the diagnosis was missed entirely (100%) in the routine hospital radiology reports. This phenomenon can be elucidated by the concept of 'Inattentional Blindness' in radiology [14]. When radiologists focus primarily on more prominent pathologies such as disc herniations and spinal canal stenosis in routine practice, minor edema signals or cortical irregularities in a highly specific anatomical region like the pars interarticularis often go unnoticed. The fact that these findings became 'invisible' in the routine workflow, contrary to our CT-guided retrospective scrutiny, underscores the critical importance of clinical suspicion and radiologist awareness.

Clinically and radiologically, MRI and CT represent opposite ends of the spondylolysis spectrum. While MRI excels at demonstrating early-stage stress reactions and edema (the pre-spondylolytic phase), it possesses inherent technical limitations in visualizing an established fracture line (the pseudoarthrosis phase), as evidenced by our study [15]. In our cohort, a distinct fracture line—defined as a "definitive finding" on MRI was observed in only 13.4% of the patients. In the vast majority of the group, MRI either yielded only non-specific edema signals or remained completely silent. This technical blindness can be attributed to the fact that the defect in the pars interarticularis occurs within the cortical bone, and MRI is substantially less sensitive than CT in acquiring signals from cortical osseous structures [16].

Another significant finding of our study is the inverse relationship between the presence of degenerative changes and diagnostic success. Contrary to expectations, the rate of missed diagnoses on MRI was notably higher in younger patients without degeneration (51% of patients) compared to the cohort with degenerative changes (31% of patients). While secondary findings such as facet joint hypertrophy or sclerosis might serve as alerting signs for the radiologist in the presence of advanced age and degeneration, the "clean" appearance of the spine in younger patients may facilitate the oversight of an isolated pars defect. This emphasizes that even in the face of a normal MRI—particularly in risk groups with "healthy-looking" spines such as young athletes and adolescents—clinical suspicion must be maintained, and CT imaging must be integrated into the diagnostic process if corresponding clinical history and physical examination findings are present [4].

One of the most striking findings of our study is that 94% of the CT reports, which is considered the gold standard imaging modality for spondylolysis, were reported as normal by the radiologists in the routine clinical workflow. This paradox can be largely attributed to the radiological phenomena known as 'Satisfaction of Search' (SoS) and 'Inattentional Blindness' [14]. In routine practice, radiologists primarily focus on identifying disc herniations, spinal canal stenosis, or gross degenerative changes, which are the most common causes of chronic low back pain. Once a degenerative pathology or disc bulging is identified, the search for secondary or less common bony pathologies, such as a pars interarticularis defect, is often prematurely terminated [15]. Furthermore, the complex anatomical orientation of the pars interarticularis may cause the defect to blend with the adjacent facet joints on routine axial slices, unless specifically reformatted parasagittal or oblique views are actively scrutinized [17]. Our findings strongly suggest that without a specific clinical suspicion or a direct request from the clinician to rule out spondylolysis, radiologists may overlook pars defects, evaluating the images solely through the lens of degenerative disc disease.

In conclusion, MRI remains a valuable first-line investigation for ruling out disc and soft-tissue pathologies in patients presenting with chronic low back pain [18]. Nevertheless, our results establish that a normal MRI scan is insufficient to rule out spondylolysis. In patients with a clinical history and physical examination raising suspicion of spondylolysis but possessing a normal MRI report, CT imaging ideally utilizing low-dose protocols to mitigate radiation risk—can be a crucial component of the diagnostic algorithm.

Limitations of the Study Certain limitations should be acknowledged when interpreting the results of our study. First, the retrospective and single-center design may restrict the generalizability of our findings to the broader population. Second, the strict inclusion criterion requiring the simultaneous availability of both CT and MRI scans inherently limited the sample size (n=67). A third, technical limitation is that the reviewed MRI images were acquired using standard lumbar spine protocols. Novel "MRI Bone Imaging" sequences, which have recently emerged in the literature promising CT-like visualization of cortical bone, were not utilized in our study. However, this could also be perceived as a strength, as our study reflects "real-world data," given that these specialized sequences are not yet widely implemented in daily clinical practice.

CONCLUSION

In conclusion, routine lumbar MRI examinations alone are inadequate for diagnosing spondylolysis, a significant etiology in chronic low back pain. Our study demonstrates that standard MRI possesses low sensitivity in detecting defects of the pars interarticularis, and the risk of a missed diagnosis is markedly higher, particularly in younger patients lacking degenerative changes. Although MRI is the preferred initial modality due to radiation concerns, a "normal" MRI report does not guarantee the absence of spondylolysis. Therefore, in cases where clinical suspicion of spondylolysis persists based on physical examination and patient history, yet MRI findings are normal or equivocal, Computed Tomography the gold standard must be incorporated into the diagnostic algorithm utilizing low-dose protocols.

Declarations

Ethics approval and consent to participate The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Karabuk University Faculty of Medicine (Approval No: 2568). Due to the retrospective nature of the study, the need for informed consent was waived by the Non-Interventional Clinical Research Ethics Committee of Karabuk University Faculty of Medicine.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AT conceptualized the study design and methodology. ED performed the radiological evaluation of the imaging modalities and assisted in data collection. All authors read and approved the final manuscript.

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Authors' information

Not applicable.

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Figures

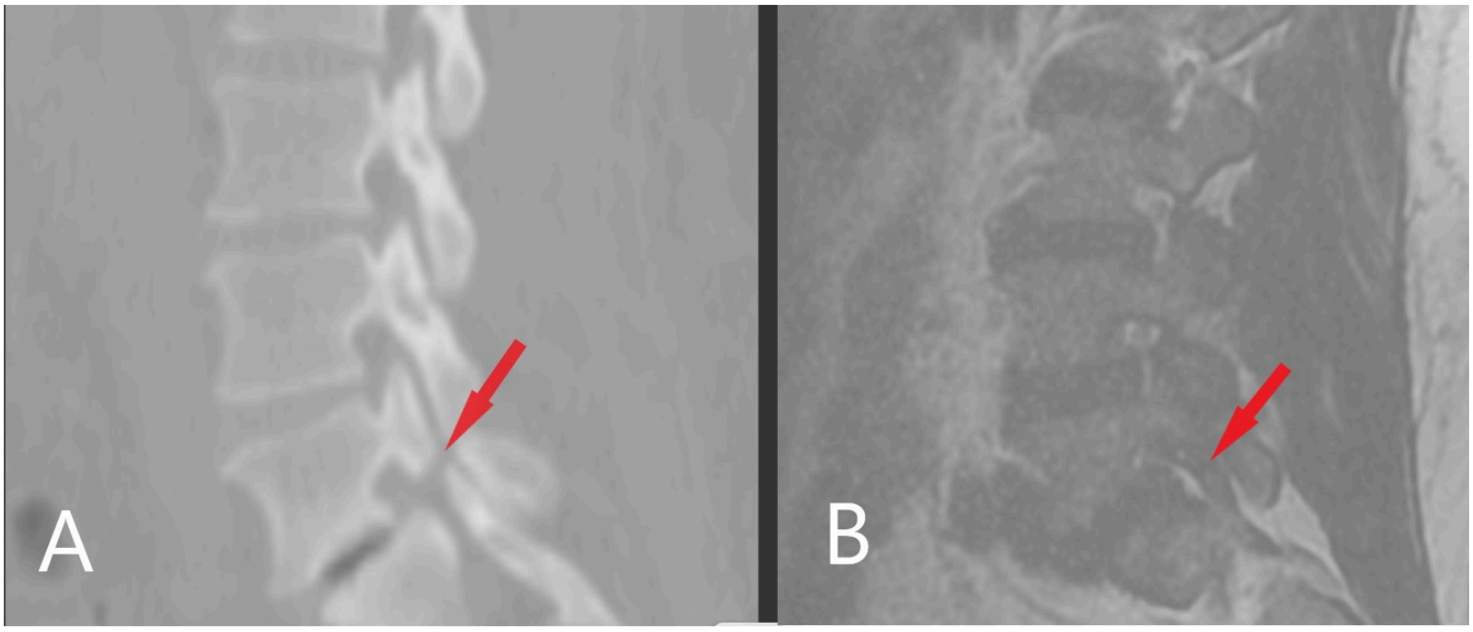


Figure 1

Radiological imaging of Patient 1. **(A)**CT scan demonstrating a fracture line at the pars interarticularis of the L5-S1 level. **(B)** MRI scan showing suspicious findings at the L5-S1 level, characterized by mild bone

marrow edema with preserved cortical integrity.

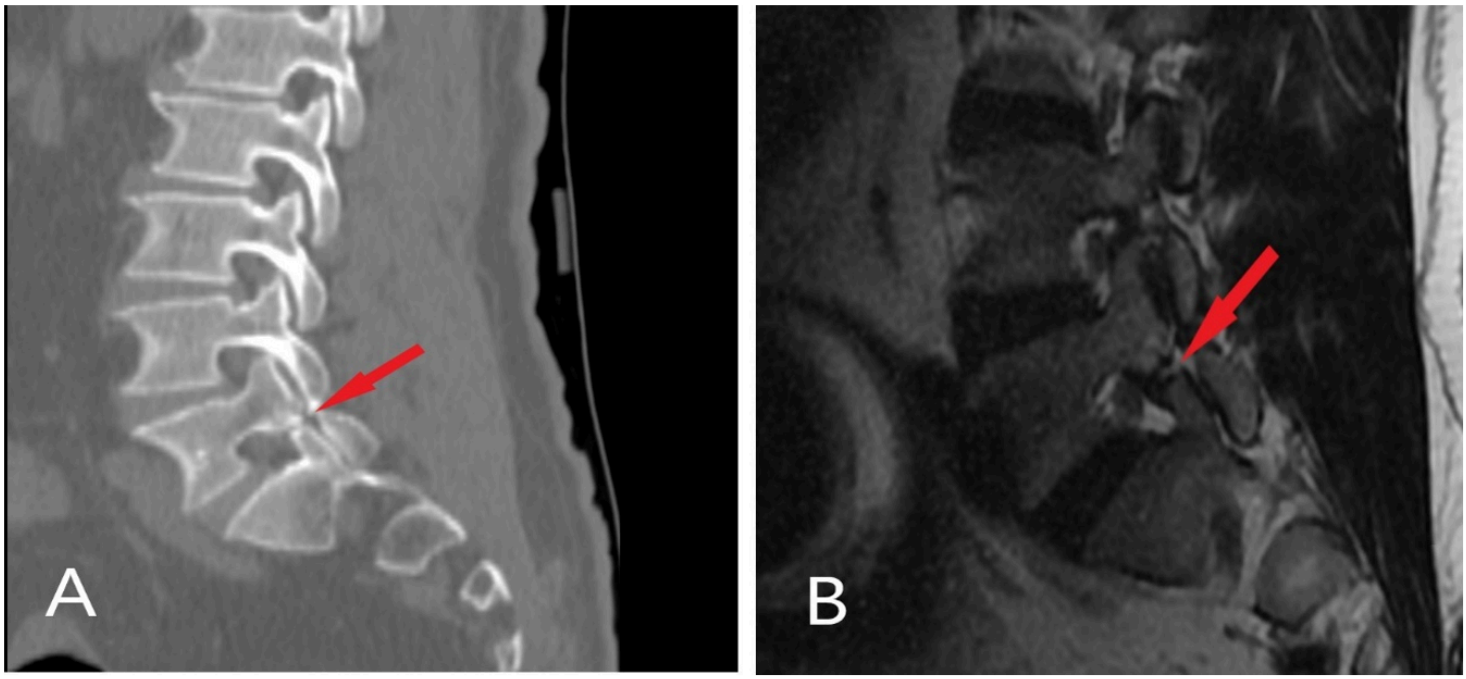


Figure 2

Radiological imaging of Patient 2. **(A)**CT scan demonstrating a fracture line at the pars interarticularis of the L5-S1 level. **(B)** MRI scan displaying definitive findings at the L5-S1 pars interarticularis, with a visible fracture line and loss of cortical integrity.