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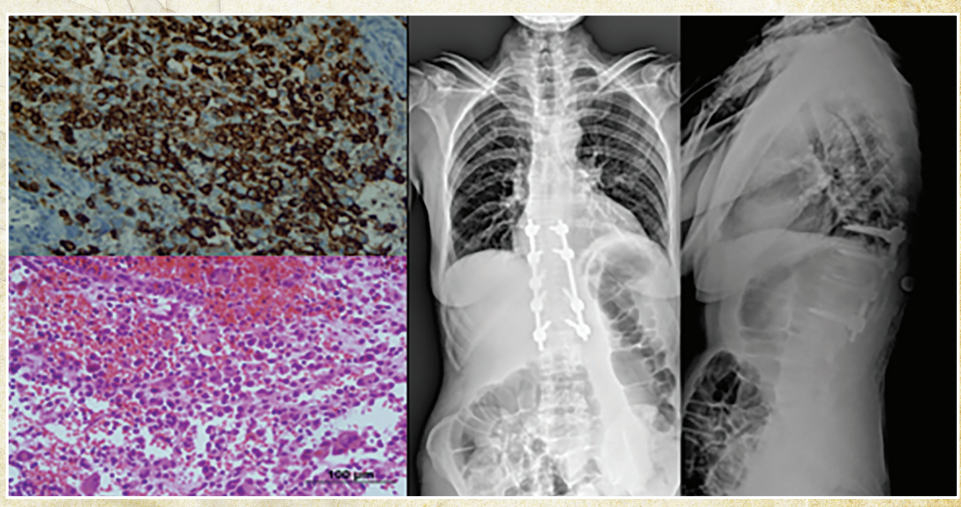

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JOURNAL OF TURKISH SPINAL SURGERY

EDITORIAL

Dear Colleagues,

We are pleased to present the new issue of the Journal of Turkish Spine Surgery, which continues to serve as a platform for sharing scientific knowledge and clinical experience in the field of spine surgery. In this issue, we bring together a total of seven valuable manuscripts, including six clinical studies and one case report, each contributing important insights into various aspects of spinal pathology and treatment.

The articles in this issue address a broad spectrum of spinal disorders, including spondylodiscitis, spinal tumors, degenerative spine diseases, and adolescent idiopathic scoliosis. These studies reflect the ongoing efforts of researchers and clinicians to better understand the diagnosis, management, and outcomes of complex spinal conditions. The inclusion of both clinical investigations and a case report provides readers with perspectives ranging from systematic analyses to unique clinical experiences.

One of the most gratifying aspects of this issue is the strong representation of contributions from both neurosurgery and orthopedics. Spine surgery has long been a field that benefits from the collaboration of these two disciplines. The coexistence of different perspectives, training backgrounds, and surgical philosophies enriches the scientific discussion and ultimately improves patient care. We are delighted to see this multidisciplinary spirit reflected in the manuscripts published in this issue.

We believe that the studies presented here will contribute meaningfully to the growing body of spine literature and stimulate further research and collaboration among spine specialists. On behalf of the editorial board, we would like to thank all authors for their valuable contributions and the reviewers for their careful evaluations and constructive feedback.

We hope that you will find this issue informative and inspiring.

Sincerely,

Co-Editor-in-Chief

Ender Köktekir, M.D.,

ORIGINAL ARTICLE

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MICROSCOPIC UNILATERAL LAMINOTOMY FOR BILATERAL DECOMPRESSION FOR LUMBAR SPINAL STENOSIS: DOES DRAIN DIAMETER MATTER? A RETROSPECTIVE COHORT STUDY

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ABSTRACT

Objective: Microscopic unilateral laminotomy for bilateral decompression (ULBD) is performed for symptomatic lumbar spinal stenosis in selected patients who do not require fusion. It is unknown whether a larger closed-suction drain improves postoperative drainage or early clinical outcomes after ULBD. We compared 12-French (12F) and 16-French (16F) drains after ULBD.

Materials and Methods: We retrospectively analyzed 49 consecutive patients who underwent microscopic ULBD performed by a single team between May and December 2023. Patients received either a 12F (n=25) or a 16F (n=24) closed-suction drain under a uniform perioperative protocol. The primary outcome was total drain output (mL). Secondary outcomes were change in pain [Δvisual analog scale (VAS)=preoperative minus postoperative VAS] and length of stay (LOS, days). Exploratory analyses assessed associations among drainage, ΔVAS, and patient or surgical variables. Group comparisons were performed using parametric or non-parametric tests, as appropriate; multivariable linear regression was used to evaluate independent predictors.

Results: Baseline demographics and clinical variables were similar between groups. No significant differences were observed between 12F and 16F drains in total output (p=0.607), ΔVAS (p=0.935), postoperative VAS (p=0.837), or LOS (p=0.448). Prior surgery (p=1.000), anticoagulant or antiplatelet use (p=0.909), and surgical level distribution (p=0.265) did not differ between groups. Surgical extent was the only variable associated with higher drainage on univariate analysis (p<0.001). Higher preoperative VAS predicted greater ΔVAS (Pearson's r=0.604, p<0.001). In multivariable models, preoperative VAS remained the principal predictor of ΔVAS, while drain size was not an independent predictor of output or pain improvement.

Conclusion: Upsizing closed-suction drains from 12F to 16F after microscopic ULBD did not reduce pain, shorten hospitalization, or change the total output. A 12F drain appears adequate for routine ULBD; surgical extent, rather than drain diameter, drives postoperative drainage volume.

Keywords: Microscopic lumbar decompression, drainage volume, surgical drains, postoperative bleeding

INTRODUCTION

Lumbar spinal stenosis commonly necessitates surgical decompression when symptoms persist despite conservative care. Microscopic unilateral laminotomy for bilateral decompression (ULBD) is a tissue-sparing decompression technique that preserves midline structures and limits dead space relative to open laminectomy. In clinical practice, ULBD is typically selected for patients with degenerative central and/or lateral recess stenosis without radiographic instability or deformity that would otherwise mandate fusion[1,2]. Even with meticulous hemostasis, postoperative epidural or paraspinal collections remain a concern, and many surgeons place closed-suction drains as a risk-mitigation strategy[3-5].

Whether drains meaningfully improve outcomes in lumbar surgery is debated. Prior studies in open procedures have reported inconsistent effects on hematoma, infection, transfusion, and length of stay, and there is no consensus on drain selection or management[3-7]. In minimally invasive decompression, the surgical corridor and residual cavity differ substantially from open surgery, so evidence from open cohorts may not generalize[6,7]. A specific, unaddressed question is whether drain caliber matters in ULBD: a larger tube could theoretically reduce residual clot by lowering flow resistance, yet flow in narrow cavities may instead be limited by tissue

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apposition, clot viscosity, or fenestration geometry rather than lumen diameter alone[3,6,7]. As a result, upsizing may add local irritation without improving evacuation.

The present retrospective cohort study evaluates two commonly used drain diameters, 12 French (12F) and 16 French (16F), in consecutive patients undergoing standardized microscopic ULBD by the same surgical team. The primary outcome was total drain output; secondary outcomes were change in pain intensity and hospital length of stay. We additionally explored whether patient and operative variables (for example, extent of decompression) predicted drainage volume or pain improvement. Our a priori hypothesis was that larger-caliber drains would not confer a clinically meaningful advantage in the ULBD setting. By focusing on a single technique, uniform perioperative care, and clearly defined outcomes, this study aims to address a practical question that has direct implications for routine postoperative management.

MATERIALS AND METHODS

Study Design and Patient Selection

This retrospective cohort study included 49 consecutive adult patients who underwent microscopic ULBD between May 2023 and December 2023. All patients had a clinical diagnosis of lumbar spinal stenosis (neurogenic claudication and/or radiculopathy) with radiologic confirmation and had persistent symptoms despite conservative management. Patients were selected for decompression-only surgery (i.e., ULBD without fusion) based on the operating team's routine preoperative evaluation, including the absence of clinical or radiographic instability or deformity that would otherwise mandate fusion. Patients were grouped based on the diameter of the postoperative closed-suction drain placed (12F or 16F) under a uniform perioperative protocol. Patients with single-level stenosis, spinal infection, tumor, prior lumbar instrumentation, or other indications requiring fusion were excluded.

Ethical Statement

Bahçeşehir University Institutional Review Board approved this retrospective file review (approval no: 2025-15/03, date: 15.12.2025). The Declaration of Helsinki is followed during the investigation. Before being enrolled in the study, each participant signed an informed consent form that had been authorized by the institutional review board. The signed informed consent form for this study includes approval to publish clinical and medical information. The patient gave written informed consent for her case to be included in research, allowing for the release of the patient's medical records and any related photos. Upon request, a copy of the permission form is provided.

Surgical Technique, Drain Types, and Postoperative Care

All surgeries were performed using a standard bilateral decompression via a unilateral approach under an operating microscope. After midline skin incision and paramedian fascial opening, the multifidus muscle was elevated and retracted to expose the ipsilateral lamina. Using Kerrison rongeurs and a high-speed burr, a laminotomy of the cephalad and caudal hemilamina was performed in a trumpeted fashion, facilitating ligamentum flavum removal and ipsilateral decompression. The microscope was then angulated medially to perform contralateral decompression beneath the interspinous ligament. At the end of the procedure, bipolar coagulation and hemostatic gel-foam were used for hemostasis, and a closed-suction drain was placed in the surgical bed.

Two types of surgical drains were used in this study:

- Closed-suction 12F redon drains (Figure 1A, right)
- Closed-suction 16F redon drains (B-Vak Wound Drainage System, Koç Medical, İstanbul, Türkiye) (Figure 1A, left).

Drain placement and management protocols were uniformly applied across all patients. Both systems used a 400 mL collection reservoir that was maintained under negative pressure per manufacturer instructions (reservoir fully compressed after closure and re-compressed after emptying). The reservoir was kept below the level of the surgical site during hospitalization. Drains were positioned 2 cm lateral and 2 cm superior to the surgical incision on the operative side and placed subfascially. Perioperative antibiotic prophylaxis followed our institutional standard for decompression surgery (cefazolin for 24 hours postoperatively) and was not extended solely because a drain was used. Patients were encouraged to mobilize as tolerated within the first postoperative day. Patients on anticoagulant therapy prior to surgery, and/or those with limited mobility, received low molecular weight heparin (4000 U) as thromboprophylaxis. Drain removal was indicated when output dropped below 100 mL over the preceding 24 hours or by postoperative day 2, whichever criterion was met

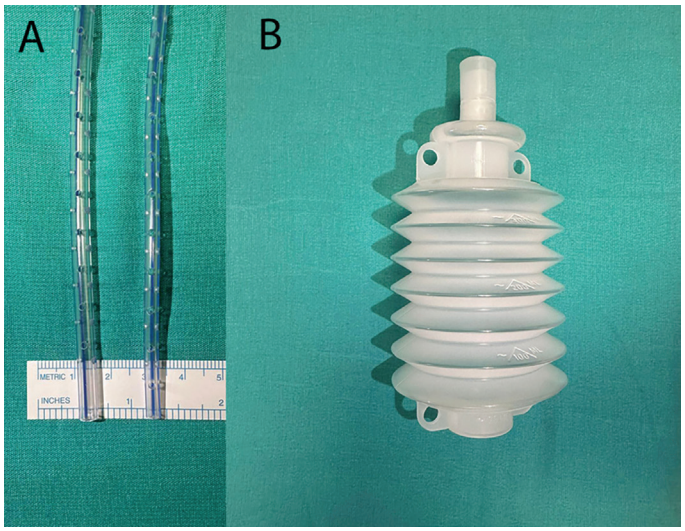

Figure 1. **(A)** The left specimen is a 16F drainage catheter, characterized by an outer diameter of 4 mm, while the right specimen is a 12F drainage catheter, featuring an outer diameter of 3 mm. **(B)** The closed drainage system is equipped with a drainage collection unit capable of accommodating a maximum volume of approximately 400 mL. 16F: 16 French, 12F: 12 French

first. Discharge was planned after mobilization and pain control criteria were met and the drain was removed, unless other medical reasons required longer observation.

Data Collection

For the study, a range of variables to evaluate the outcomes of patients undergoing lumbar surgery were collected. Demographic information included age, sex, and body mass index (BMI), while clinical parameters assessed the use of anticoagulant or antiplatelet drugs and any history of previous lumbar surgery. Surgical details focused on the number of decompressed levels and the size of the drain used. Outcomes were measured through preoperative and postoperative visual analog scale (VAS) scores, changes in VAS scores to determine pain reduction, total drain output measured in milliliters, and the length of hospital stay in days.

The preoperative VAS scores were obtained within 24 hours prior to the surgical intervention, while the postoperative VAS scores were recorded prior to the removal of the drainage. Between-group differences in change in the ΔVAS were defined as preoperative VAS minus postoperative VAS. Discharge day was counted as calendar days from the surgery date to discharge.

The primary endpoint of this study is the between-group difference in total drain output (measured in milliliters) between the 12F and 16F drainage systems. Key secondary endpoints include the ΔVAS scores and the day of discharge. Additionally, exploratory analyses will investigate potential predictors of bleeding, including age, BMI, surgical level, use of anticoagulants, and history of previous surgeries, as well as predictors of ΔVAS.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY). Normality of continuous variables was assessed with the Shapiro-Wilk test. Normally distributed variables were analyzed using independent samples t-tests; non-normally distributed variables were compared using Mann-Whitney U or Kruskal-Wallis tests. Categorical data were assessed using the chi-square or Fisher's exact test where appropriate.

Correlations were analyzed using Pearson or Spearman correlation coefficients, depending on distribution. Multivariate linear regression was used to assess independent predictors of drain output and pain reduction. Statistical significance was set at $p<0.05$.

RESULTS

A total of 49 consecutive patients who underwent microscopic lumbar microdecompression were included in the analysis. Table 1 shows the overall characteristics of the whole patient population. From these operated patients, 25 patients received a 12F drain, and 24 patients received a 16F drain.

Table 1. Overall characteristics and descriptive statistics of the patient population

	Descriptive statistics
Age	68.76±2.84
Gender	
Male	20 (40.82%)
Female	29 (59.18%)
BMI	29.00±1.54
Surgical levels	
2 levels	22 (44.9%)
3 levels	19 (38.78%)
4 levels	6 (12.24%)
5 levels	2 (4.08%)
Anticoagulant/platelet use	
No	30 (61.22%)
Yes	19 (38.78%)
Previous lumbar surgery	
No	45 (91.84%)
Yes	4 (8.16%)
Surgical drain size	
12F	25 (51.02%)
16F	24 (48.98%)
Preoperative VAS score	7.96±0.57
Postoperative VAS score	2.57±0.57
Total drainage (mL)	156.73±47.5
Discharge days	1.39±0.22

BMI: Body mass index, VAS: Visual analog scale, 12F: 12 French, 16F: 16 French

Primary Outcomes - Comparison of Drain Sizes

There was no statistically significant difference between the 12F and 16F drain groups in terms of demographic characteristics and key postoperative outcomes (Table 2). Specifically, the groups were statistically similar in terms of age (p=0.289), BMI (p=0.267), preoperative pain scores (p=0.487), postoperative pain scores (p=0.837), pain reduction (ΔVAS, p=0.935), total drain output (p=0.607), and discharge day (p=0.448). The results of this study indicate that increasing the drain diameter from 12F to 16F does not offer any significant clinical advantages (Figure 2A). There were also no significant differences in rates of previous lumbar surgery (p=1.000), anticoagulant use (p=0.909) (Figure 2B), or surgical level distribution (p=0.265) between the two drain size groups. Specifically, there was no observed reduction in postoperative pain levels among patients, nor was there an increase in the postoperative drainage. Drains were maintained under negative pressure throughout hospitalization and were removed according to the prespecified criteria in all patients; no patient required drainage beyond postoperative day 2. These outcomes highlight that simply enlarging the drain size may not enhance patient recovery or outcomes, which was the main objective of our investigation.

Table 2. Comparisons between 12F and 16F drains after microscopic ULBD

	Drain size		
	12F (small size)	**16F (large size)**	**p-value**
Age	66.52±4.37	71.08±3.54	0.289
BMI	30.1±2.17	27.86±2.1	0.267
Total drainage (mL)	157.6±74.1	155.83±59.56	0.607
Discharge day	1.52±0.39	1.25±0.18	0.448
Preop VAS	8.08±0.78	7.83±0.85	0.487
Postop VAS	2.72±0.88	2.42±0.72	0.837
Δ VAS	5.36±1.06	5.42±0.88	0.935
Previous surgery			
Yes	2 (8%)	2 (8.3%)	1.000
No	23 (92%)	22 (91.7%)	
Anticoagulant/platelet use			
Yes	16 (64%)	14 (58.3%)	0.909
No	9 (36%)	10 (41.7%)	
Surgical level			
2 levels	11 (44%)	11 (45.8%)	
3 levels	12 (48%)	7 (29.2 %)	0.265
4 levels	2 (8%)	4 (16.7 %)	
5 levels	0 (0%)	2 (8.3%)	
Gender			
Male	10 (40%)	10 (41.7%)	0.906
Female	15 (60%)	14 (58.3%)	

ULBD: Unilateral laminotomy for bilateral decompression, BMI: Body mass index, VAS: Visual analog scale, 12F: 12 French, 16F: 16 French

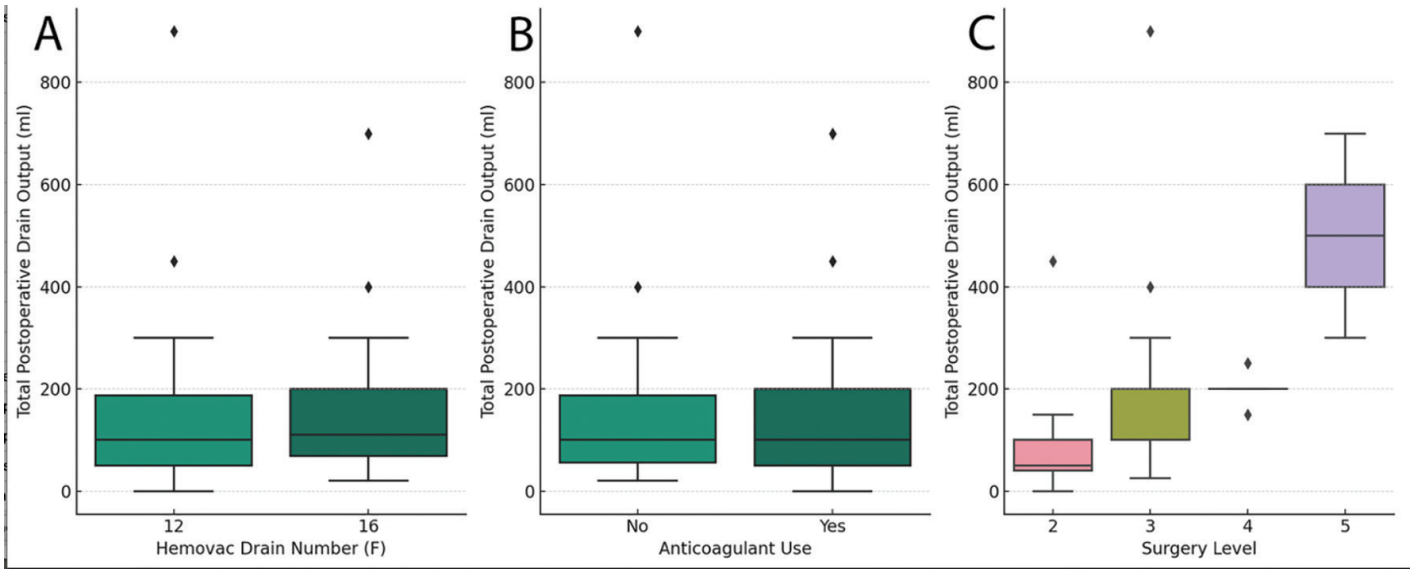

Figure 2. Total postoperative drain output in terms of **(A)** hemovac drain size, **(B)** anticoagulant use and **(C)** number of surgical level decompressed

Table 3. Association of patient/surgical factors with total drainage (mL)

	Total drainage (mL)	p-value	Post-hoc p-value
Age	156.73±47.5	0.165	-
BMI		0.382	-
Gender			
Male	168.25±83.78	0.436	-
Female	148.79±56.22		
Previous surgery			
Yes	181.25±85.09	0.246	-
No	154.56±51.02		
Anticoagulant/platelet use			
Yes	167.11±77.17	0.764	-
No	150.17±60.67		
Surgical levels			
2 levels	89.32±38.5	**0.000**	2-3: 0.321 **2-4: 0.000** 2-5: 0.868 3-4: 1.000 3-5: 0.925 4-5: 0.940
3 levels	185.0±90.14		
4 levels	200.0±25.82		
5 levels	500.0±400.0		

BMI: Body mass index

Table 4. Predictors of pain improvement (ΔVAS) after microscopic ULBD

	ΔVAS	p-value
Age	5.39±0.69	0.363
BMI		0.652
Preop VAS score		**0.000**
Draiange amount (mL)		0.100
Discharge day		0.108
Gender		
Male	4.60±1.136	0.056
Female	5.93±0.812	
Previous surgery		
Yes	7.00±0.82	0.164
No	5.24±0.72	
Anticoagulant/platelet use		
Yes	4.68±1.27	0.104
No	5.83±0.76	
Surgical levels		
2 levels	6.09±1.02	0.144
3 levels	4.42±1.18	
4 levels	6.00±0.89	
5 levels	5.00±2.00	

VAS: Visual analog scale, BMI: Body mass index

Secondary Outcomes - Predictors of Drainage Amount and Pain Reduction

Surgical level was the only variable significantly associated with drain output (Kruskal-Wallis, $p<0.001$). Post-hoc comparisons showed that patients undergoing 4-level surgeries had significantly higher drain volumes compared to those undergoing 2-level surgeries (mean difference =110.7 mL, $p<0.001$) (Figure 2C, Table 3).

When examining predictors of postoperative bleeding, univariate analysis revealed a statistically significant negative correlation with preoperative VAS scores (Spearman $\rho=-0.335$, $p=0.018$), indicating that patients with higher preoperative pain scores had lower drain outputs. However, this association did not remain statistically significant in a multivariate linear regression model adjusting for age, BMI, blood thinner use, drain size, and previous surgery (adjusted $R^2=0.051$, $p=0.227$).

Regarding predictors of pain reduction, only the preoperative pain score was significantly associated with the degree of pain reduction (Pearson's $r=0.604$, $p<0.001$). This indicates that patients experiencing higher preoperative pain experienced significantly greater pain reduction after surgery. Other variables including drain output ($p=0.100$), age ($p=0.363$), BMI ($p=0.652$), discharge day ($p=0.108$), blood thinner use ($p=0.104$), gender ($p=0.056$), previous surgery ($p=0.164$), and surgical level ($p=0.144$) were not significantly associated with pain reduction (Table 4). Additionally, there was no significant correlation between total drain output and pain reduction (Spearman $\rho=-0.232$, $p=0.108$).

No variables were found to be significantly associated with length of hospital stay in either univariate or correlation analyses.

DISCUSSION

ULBD is a widely recognized surgical modality employed to treat lumbar spinal stenosis. This technique is favored for its minimally invasive characteristics when juxtaposed with traditional decompression and posterior fusion surgeries, which often result in greater tissue disruption. Consequently, the relative risk of hematoma formation and the overall volume of intraoperative bleeding are significantly lower. Nonetheless, despite the reduced hemorrhagic volume typically associated with this procedure, the potential for mass effect from even a small hematoma collection remains a concern. This is largely attributable to the constrained anatomical space that persists postoperatively in comparison to more extensive open surgical interventions.

In recent years, the efficacy of drain placement in open surgical procedures has come under scrutiny. Evidence suggests that the routine placement of drains does not significantly reduce the incidence of epidural hematoma formation, nor does it lead to a measurable decrease in postoperative complications[3-8]. Furthermore, the introduction of drains is associated with increased rates of bleeding and necessitates higher transfusion requirements, in addition to contributing to patient discomfort during the postoperative recovery period[3,5].

Despite the growing body of research that challenges the utility of wound drainage, it continues to be standard practice among many surgeons[3-7]. This persistence exists in spinal surgical procedures, where the application of drain systems lacks a standardized protocol regarding critical factors. These factors include the choice between negative or natural drainage, as well as considerations related to the size, length, type, quantity, and positioning of the drains. The absence of a uniform guideline raises important questions about the best practices in postoperative care and the potential need for reevaluation of current protocols in surgical practice.

Previous research has demonstrated no significant correlation between drain size and outcomes in open lumbar fusion surgeries[3,5-7,9,10]. Additional studies indicate that the use of two drains, as opposed to one, may reduce failure rates associated with drain placement and lower the incidence of hematoma formation[9]. One particular investigation highlighted that when a drain was positioned 5 cm outside the surgical incision, the drainage efficacy was insufficient[11]. While these findings pertain primarily to open posterior lumbar fusion surgeries, there is a notable gap in the literature regarding ULBD procedures.

Furthermore, it is essential to consider that the placement of drains can have a significant impact on postoperative recovery. The necessity for drains tends to prolong hospital stays, and increased blood loss associated with their use may elevate the risk of surgical site infections and hemorrhagic anemia[3,5]. Thus, further research is warranted to elucidate the effects of drain placement specifically in the context of ULBD.

In this single-team cohort study on microscopic lumbar microdecompression, increasing the closed-suction drain size from 12F to 16F showed no significant impact on postoperative bleeding, pain reduction, or length of hospital stay. The only factor linked to higher drainage volumes was the extent of decompression. Additionally, preoperative pain intensity was a more reliable predictor of postoperative pain relief than either drain size or drainage volume. These findings indicate that the drainage device's size does not substantially influence the volume of postoperative drainage, which aligns with prior research on open surgical procedures[8,12].

Given that routine postoperative imaging to assess the volume of blood at the surgical site is not performed, we identified the need for surrogate markers to evaluate hematoma-related outcomes. Consequently, pain scale assessments and loss of muscle strength were selected as appropriate indicators. Specifically, an increase or lack of reduction in pain scores, along with a newly developed decrease in muscle strength, absent any apparent nerve injury during surgery, could suggest the presence of blood accumulation over the thecal sac[11].

In our patient cohort, only two patients reported no change in pain levels following surgery, both of whom were experiencing moderate to severe neuropathic pain. Notably, no loss of muscle strength was observed among the patients. Furthermore, the reduction in postoperative pain scores implies that there is no associated increase in pain related to blood collection among the analyzed patients. Additionally, we did not observe any cases of drainage obstruction during the study.

One of the notable findings from our study indicated that the reduction in postoperative pain levels is correlated with the intensity of preoperative pain experienced by patients. Specifically, a higher baseline level of pain was associated with greater analgesic relief following surgical intervention. While no direct correlation was established regarding the types or volumes of drainage employed, this outcome presents an intriguing avenue for further investigation within the context of pain management and surgical outcomes.

This study was not designed to address the broader question of drain use versus no-drain after ULBD. Drain placement is not universal, and some centers mobilize patients within hours and discharge without drains. In our practice setting during the study period, a single closed-suction drain was routinely used for multilevel ULBD to mitigate concerns about postoperative collections, with early mobilization encouraged within the first postoperative day and only standard 24-hour perioperative antibiotic prophylaxis. Accordingly, our results should be interpreted as addressing a narrower, pragmatic question: when a drain is used after microscopic ULBD, does increasing diameter from 12F to 16F provide measurable benefit? Future prospective studies incorporating a no-drain arm and standardized mobilization/discharge pathways would be required to determine whether drains are necessary in this population and to quantify any impact on rare hematoma-related outcomes.

Our study presents several limitations that could be mitigated through the implementation of larger cohort studies. This retrospective, single-center investigation is characterized by a modest sample size. Additionally, we did not routinely obtain postoperative imaging to quantify hematoma formation, and within our patient population, we observed no complications associated with hematoma development. This absence of complications restricts our ability to thoroughly evaluate the potential adverse effects related to hematoma formation. Future work should standardize drain algorithms for minimally invasive ULBD, covering indications for placement, negative vs natural pressure, exit-site/trajectory, and removal thresholds, to enable reproducible comparisons across centers[11,13-16].

Study Limitations

This study has several limitations. First, its retrospective, single-center design with a modest sample size limits statistical power and generalizability, and drain selection was not randomized, leaving the possibility of selection bias and residual confounding despite a standardized surgical technique and perioperative protocol. Second, the study did not include a no-drain control group; therefore, conclusions are restricted to comparisons between drain diameters among patients who received routine closed-suction drainage. Third, we did not routinely obtain postoperative imaging to quantify epidural/paraspinal hematoma, and no hematoma-related complications occurred in this cohort; therefore, we cannot draw conclusions regarding drain caliber and rare but clinically important hematoma outcomes. Finally, outcomes were limited to early surrogate measures and short-term hospitalization data, which may not capture clinically meaningful differences in neurologic function, patient-reported recovery trajectories, or late complications.

CONCLUSION

In this single-team cohort of microscopic ULBD, increasing drain diameter from 12F to 16F was not associated with lower postoperative pain, shorter hospitalization, or meaningfully different total drainage. Across prespecified comparisons and adjusted analyses, results were directionally consistent, and the only variable that tracked with higher drainage was greater decompression extent, while higher baseline pain predicted larger postoperative pain reduction. These findings suggest that, under standardized hemostasis and postoperative care, drain performance in ULBD is not materially improved by upsizing the lumen.

Clinically, a 12F closed-suction drain appears adequate for routine ULBD, and choice of diameter can be guided by surgeon preference and workflow rather than expectations of superior outcomes with a larger-caliber. Because this was a retrospective, single-center study with a modest sample size, prospective studies with protocolized drain management and patient-reported endpoints are warranted to confirm these observations, refine selection for atypical scenarios, and define evidence-based criteria for drain placement and removal.

Ethics

Ethics Committee Approval: Bahçeşehir University Institutional Review Board approved this retrospective file review (approval no: 2025-15/03, date: 15.12.2025).

Informed Consent: The patient gave written informed consent for her case to be included in research, allowing for the release of the patient's medical records and any related photos.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.Z.Y., D.K., Concept: B.P., Ö.E., M.Z.Y., Design: B.P., Ö.E., Data Collection or Processing: Ö.E., Y.K., Analysis or Interpretation: B.P., Ö.E., Literature Search: B.P., Writing: B.P., Ö.E., D.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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SINGLE-STAGE POSTERIOR RECONSTRUCTION FOR VERTEBRAL TUBERCULOSIS: KYPHOSIS CORRECTION AND FUNCTIONAL OUTCOMES

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ABSTRACT

Objective: Single-stage posterior reconstruction is used for spinal tuberculosis, but outcome data vary. To report outcomes after single-stage posterior debridement/decompression, titanium mesh cage fusion, and posterior instrumentation.

Materials and Methods: Retrospective series of 18 patients (2014-2019) treated with a posterior single-stage approach and ⩾22 months' follow-up. Indications included neurological deficit; instability, progressive collapse, or deformity; compressive epidural or paravertebral abscess; and/or failure of anti-tuberculosis therapy. Outcomes included regional kyphosis/lordosis, visual analog scale (VAS), Frankel grade, Oswestry disability index (ODI) at final follow-up, and C-reactive protein (CRP)/erythrocyte sedimentation rate (ESR).

Results: Mean age was 36.3±11.7 years; mean follow-up 37.9±20.1 months. Involvement was thoracolumbar in 10 cases, thoracic in 4, and lumbar in 4. In thoracic/thoracolumbar cases (n=14), kyphosis improved from approximately 30° to 15.2° (p=0.005); lumbar lordosis showed no significant change (p=0.655). VAS decreased from 7.81 to 3.15 (p<0.002). Frankel increased from 4.75±0.52 to 4.92±0.28 (p>0.05); two patients improved (D→E) with no deterioration. Final ODI was 27.33±17.40 (median 22; 10-64). CRP rose early and returned toward baseline by ~3 months; ESR showed no significant change at ~3 months.

Conclusion: Posterior single-stage reconstruction was associated with maintained regional kyphosis correction and significant pain reduction; functional improvement could not be quantified without baseline ODI.

Keywords: Kyphosis correction, spinal tuberculosis, regional kyphosis correction, titanium mesh cage, single-stage posterior surgery

INTRODUCTION

Pott disease is a granulomatous infection by *Mycobacterium tuberculosis* that primarily involves the vertebral bodies, spreads subligamentously across discs, and can lead to collapse, kyphosis, and neurologic deficit[1]. Extrapulmonary involvement accounts for ~15-20% of all tuberculosis (TB) cases in recent cohorts; half of these involve the spine, and 10-45% develop neurological deficits and vertebral damage[2-5]. The spine is the most frequently affected skeletal site and the one most prone to serious complications[2-5]. Pathological fractures and dislocations produce mechanical instability, while compression from bony fragments or abscesses leads to neurological compromise-scenarios that often render surgery unavoidable[6,7].

Surgical goals in spinal TB are to eradicate infection, restore spinal stability, and address neurological dysfunction. To this end, a spectrum of procedures has been described: abscess drainage[8], anterior[9] and posterior[6,7] debridement, postero-lateral[10,11] approaches, anterior or posterior grafting[12] and kyphosis correction with preservation of fusion to prevent late deformity[7,13]. Because anterior and postero-lateral strategies can demand broader multidisciplinary resources and may carry higher complication profiles, single-stage posterior surgery is increasingly favored. In this study, we evaluate outcomes of single-stage posterior transpedicular debridement and decompression with titanium mesh cage fusion and posterior instrumentation, and we outline its advantages and limitations relative to alternative methods.

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MATERIALS AND METHODS

Between 2014 and 2019, 18 patients (12 females, 6 males) with vertebral TB, who underwent single-stage posterior debridement, decompression, fusion and instrumentation, were included in the study. The mean age was 36.3±11.7 years (range: 18-72). Eligible patients were those with vertebral TB treated with single-stage posterior debridement, decompression, titanium mesh cage fusion, and posterior instrumentation, with a minimum follow-up of 22 months. Patients with follow-up <22 months and/or incomplete clinical-radiographic data were excluded. Surgical indications included neurological deficit due to compression, mechanical instability/progressive collapse or deformity, compressive epidural/paravertebral abscess, and/or failure of appropriate anti-TB chemotherapy with clinical or radiological progression. The level of involvement at presentation was thoracolumbar (TL) in 10, thoracic (T) in 4, and lumbar (L) in 4 patients. Ethical approval was obtained from the University of Health Sciences Türkiye, Gazi Yaşargil Training and Research Hospital Ethics Committee for Non-Interventional Studies (approval no: 694, date: 07.11.2025). In addition, a written informed voluntary consent form was obtained from all patients participating in the study. For final follow-up assessment, patients were contacted by phone/e-mail and invited for clinical and radiographic evaluation. Demographic data, medical history, treatment modalities, physical examination findings, functional outcomes, and laboratory results were evaluated. Imaging studies, including plain radiographs, magnetic resonance imaging, and computed tomography, were also reviewed. In addition, preoperative and postoperative physical examination, laboratory, and radiography findings of the patients were retrieved via the hospital information system. Neurological status was graded preoperatively and at final follow-up using the Frankel classification (A-E)[14]. Pain intensity was assessed preoperatively and postoperatively using the visual analog scale (VAS)[15]. Functional status was evaluated at final follow-up using the Oswestry disability index (ODI)[16], with higher scores indicating greater disability.

Surgical Procedure

A midline incision was performed, hemostasis was achieved, and the paraspinal muscles were subperiosteally elevated to allow pedicle screw placement. Depending on the level of involvement, laminectomy was performed to expose the spinal cord, and tuberculous debris was circumferentially debrided with specimens sent for microbiology and pathology. The cleaned cavity was irrigated and filled with an appropriately sized titanium cage, and rods were contoured for kyphosis/lordosis correction and fixed. Facet and pedicle sites were grafted and vancomycin powder was applied, a Hemovac drain was placed, and the wound was closed in layers (Figure 1A-G). Postoperative management included thoracolumbosacral orthosis measurement on the first postoperative day; if there was no contraindication, the patient was mobilized and instructed to wear the corset during mobilization. Corset use for 6-12 months was recommended depending on the level of involvement. Anti-TB chemotherapy was initiated postoperatively under infectious disease supervision using a daily 4-drug regimen (isoniazid, rifampicin, pyrazinamide, and ethambutol) for 2 months, followed by daily isoniazid plus rifampicin for 10 months with weight-based dosing. Microbiological specimens were routinely submitted for smear/culture and drug-resistance assessment (drug-susceptibility testing when culture yielded growth and rapid molecular testing when available), and the regimen was modified according to susceptibility results and tolerability. A 12-month duration was selected for this spinal osteoarticular TB cohort treated with instrumentation, consistent with expert recommendations and contemporary World Health Organization/national guidance that commonly allow extended treatment durations for bone/joint (including spinal) disease[17,18]. Routine controls were scheduled at post-op 2 weeks, 6 weeks, 3 months, 6 months, and annually thereafter. Radiological fusion was defined as trabecular bridging across the cage/graft-endplate interfaces without progressive radiolucency or hardware failure. Loss of correction was defined as ≥5° deterioration in regional kyphosis/lordosis versus immediate postoperative values. Implant loosening was defined as progressive ≥1-mm peri-screw radiolucency and/or hardware migration/breakage, and cage subsidence as ≥3-mm loss of segmental height or cage sinking compared with immediate postoperative films. Infection recurrence was defined as renewed disease activity after initial improvement, supported by rising erythrocyte sedimentation rate (ESR)/C-reactive protein (CRP) and radiological progression (progressive abscess or bone destruction). Regional kyphosis/lordosis angles were measured by specialist surgeons in our clinic and were re-evaluated by a senior surgeon; measurements were revised when necessary after repeat assessment.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 21.0. Continuous variables are presented as mean ± standard deviation and categorical variables as n (%). Normality was assessed with Kolmogorov-Smirnov/Shapiro-Wilk tests. Paired comparisons used the paired t-test or Wilcoxon signed-ranks test, as appropriate. All tests were two-tailed; p≤0.05 was considered significant.

RESULTS

Eighteen patients (12 female, 6 male) were analyzed. Mean age was 36.3±11.7 years (range: 18-72). Mean hospital stay was 8.25±3.41 days and mean follow-up was 37.92±20.1 months (range: 22-94). The involved levels were TL (n=10), T (n=4), and L (n=4) (Table 1). In the L subgroup (n=4), lordosis showed no significant change (preoperative mean 27.5°; p=0.655). Pain decreased from a mean VAS of 7.81 preoperatively to 3.15 postoperatively (p<0.002) (Figure 2). In the T/TL subgroup

(n=14), regional kyphosis improved from approximately 30° preoperatively to approximately 15.2° at final follow-up (p=0.005) (Figure 3). Mean Frankel grade increased from 4.75±0.52 (median 5; range: 4-5) preoperatively to 4.92±0.28 (median 5; range: 4-5) at final follow-up (p>0.05). Two patients improved from Frankel D to E, and no neurological deterioration occurred. At final follow-up, functional status was assessed using the ODI. The mean ODI was 27.33±17.40 (median 22; range: 10-64), as summarized in Table 1. Regarding inflammatory markers, CRP increased in the early postoperative period (1.39→13.49 mg/L) and returned toward baseline by 3 months (2.08 mg/L), while ESR showed no significant change at 3 months (32.83→30.08 mm/h). No recurrence or loss of correction was observed during follow-up according to the predefined criteria.

DISCUSSION

Defining a single, universally applicable treatment algorithm for spinal TB is challenging because acceptable outcomes can be achieved with different surgical strategies. That said, contemporary implants and posterior techniques have made single-stage posterior surgery a commonly preferred option in many centers, as it can provide decompression/debridement, regional deformity correction, and stable reconstruction through one approach with less soft-tissue morbidity than combined procedures. Anterior or combined anterior-posterior approaches may still be appropriate in selected scenarios (e.g., extensive anterior column destruction, specific abscess patterns, or cases requiring anterior structural support), but our study was not designed to compare strategies and therefore does not support claims of superiority.

Pain reduction in our cohort was comparable to prior posterior-only series, where VAS reductions of approximately 4-6 points have been reported[9,10,13]. In this study, mean VAS decreased from 7.81 to 3.15 (p<0.002), indicating a clinically relevant reduction in pain after single-stage posterior reconstruction.

Neurological change in our cohort was modest. Although neurological improvement after posterior surgery is frequently reported[11,13], only two patients improved (Frankel D→E) and the overall change was not statistically significant. Mean Frankel grade increased from 4.75±0.52 (median 5; range: 4-5) preoperatively to 4.92±0.28 (median 5; range: 4-5) at final follow-up (p>0.05), with no neurological deterioration. This likely reflects the small sample size and the relatively preserved baseline neurological status, limiting the ability to detect measurable neurological improvement.

Radiographic findings in our study should be interpreted as regional correction rather than global sagittal realignment. Prior posterior-only series have reported meaningful reductions in T kyphosis after debridement, instrumentation, and fusion[11,19]. In our T/TL subgroup, kyphosis decreased from approximately 30° preoperatively to 15.2° at final follow-up, indicating maintained regional correction. In contrast, L lordosis did not change significantly, and this neutral finding is reported separately.

Table 1. Posterior single-stage surgery outcomes in spinal TB

No	Gender	Age (year)	Follow-up (month)	VAS (preoperative)	VAS (postoperative)	Angle (preoperative/final)	Level	Oswestry (0-100)
1	Female	18	22.0	8.06	2.79	Preop: 26°	L	22.0
2	Female	72	94.0	7.41	3.78	Preop: 30°/final: 14.8°	TL	37.0
3	Female	23	22.0	7.41	2.94	Preop: 30°/final: 15.2°	TL	22.0
4	Female	25	23.9	7.98	2.64	Preop: 30°/final: 14.8°	TL	29.4
5	Female	27	22.1	8.28	3.50	Preop: 35°/final: 15.2°	T	22.0
6	Female	29	34.7	8.23	3.12	Preop: 30°/final: 14.8°	TL	24.3
7	Female	31	81.6	7.90	3.52	Preop: 25°	L	25.6
8	Female	32	33.3	8.21	2.72	Preop: 30°	L	26.4
9	Female	34	27.1	7.59	2.91	Preop: 29°/final: 15.2°	TL	22.0
10	Female	36	30.3	8.20	3.48	Preop: 29°/final: 18.0°	T	26.7
11	Female	37	28.9	7.86	2.93	Preop: 29°/final: 15.2°	TL	24.7
12	Female	38	36.3	7.80	3.30	Preop: 30°/final: 14.8°	TL	30.0
13	Male	38	38.7	7.43	3.41	Preop: 30°/final: 14.0°	TL	22.0
14	Male	40	22.0	7.47	3.10	Preop: 30°/final: 15.2°	T	31.6
15	Male	41	37.9	7.24	3.25	Preop: 30°/final: 15.2°	TL	22.0
16	Male	42	36.6	8.06	3.14	Preop: 30°/final: 15.2°	T	29.4
17	Male	44	54.4	7.81	3.41	Preop: 29°	L	24.8
18	Male	46	37.0	7.64	2.76	Preop: 28°/final: 15.2°	TL	29.7

TB: Tuberculosis, VAS: Visual analog scale, TL: Thoracolumbar, T: Thoracic, L: Lumbar

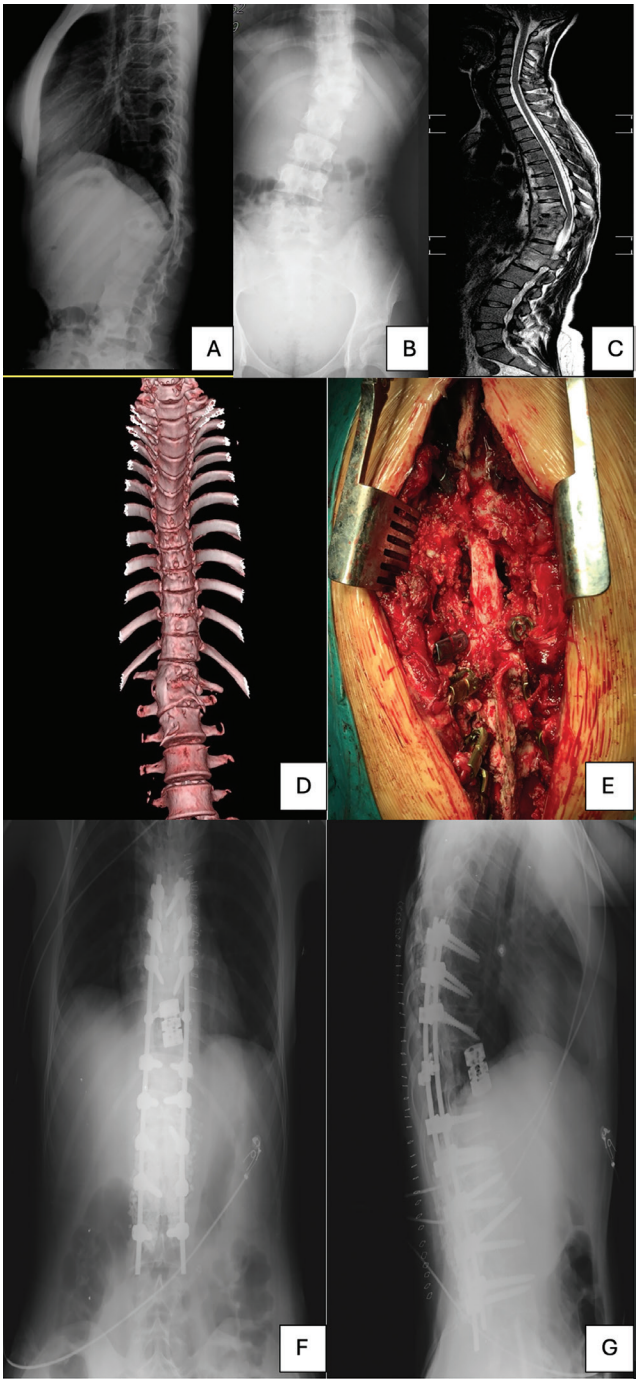

Figure 1. Panels (**A-G**) illustrate the preoperative imaging, intraoperative steps, and early postoperative radiographs in a representative patient with thoracolumbar Pott disease (**A,B**). Preoperative anteroposterior and lateral radiographs demonstrating thoracolumbar involvement (T12-L2) (**C**). Sagittal MRI showing the extent of vertebral destruction and compression (**D**). CT image detailing bony collapse and deformity (**E**). Intraoperative view during posterior debridement and long-segment pedicle screw instrumentation (**F,G**). Early postoperative anteroposterior and lateral radiographs demonstrating titanium cage reconstruction and pedicle screw instrumentation with improved regional alignment. MRI: Magnetic resonance imaging, CT: Computed tomography

Overall, these data are consistent with posterior single-stage reconstruction providing durable regional kyphosis correction in T/TL disease, while effects on L alignment appear limited in this small cohort.

In our cohort, T/TL involvement predominated and patients were relatively young (mean age 36.3 years), consistent with other published series. The mean length of hospital stay was 8.25±3.41 days, which lies at the lower end of ranges reported in prior posterior-only and combined approach cohorts (reported ~10-18 days)[20]. This comparison should be interpreted cautiously because length of stay is strongly influenced by local healthcare systems, perioperative pathways, and discharge practices.

Inflammatory markers showed a postoperative pattern that is commonly observed after major spinal procedures. CRP increased early postoperatively and returned toward baseline by approximately 3 months in our cohort, whereas ESR demonstrated a slower and less specific trajectory, as reported in prior studies[21,22]. Given that CRP/ESR were obtained at limited time points, these measures should be interpreted as supportive laboratory trends rather than standalone indicators of TB control or recurrence.

Functional interpretation is limited by measurement design. ODI was available only at final follow-up (mean 27.33±17.40; median 22; range: 10-64), and baseline ODI was not recorded; therefore, functional improvement cannot be quantified in this series. Accordingly, ODI is reported strictly as final functional status rather than pre-post change. Final ODI values were broadly comparable to those reported in prior posterior-only cohorts[23].

Study Limitations

This study is limited by its retrospective design, small and heterogeneous sample (n=18), absence of a comparator group, and limited power for subgroup analyses, particularly for L disease. Follow-up imaging was not fully standardized, and radiographic assessment was restricted to regional kyphosis/lordosis angles; global sagittal alignment and pelvic parameters were not evaluated, precluding conclusions regarding global alignment. Patient-reported outcomes were limited to VAS and ODI, with ODI available only at final follow-up and without broader health-related quality of life instruments, which restricts comparability and prevents robust assessment of functional change. CRP/ESR measurements were obtained at limited time points, and rehabilitation adherence and provider-related variability were not systematically captured. Finally, formal interobserver reliability statistics were not calculated. These limitations reduce generalizability and underscore the need for prospective comparative studies with standardized PROMs, comprehensive alignment assessment, and predefined reliability analysis.

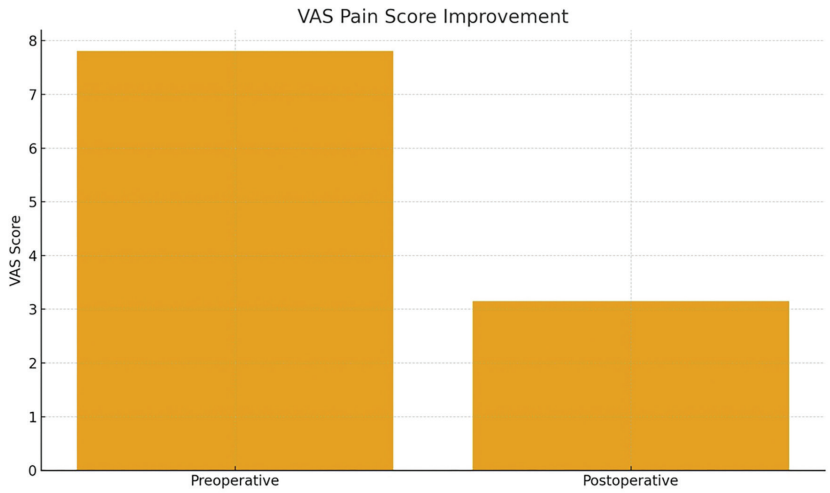

Figure 2. Mean VAS pain scores decreased from preoperative to postoperative assessment (0-10 scale). VAS: Visual analog scale

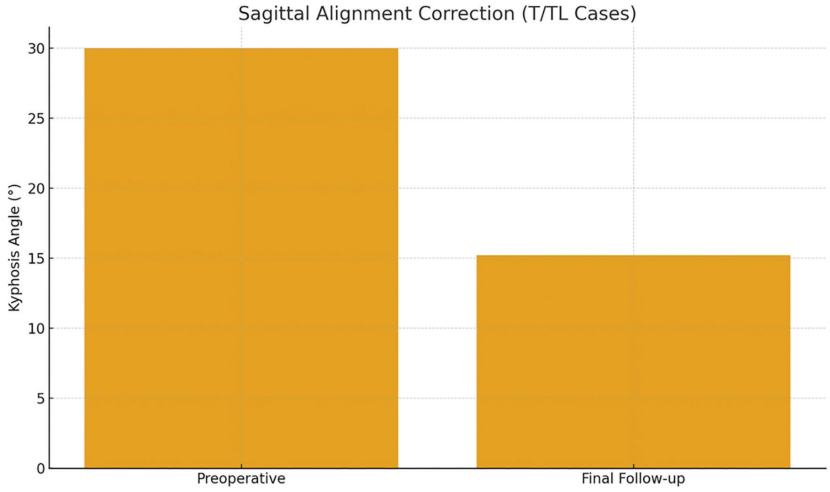

Figure 3. Change in regional kyphosis angle from preoperative to final follow-up in thoracic/thoracolumbar cases. T: Thoracic, TL: Thoracolumbar

CONCLUSION

In this small retrospective series, single-stage posterior debridement/decompression with titanium mesh cage-assisted fusion and posterior instrumentation was associated with durable regional kyphosis correction in T/TL disease and significant postoperative pain reduction. Final functional status was favorable (mean ODI 27.33±17.40; median 22; range: 10-64); however, functional improvement cannot be quantified because baseline ODI was unavailable. No recurrence or loss of correction was observed during follow-up according to the predefined radiological criteria.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the University of Health Sciences Türkiye, Gazi Yaşargil Training and Research Hospital Ethics Committee for Non-Interventional Studies (approval no: 694, date: 07.11.2025).

Informed Consent: Written informed voluntary consent form was obtained from all patients participating in the study.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: A.Y., R.A., Concept: A.Y., R.A., Design: A.Y., R.A., C.A., A.A., Data Collection or Processing: A.Y., R.A., C.A., A.A., Analysis or Interpretation: A.Y., R.A., A.A., Literature Search: A.Y., R.A., C.A., Writing: A.Y., R.A.

Conflict of Interest: No conflict of interest was declared by the authors.

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IMPACT OF LUMBAR SURGERY ON PAIN, SLEEP QUALITY, AND QUALITY OF LIFE: A PRE-POST DESIGN STUDY OF COMMON LOW BACK DISEASE

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ABSTRACT

Objective: Low back pain is common among individuals over 15 years and often leads to hospitalizations. Impaired sleep quality is a major complication. Pain and sleep interact in a vicious cycle in which pain disrupts sleep and poor sleep worsens pain. This study aimed to assess changes in sleep quality and quality of life after lumbar surgery.

Materials and Methods: A total of 106 patients underwent lumbar surgery between December 2023 and April 2024. Assessments were performed preoperatively and at 6 months postoperatively using the visual analog scale (VAS), Pittsburgh sleep quality index (PSQI), and EuroQol 5-dimension questionnaire (EQ-5D-3L).

Results: The cohort included 56 females (53%), with ages ranging from 23-78 years. Surgery was performed for lumbar spinal stenosis in 37 (35%), lumbar spondylolisthesis (LSL) in 31 (30%), and lumbar disc herniation (LDH) in 38 (35%). Postoperatively, VAS and PSQI scores decreased significantly, while EQ-5D-3L scores increased.

Conclusion: Lumbar surgery provided meaningful improvements in pain, sleep, and quality of life, particularly in patients who were unresponsive to conservative therapy. The most pronounced benefits occurred in LDH, whereas notable gains were also observed in LSL, a condition rarely studied in this context. These outcomes may reflect the less invasive nature of decompression compared with that of fusion. Overall, lumbar surgery represents an effective treatment option and offers new insights into the relationship between spinal disorders and sleep quality.

Keywords: Low back pain, quality of life, sleep quality

INTRODUCTION

Low back pain (LBP) affects approximately 80% of individuals at some point in their lives, with its prevalence increasing with age[1]. In Türkiye, it ranks as the leading cause of hospital admissions among individuals over the age of 158[2]. The lumbar region is the main load-bearing and mobile part of the spine. Consequently, it is also the site where degenerative changes, injuries, and pain most frequently occur[3]. In the management of LBP, treatment should be planned according to established algorithms, with conservative methods applied initially. The primary goal is to control symptoms and minimize functional impairment caused by pain. However, in certain cases, surgical intervention becomes unavoidable. Absolute surgical indications include cauda equina syndrome, progressive motor deficit, and failure of conservative treatment[4].

It has been emphasized in the literature that LBP not only leads to pain and functional impairment, but also has a significant negative impact on sleep patterns and overall quality of life[5]. Sleep, constituting a substantial portion of one's lifetime, is essential for both physical and mental health. Its absence or poor quality can negatively impact various aspects of life, including work performance, academic achievements, daily functioning, and overall well-being[6]. LBP may impair sleep quality, while reduced sleep quality in turn exacerbates pain and creates a vicious cycle. However, stronger evidence suggests that sleep disturbances represent a risk factor for the development and persistence of LBP[7]. In the literature, the effects of chronic LBP, gabapentin use, medical treatment, and surgical treatment [particularly in patients with lumbar disc herniation (LDH) or lumbar spinal stenosis (LSS)] on sleep quality and daily activities have been investigated[7-9].

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While LDH, LSS and lumbar spondylolisthesis (LSL) have each been extensively investigated, studies that concurrently evaluate all three conditions within a homogeneous patient cohort and within the same temporal framework are notably scarce.

The aim of this study was to evaluate the effects of surgical interventions performed for LDH, LSS, and LSL on Pittsburgh sleep quality index (PSQI), pain [visual analog scale (VAS)], and quality of life [EuroQol 5-dimension questionnaire (EQ-5D-3L)] and to further compare the impact of surgery on pain, sleep quality, and quality of life among patients with these three diagnoses.

MATERIALS AND METHODS

Study Design

This study followed a prospective pre-post design and included 106 patients who underwent lumbar decompression surgery for LDH and decompression with posterior transpedicular instrumented fusion for LSS and LSL at the spine center of a tertiary referral hospital between December 2023 and April 2024. All surgical procedures were performed at a single center. Among the participants, 31 patients were diagnosed with LSL, 37 with LSS, and 38 with LDH. The date of the last surgical procedure was April 30, 2024, and the final follow-up assessment was completed on October 31, 2024. Of the initially eligible patients, three could not be reached at the 6-month postoperative follow-up, and one patient did not complete the 6-month postoperative questionnaire.

Inclusion criteria for surgery were as follows: for LDH, patients were selected based on the presence of radicular pain, motor weakness, and failure of conservative treatment (defined as persistent symptoms despite at least 6 weeks of non-operative management, including physical therapy, analgesic medications, and/or steroid injections). For LSS, patients with a canal diameter less than 10 mm (measured on axial T2-weighted magnetic resonance imaging at the narrowest level and independently assessed by a neurosurgeon and a radiologist), radicular pain, motor weakness, positive neurogenic claudication, and failure of conservative treatment were included. For LSL, patients with Meyerding grade 1-2, either degenerative or isthmic type, motor weakness, radicular pain, positive neurogenic claudication, and no improvement with conservative treatment were considered eligible for surgery and were enrolled in the study.

Exclusion criteria encompassed patients with recurrence, patients younger than 18 years of age, patients who had undergone surgery due to knee and/or hip osteoarthritis; patients with spinal infection; patients with radiological findings of spinal tumor; patients with spondylolisthesis or disc pathology after trauma; patients with sleep apnea; those with advanced heart failure, pulmonary disease, psychiatric disorders or related medication use; night-shift workers; and patients with a body mass index greater than 30 kg/m^2 were excluded from the study. These criteria were intended to reduce the influence of major comorbidities that could affect postoperative pain, sleep, and quality of life outcomes, thereby allowing the evaluation of a more homogeneous patient cohort. Exclusion criteria were determined based on diagnostic records in patient files, clinical history, and routine preoperative assessment findings, without the use of additional screening instruments.

Perioperative pain management and sleep-related treatment were administered according to the institution's standard clinical practice. The same analgesic and sleep-related treatment regimen was applied during both the preoperative and postoperative periods, with no systematic changes made throughout the follow-up period. (e.g., non-steroidal anti-inflammatory drugs, muscle relaxants, tramadol, and opioids).

The sample size for the study was calculated as a minimum of 90 with an alpha error of 0.05, a power of 80% and an effect size of 0.3 using the G*Power v3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) programme. After voluntarily agreeing to participate in the study, subjects who completed both questionnaires completely were included in the study. Ethical approval was obtained from the Ankara Yıldırım Beyazıt University (approval no: 10-497, date: 19.12.2023).

Data Collection

VAS, PSQI and EQ-5D-3L evaluation scales were performed preoperatively and at 6 months postoperatively in the 106 patients included in the study. The questionnaires were administered through face-to-face interviews by a separate researcher who was blinded to the patients' diagnoses, while the diagnoses were independently established by the investigators. In the first part, age, gender and diagnosis information of the participants were recorded. In the second part, the pain levels of the participants were determined using VAS. The participants rated the severity of radicular leg pain on a scale ranging from 0 (no pain) to 10 (most severe pain)[10]. In the third part, PSQI was used to determine sleep quality. PSQI is a scale consisting of 24 questions and 7 components. Nineteen of the 24 questions are answered by the person himself/herself and used in the assessment. The other 5 questions are answered by the person's relatives and are not used in the assessment. The 19 questions included in the assessment are distributed in 7 components. Each component is scored between 0 to 3. The total score of the scale is obtained by summing the scores of these components and takes values between 0-21. An increase in the total score indicates deterioration in sleep quality. Although the PSQI does not indicate whether there is a sleep disorder, a total score of 5 and above means poor sleep quality. PSQI was developed by Buysse et al.[11] in 1989 and its Turkish validity and reliability study was conducted by Ağargün et al.[12] in 1996.

The fourth part of the study employed the EQ-5D-3L general quality of life scale to evaluate participants' quality of life. This scale comprises five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each

dimension offers response options of 1 (no problems), 2 (some problems), and 3 (extreme problems). The total score ranges from -0.59 to 1, with 1 denoting perfect health and 0 indicating death. Scores below zero represent health states considered worse than death, such as unconsciousness or being bedridden. Originating in 1987, the scale was developed by the EuroQol Group and has since been translated into over 60 languages, including Turkish[13]. The Turkish validity and reliability study of the scale was conducted by Kahyaoğlu Süt[14] in 2009 as part of a master's thesis in internal medicine nursing involving patients with acute coronary syndrome. For this study, scoring values outlined in Golicki et al.'s[15] work were adopted.

Statistical Analysis

Statistical analyses were conducted using IBM-SPSS v25 software (IBM Corp., Armonk, NY, USA). Descriptive statistics, including median, 1st and 3rd quartiles, and percentages, were utilized to present participant characteristics. Normality analyses was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Parametric tests were used when the dependent variables showed normal distribution; otherwise non-parametric tests were used. Due to the non-normal distribution of the data, the Wilcoxon paired two-sample test with Bonferroni correction was employed to evaluate changes in sleep quality, pain scores, and quality of life before and after intervention. To compare differences in these variables between groups based on age, gender, and diagnosis, the Mann-Whitney U test and Kruskal-Wallis test were applied. The effect size of postoperative scale score changes for all three diagnostic group was evaluated and classified using the eta squared coefficient[16]. In this study pain level (VAS), health related quality of life (EQ-5D-3L) and sleep quality of participants were defined as three pre-determined co-primary endpoints. The sub-dimensions of the PSQI were evaluated as secondary analysis to examine the components of variation in sleep quality, and a significance level of $p<0.007$ was set using Bonferroni correction to control for multiple comparisons. Moreover, to evaluate the impact of baseline differences on score change, a multiple linear regression analysis was conducted with EQ-5D-3L pre- and postoperative scores as dependent variable. Baseline EQ-5D-3L score of the participants, diagnostic groups and their interaction term were included as independent variables. Age was categorized into two groups: 65 years and older, and younger than 65 years. Subgroup analyses were performed on quality of life, sleep quality, and pain score changes within specific diagnostic groups. For variables conforming to a normal distribution, the Student's t-test was used, while the Mann-Whitney U test was applied for non-normally distributed data.

RESULTS

A total of 106 patients completed both surveys and were included in the study. Of these, 56 (53%) were women. The median age was 57 years (range 23-78). Surgery was performed for LSS in 37 patients (35%), for LSL in 31 (30%), and for LDH in 38 (35%) (Table 1).

Among 38 LDH patients, levels were L2-3 in 1 (2.6%), L3-4 in 3 (7.9%), L4-5 in 17 (44.7%), and L5-S1 in 17 (44.7%). Of 31 LSL patients, 4 (12.9%) had L3-4 (all degenerative), 16 (51.6%) had L4-5 (4 isthmic, 12 degenerative), and 11 (35.5%) had L5-S1 (10 isthmic, 1 degenerative). Among 37 LSS patients, 24 (64.9%) had 2 levels involved, 12 (32.4%) had 3 levels, and 1 (2.7%) had 4 levels.

In the baseline, the VAS and PSQI total scores of LSS, LSL and LDH patient groups were similar ($p>0.05$ for each). However, while the baseline EQ-5D-3L scores of the LSS and LSL groups were similar, the EQ-5D-3L score of the LDH group was lower ($p=0.032$). As a result of the multiple linear regression analysis conducted to evaluate the effect of baseline differences on change in EQ-5D-3L scores, the findings indicate that the observed improvement can not be attributed solely to the lower baseline scores in the LDH group. The results demonstrate that the surgical response varies according to both diagnostic category and baseline quality of life level.

The VAS scores of participants significantly improved, decreasing from a preoperative median of 10 (range: 9-10) to a postoperative median of 1 (range: 0-1). Similarly, the PSQI total scores showed significant improvement, decreasing from a preoperative median of 15 (range: 14-16) to a postoperative median of 4.5 (range: 3-6). The EQ-5D-3L general quality of life scores increased markedly from a preoperative median of 0.10 (range: -0.17-0.53) to a postoperative median of 1 (range: 0.89-1).The changes in VAS, PSQI total scores, and EQ-5D-3L scores were statistically significant. Additionally, the changes in six subcomponents of the PSQI scale, excluding sleep duration, were also found to be statistically significant (Table 2).

In all three surgical groups, significant postoperative improvements were observed in EQ-5D-3L quality of life, PSQI sleep quality, and VAS pain scores ($p<0.05$). Among these, the LDH group demonstrated the most pronounced gains, with moderate to large effect sizes for quality of life, sleep quality, and pain reduction. By diagnosis, only LDH patients

Table 1. Baseline characteristics of the participants

Characteristics	Median (IQR1-IQR3)
Age	57 (49-64)
	n (%)
Gender	
1. Female	56 (53)
2. Male	50 (47)
Diagnosis	
1. LSS	37 (35)
2. LSL	31 (30)
3. LDH	38 (35)

IQR: Interquartile range, LSS: Lumbar spinal stenosis, LSL: Lumbar spondylolisthesis, LDH: Lumbar disc herniation

showed significant improvements across all three measures, with greater gains compared to the other groups (quality of life, p=0.008; sleep quality, p=0.008; pain reduction, p=0.004). In addition the eta squared sizes of postoperative scale score changes for all three diagnosis were found between 0.07-0.09, indicating that these changes had a moderate-high clinical impact (Table 3).

Moreover when the diagnostic groups were divided into two groups those who underwent instrumentation (LSS, LSL) (n=68) and those who did not (LDH) (n=38) the change in scale scores from the preoperative and postoperative period was higher in the intrumentation group for VAS and PSQI scales (p<0.001 and p=0.002, respectively), whereas the change in EQ-5D-3L scores was significantly higher in the non-instrumentation group (p=0.02)

Changes in VAS, PSQI, and EQ-5D-3L were analyzed by age, gender, and diagnosis. VAS improvement was greater in patients <65 years (p=0.02), while EQ-5D-3L and PSQI showed no age-related differences. Men had a larger reduction in PSQI scores than women (p=0.02), with no gender differences in VAS or EQ-5D-3L (Table 4). Among 36 LSS patients (23 with two levels, 13 with three levels), VAS reduction was greater in two-level cases (p=0.038), while EQ-5D-3L and PSQI showed no group differences.

In LSL patients, EQ-5D-3L, PSQI, and VAS changes did not differ between L4-5 (n=16) and L5-S1 (n=11) levels, nor between isthmic (n=14) and degenerative (n=17) types (p>0.05).

In LDH patients, EQ-5D-3L, PSQI, and VAS changes were similar at L4-5 (n=17) and L5-S1 (n=17) levels (p>0.05).

No complications requiring reoperation, such as spondylodiscitis, permanent neurological deficits, or implant issues, were observed in the 106 patients during the postoperative period and 6-month follow-up. Minor complications included dural tears in 7 patients, which were repaired. Two patients had partial nerve root damage, but no additional deficits were noted postoperatively. One patient had a misplaced screw that contacted the nerve root, but it was corrected during surgery, and the patient experienced temporary weakness for 6 hours. Additionally, 5 patients had fat necrosis at the wound site, which resolved with treatment.

DISCUSSION

Several studies have investigated the impact of LSS and LDH on sleep quality. Some of these have focused on preoperative LDH[17], while others have examined outcomes in postoperative LDH[18,19]. In addition, studies have evaluated preoperative LSS[20,21] as well as pre- and postoperative comparisons in LSS[22-24]. Beyond these, previous studies have

Table 2. Comparison of pre- and postoperative changes in VAS, PSQI and EQ-5D-3L scores

Scale	Preoperative median (IQR1/IQR3)	Postoperative median (IQR1/IQR3)	p-values
EQ-5D-3L index score	0.10 (-0.17/0.53)	1 (0.89/1)	**<0.001**
VAS	10 (9/10)	1 (0/1)	<0.001
PSQI total score	15 (14/16)	4.5 (3/6)	**<0.001**
Component 1 sleep quality	3 (2/3)	0 (0/1)	**<0.001**
Component 2 sleep latency	1 (1/1)	0 (0/0)	**<0.001**
Component 3 sleep duration	3 (3/3)	3 (3/3)	>0.05
Component 4 sleep efficiency	3 (3/3)	0 (0/1)	<0.001
Component 5 sleep disturbance	2 (2/2)	1 (0/1)	**<0.001**
Component 6 sleep medication	0 (0/1)	0 (0/0)	**<0.001**
Component 7 daytime sleep dysfunction	3 (3/3)	0 (0/0)	**<0.001**

Wilcoxon test was performed. Bonferroni correction was performed for multiple hypothesis testing of PSQI total score. Corrected p-value is "0.05/7=0.007". VAS: Visual analog scale, IQR: Interquartile range, PSQI: Pittsburgh sleep quality index, EQ-5D-3L: EuroQol 5-dimension questionnaire

Table 3. Comparison of pre- and postoperative changes in VAS, PSQI and EQ-5D-3L scores according to diagnosis of the participants

Diagnosis	EQ-5D-3L change median (IQR1/IQR3)	p-value/ETA²	PSQI change median (IQR1/IQR3)	p-value/ETA²	VAS change median (IQR1/IQR3)	p-value/ETA²
LSS	0.55 (0.28-0.97)	0.008/0.07	-10 [-12-(-8)]	**0.008/0.07**	-8 [-9-(-8)]	**0.004/0.09**
LSL	0.74 (0.39-1.03)		-9 [-12-(-8)]		-8 [-9-(-8)]	
LDH	0.91 (0.58-1.3)		-12 [-13-(-10)]		-9 [-10-(-9)]	

KW test was performed. ETA² : Effect size is used for KW test, KW: Kruskal-Wallis, VAS: Visual analog scale, IQR: Interquartile range, PSQI: Pittsburgh sleep quality index, EQ-5D-3L: EuroQol 5-dimension questionnaire, LSS: Lumbar spinal stenosis, LSL: Lumbar spondylolisthesis, LDH: Lumbar disc herniation

Table 4. Comparison of pre- and postoperative changes in VAS, PSQI and EQ-5D-3L scores according to age and gender of the participants

Characteristics	EQ-5D-3L change median (IQR1/IQR3)	p-value	PSQI change median (IQR1/IQR3)	p-value	VAS change median (IQR1/IQR3)	p-value
Age						
1. Below 65	0.88 (0.45/1.12)	0.09	-11 (-12/-8)	0.14	-9 (-10/-8)	**0.02**
2. 65 and above	0.67 (0.28/1.06)		-10 (-11.25/-8)		-8 (-9/-7)	
Gender						
1. Female	0.67 (0.35/0.95)	0.051	-10 (-12/-8)	**0.02**	-9 (-10/-8)	0.85
2. Male	0.90 (0.47/1.34)		-12 (-13/-9.5)		-9 (-10/-8)	

KW and MWU tests were performed. KW: Kruskal-Wallis, MWU: Mann-Whitney U, VAS: Visual analog scale, IQR: Interquartile range, PSQI: Pittsburgh sleep quality index, EQ-5D-3L: EuroQol 5-dimension questionnaire

investigated degenerative spine surgery patients undergoing either decompression alone (without fusion) or posterior decompression with transpedicular instrumented fusion[25,26]. And those who underwent lumbosacral fusion surgery[27] in terms of sleep quality. Distinct from previous investigations, our study included not only LDH and LSS but also LSL, a condition that has not been previously evaluated in relation to sleep quality. Furthermore, unlike earlier studies, we performed a comparative analysis among the three diagnostic groups. Based on our findings, this study provides novel insights and contributes uniquely to the existing literature, with each result discussed individually in detail. In our study, the changes observed in EQ-5D-3L, PSQI, and VAS scores were statistically significant. These results indicate that lumbar surgery is associated with improvements in quality of life and sleep quality, as well as a reduction in pain.

In our study, a significant reduction in VAS scores was observed following surgical intervention in patients with a high prevalence of pain. Similarly, previous studies have also reported a marked decrease in pain levels after surgery[19,22,23,27]. Particularly in cases unresponsive to conservative treatment, lumbar surgery has demonstrated highly favorable outcomes in terms of pain reduction. In the diagnosis-based change analysis, significant within-group postoperative improvements were observed in pain, quality of life, and sleep quality parameters across all surgical groups. However, in the between-diagnosis comparison, the magnitude of postoperative improvement across all three outcome measures was found to be more pronounced in patients with LDH compared with those with LSS and LSL. Although there is no strong evidence in the literature that directly explains this difference, the more pronounced improvement observed in the LDH group may be associated with factors such as a more limited surgical intervention, the minimally invasive nature of posterior decompression, preservation of motion segments due to the absence of fusion, and reduced soft tissue trauma. These interpretations do not imply a causal relationship and should be regarded as potential mechanisms to help explain the observed findings.

In addition, subgroup analysis of patients who underwent posterior decompression for LDH revealed no significant difference between the L4-5 and L5-S1 levels. In our study, it was also determined that as the number of surgical levels increased in LSS, the degree of pain improvement decreased. In a previous study investigating LSS and sleep quality, no significant difference was found in pain reduction according to the number of fused levels when four or more levels were treated[27]. However, in our cohort of 37 patients with LSS who underwent two-, three-, or four-level decompression with posterior transpedicular instrumented fusion, we found that the reduction in VAS scores was more pronounced in patients who underwent two-level fusion compared to those who underwent three-level fusion. In conclusion, our findings suggest that a lower number of fused levels in LSS surgery provides better outcomes in terms of pain control[28].

In the literature, LSL patients have not been specifically evaluated in terms of sleep quality. In our study, however, these patients demonstrated a postoperative decrease in VAS and PSQI scores and an increase in EQ-5D-3L scores. No significant differences were observed with respect to the level (L4-5 vs. L5-S1) or type (degenerative vs. isthmic) of LSL. Our findings indicate that in low-grade LSL patients, surgery leads to improvements in both sleep quality and quality of life, and provides significant benefits in terms of pain relief, particularly in cases unresponsive to conservative treatment. The posterior decompression with transpedicular instrumented fusion technique applied in our series appears to be effective in this patient group, as it restores spinal stability and relieves nerve root compression[24]. Future studies should evaluate LSL patients both preoperatively and postoperatively, focusing on both sleep quality and quality of life. Increasing the sample size, including different types of LSL, comparing various surgical techniques, and extending the follow-up period would contribute to more accurate preoperative patient selection and more effective postoperative care. Moreover, subgroup analyses based on specific surgical techniques could provide valuable insights into optimizing patient outcomes.

When examining gender differences, the reduction in PSQI total scores was greater in men than in women. However, in the study by Lee et al.[23] which analyzed gender subgroups of surgically treated patients in terms of sleep quality, no significant difference was observed.

In our study, 68 patients underwent decompression with posterior transpedicular instrumented fusion and 38 patients underwent alone posterior decompression not instrumented fusion. When studies investigating the relationship between lumbar surgery and sleep quality in the literature are evaluated; Lee et al.[23] reported 63 patients with LSS, although the surgical technique was not specified. Bozduman et al.[27] reported 20 patients with LSS who underwent decompression with posterior transpedicular instrumented fusion. Kim et al.[22] analyzed 48 patients with LSS, of whom 9 underwent posterior decompression (without fusion) and 39 underwent posterior decompression with transpedicular instrumented fusion. Papavero et al.[24] reported 140 patients with LSS who were treated with posterior decompression (without fusion). McNassor et al.[25] reported 349 patients who decompression with transpedicular instrumented fusion and 123 who underwent posterior decompression (without fusion) , with the overall diagnosis described as degenerative spine conditions. In our series, patients who underwent posterior decompression combined with transpedicular instrumented fusion (68 patients) demonstrated greater improvement in sleep quality compared with those who underwent posterior decompression (without fusion) (38 patients). McNassor et al.[25] reported no significant difference in sleep quality improvement between posterior decompression (without fusion) and decompression with posterior transpedicular instrumented fusion, although both groups showed overall improvements. When the findings of both studies are considered together, it appears that the extent of the surgical technique alone does not determine changes in sleep quality. This suggests that sleep quality is a multidimensional parameter influenced by various clinical and individual factors beyond the surgical approach itself.

Study Limitations

Although this study provides important findings regarding the relationship between lumbar surgery, sleep quality, pain reduction, and quality of life, several limitations should be acknowledged. Since only patients with surgical indications were included, a control group could not be established. The follow-up period was limited to 6 months, and longer-term follow-up would help to better assess the durability of surgical outcomes. The single-center design may limit the generalizability of the results.

CONCLUSION

Lumbar surgery provides substantial benefits in terms of pain control, improved sleep quality, and enhanced quality of life, particularly in patients unresponsive to conservative treatment. The most pronounced improvements were observed in LDH cases, while notable postoperative gains were also identified in LSL, which has not previously been evaluated in this context. Overall, in patients with surgical indications who did not benefit from conservative treatment, lumbar surgery consisting of appropriate decompression with additional fusion in the presence of instability was found to be associated with clinically meaningful improvements in patient outcomes.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ankara Yıldırım Beyazıt University (approval no: 10-497, date: 19.12.2023).
Informed Consent: Prospective pre-post design.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.T., Ö.F.Ş., H.İ.A., Concept: B.T., E.Ü., Design: B.T., E.Ü., E.A., Data Collection or Processing: B.T., E.A., Ü.G., H.İ.A., Analysis or Interpretation: E.Ü., E.A., Ü.G., Literature Search: B.T., E.Ü., E.A., Writing: B.T., E.Ü., Ö.F.Ş.
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PREVALENCE OF INTERVERTEBRAL DISC DEGENERATION ON MAGNETIC RESONANCE IMAGING IN LUMBAR SPONDYLOLYSIS AND SPONDYLOLISTHESIS

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ABSTRACT

Objective: To compare the prevalence of cranial lumbar disc degeneration (L1-L4) in patients with spondylolysis (SL) and isthmic spondylolisthesis (IS) with those having L5-S1 lumbar disc herniation (LDH) and asymptomatic individuals with normal lumbar vertebrae (NLV).

Materials and Methods: This retrospective study included 133 individuals aged 25-50 years, divided into four groups: IS (n=28), SL (n=38), LDH (n=34), and NLV (n=33). Lumbar intervertebral discs were evaluated using the Pfirrmann classification on sagittal T2-weighted magnetic resonance imaging. Disc degeneration was defined as Pfirrmann grade ⩾3. Intergroup comparisons of degeneration prevalence were performed using the chi-square test.

Results: Upper lumbar degeneration rates did not differ significantly among the SL, IS, and LDH groups (31.6%, 39.3%, and 29.4%, respectively; p>0.05). However, all three groups demonstrated higher degeneration rates than the NLV group (18.2%; p<0.05). Although the IS group was significantly older than the NLV group (p<0.001), there was no significant correlation between age and degeneration at the upper lumbar levels.

Conclusion: IS and L5-S1 LDH are associated with higher rates of cranial lumbar disc degeneration than in asymptomatic individuals. These findings may suggest that altered biomechanical factors contribute beyond chronological aging; however, causal inference is limited by the retrospective design.

Keywords: Lumbar spine, disc degeneration, MRI, spondylolysis, spondylolisthesis

INTRODUCTION

Lumbar spondylolysis (SL) involves a unilateral or bilateral defect in the pars interarticularis, typically affecting the L5 vertebra. It is a common cause of low back pain in adolescents and young adults, often attributed to repetitive mechanical stress and hyperextension[1-4]. If left untreated or under ongoing mechanical load, this defect can progress to isthmic spondylolisthesis (IS), defined as the anterior slippage of the vertebral body[2,3].

While the relationship between the pars defect and the affected segment is well-documented, the impact of these pathologies on the adjacent and upper lumbar intervertebral discs remains a subject of debate.

Previous literature presents conflicting data regarding disc degeneration in these patients. Some studies suggest that upper adjacent disc degeneration in SL cases is generally no different from that in the normal population[5]. Conversely, other reports indicate an accelerated rate of degeneration at adjacent levels, particularly in young patients with spondylolisthesis[6]. Furthermore, the precise role of disc degeneration in the progression from SL to spondylolisthesis has recently been scrutinized, highlighting a complex interplay between instability and disc integrity[7-9]. Understanding the extent of multilevel disc degeneration is clinically critical, as it influences surgical decision-making-specifically, the choice between direct pars repair and segmental fusion. If the degeneration is confined to the slipping level, motion-preserving techniques or short-segment fusion may be appropriate; however, multilevel degeneration might necessitate a more extensive surgical strategy[10,11].

The aim of this study is to compare the prevalence of cranial lumbar disc degeneration (L1-L4) in patients with SL and IS against those with L5-S1 lumbar disc herniation (LDH) and a strictly selected asymptomatic control group [normal lumbar vertebrae (NLV)]. By doing so, we aim to clarify whether isthmic pathologies are associated with a generalized degenerative pattern in the lumbar spine.

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MATERIALS AND METHODS

Clinical records and related imaging data of patients visiting the neurosurgery outpatient clinic between February 2017 and July 2024 were retrospectively analyzed.

The study protocol was approved by the İstanbul Medipol University of Non-Interventional Clinical Research Ethics Committee (approval no: E-10840098-202.3.02-6545, date: 05.09.2024). This study was a retrospective study. Patient consent was not required.

This study included four groups of individuals aged 25-50 years. The inclusion criteria were determined for each group. The SL group had bilateral pars interarticularis defects in the L5 vertebra, while the IS group had Meyerding[12] stage 1 or stage 2 mild spondylolisthesis at the L5-S1 level; the normal lumbar spine (NLV) group consisted of asymptomatic individuals aged 25-50 years who underwent lumbar magnetic resonance imaging (MRI) for reasons other than chronic low back pain or radiculopathy, and whose images were assessed as normal (Pfirrmann grade I or II). The exclusion criteria for each group, including the NLV group, were spinal tumors, infection, or previous spinal surgery. In the spondylolisthesis group, patients with non-isthmic disc herniation were excluded from the study. There were 28 patients in the IS group, 38 in the SL group, 34 in the LDH group, and 33 in the NLV group.

MRI was performed using a 1.5T system (Avanto; Siemens, Erlangen, Germany) with a spine coil. All the patients were examined in the supine position.

On sagittal turbo spin-echo T2-weighted images (TR/TE, 4250/109 msec; FOV, 30; matrix, 384×288; section thickness, 4 mm); L1-2, L2-3, L3-4, L4-5, L5-S1 intervertebral disc spaces were evaluated according to Pfirrmann classification[13]. Grades I and II: the nucleus pulposus may be homogeneous or heterogeneously bright, respectively, whereas in grade II, a thin, black horizontal band may be present. In both grades, the annulus fibrosus borders are distinct, and there is no loss of disc height. Grade III: the nucleus pulposus is heterogeneous with medium signal intensity and is gray in color. The annulus fibrosus borders are indistinct and the disc height is slightly decreased. Grade IV: the nucleus pulposus has a medium-to-low signal intensity and appears dark gray. The annulus fibrosus borders are absent, and the disc height is moderately decreased. Grade V: the nucleus pulposus has a low signal intensity and appears black, the annulus fibrosus borders are absent, and the disc height is significantly decreased. Segments with a grade ⩾3 were considered degenerated (Figure 1).

Statistical Analysis

Statistical analysis was performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro-Wilk test. Age was normally distributed and is presented as mean ± standard deviation. Disc degeneration was defined as Pfirrmann grade ⩾3. The prevalence of degeneration across groups was compared using the chi-square test. Spearman's rank correlation coefficient was used to assess the relationship between age and disc degeneration. A p-value <0.05 was considered statistically significant.

Radiological Evaluation

"All MRI scans were independently evaluated by two experienced observers (a radiologist and a neurosurgeon) who were blinded to the patients' clinical information and group assignments. Inter-observer reliability was assessed using the Cohen's Kappa coefficient, which demonstrated substantial agreement (Kappa =0.85). In cases of disagreement, a final consensus was reached through joint review. Disc degeneration at each level (L1-S1) was graded according to the Pfirrmann classification system.

RESULTS

The study population consisted of 133 patients, comprising 28 in the IS group, 38 in the SL group, 34 in the L5-S1 LDH group, and 33 in the NLV group. The IS group included 11 men and 17 women aged 25-50 years (mean 42.43±6.03 years); the SL group included 21 men and 17 women (mean 38.03±7.80 years); the L5-S1 LDH group included 20 men and 14 women (mean 36.41±7.17 years); and the NLV group included 9 men and 24 women (mean 35.48±8.82 years). Statistical analysis revealed significant differences among the groups in terms of mean age ($p<0.001$) and gender distribution ($p=0.027$). The IS group had the highest mean age (42.43±6.03 years), while the NLV group was the youngest (35.48±8.82 years). Regarding gender, the NLV group showed a higher female predominance compared to the other groups. Detailed demographic characteristics and statistical comparisons are presented in Table 1.

The proportion of IDD in the upper segments (L1-L4) was 39.3% in the IS group and 31.6% in the SL group, showing no significant difference from the L5-S1 LDH group (29.4%, $p>0.05$). However, all three groups had a higher rate of degeneration compared with the NLV group (18.2%, $p<0.05$) (Figure 2). A significant

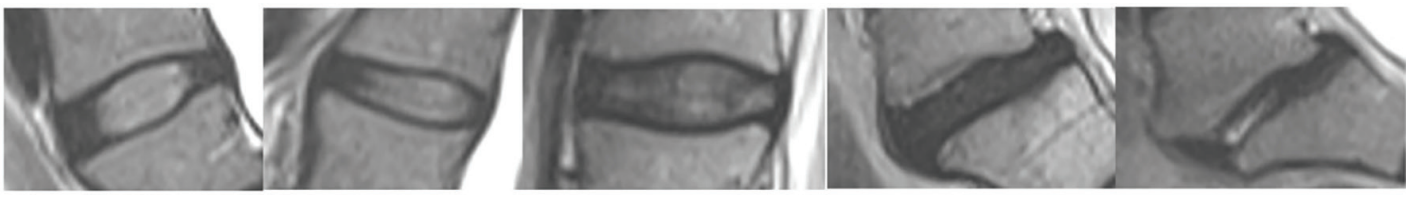

Figure 1. The Pfirrmann grading system for the evaluation of lumbar disc degeneration. The grades range from grade I to grade V, in ascending order

difference among groups was also observed at the L5-S1 level (p<0.001). Age was significantly correlated with degeneration at the L5-S1 level (p=0.015), whereas no significant correlation was found at the upper lumbar levels (p>0.05).

DISCUSSION

The principal finding of this study is that patients with IS and L5-S1 disc herniation (LDH) exhibit significantly higher rates of intervertebral disc degeneration (IDD) in the upper lumbar segments (L1-L4) compared to healthy controls. Interestingly, while the SL group did not demonstrate a statistically significant increase in degeneration compared to the normal population at the L4-5 level, the transition to spondylolisthesis appears to be associated with more widespread degenerative changes.

Our findings regarding the SL group are generally consistent with previous literature suggesting that isolated pars defects do not necessarily accelerate degeneration at adjacent levels[5]. Although the difference between the SL and NLV groups at the L4-5 level approached statistical significance (p=0.052), this finding did not reach formal significance and should therefore be interpreted cautiously. While this borderline result may suggest a possible degenerative tendency, it cannot be used to support mechanistic conclusions. Larger prospective studies are required to determine whether a true association exists. These findings may reflect the relatively stable biological behavior of isolated SL compared with the more extensive degenerative patterns observed in IS.

In contrast, the IS group demonstrated significantly higher rates of disc degeneration at cranial levels compared to healthy controls. This pattern suggests a broader degenerative involvement beyond the index level. While some earlier studies have suggested that unaffected segments in IS patients may resemble physiological aging, our findings indicate that degeneration in these patients cannot be fully explained by chronological age alone. Intervertebral discs typically begin to degenerate after the third decade of life, influenced by poor posture, abnormal loading, environmental factors, and genetics; however, the exact underlying mechanism remains unclear[14-16]. While Dai[5] reported a strong link between patient age and the

Table 1. Demographic characteristics of the study groups

Parameter	IS (n=28)	SL (n=38)	L5-S1 LDH (n=34)	NLV (n=33)	p-value
Age (mean ± SD)	42.43±6.03	38.03±7.80	36.41±7.17	35.48±8.82	<0.001*
Gender (male/female)	11/17	21/17	20/14	9/24	0.027*

*: Significant differences (p<0.05) are indicated with an asterisk, IS: Isthmic spondylolisthesis, SL: Spondylolysis, LDH: Lumbar disc herniation, NLV: Normal lumbar vertebrae, SD: Standard deviation

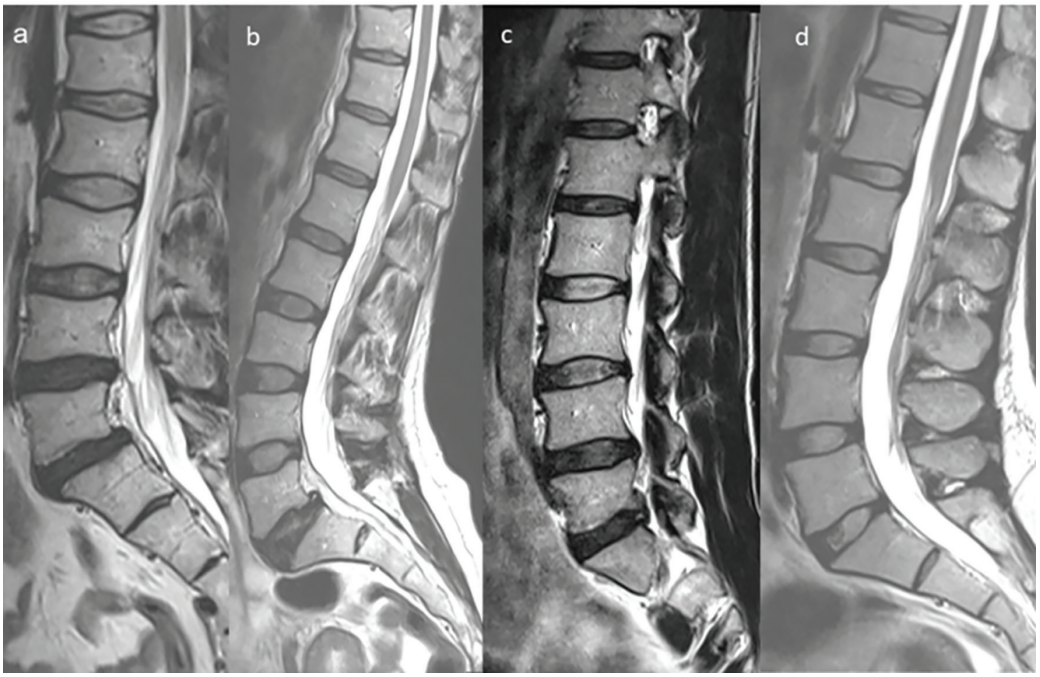

Figure 2. Comparison of lumbar intervertebral disc degeneration in patient groups with isthmic spondylolisthesis and spondylolysis and lumbar disc herniation and normal lumbar vertebrae. T2 sagital weighted MRI show lumbar intervertebral spaces. **a)** Forty-three-year-old man patient with isthmic spondylolisthesis. The patient has Pfirrmann grade 4 degeneration at levels L5-S1 and L4-5, grade 3 at levels L3-4 and L1-2 and grade 2 at level L2-3. **b)** Thirty-nine-year-old female patient with spondylolysis. The patient has Pfirrmann grade 4 degeneration at level L5-S1 and grade 3 at level L1-2, grade 2 at levels L2-3, L3-4 and L4-5. **c)** Forty-four-year old man patient with lumbar disc herniation. The patient has Pfirrmann grade 4 degeneration at levels L5-S1, L4-5 and L1-2, grade 3 at level L3-4 and grade 2 L2-3. **d)** Thirty-five-year-old female with normal lumbar vertebrae. The patient has Pfirrmann grade 2 degeneration at all levels. MRI: Magnetic resonance imaging

severity of disc degeneration above a spondylolytic defect, our findings offer a different perspective.

Although the IS group in our study was significantly older than the NLV group ($p<0.001$), age showed no significant correlation with degeneration at the upper lumbar levels (L1-L4) A significant correlation was observed only at the L5-S1 level ($p=0.015$). These results suggest that additional biomechanical factors may contribute to multilevel degeneration in IS, although the retrospective design limits definitive causal interpretation. This distinction between SL and IS may suggest that segmental instability, rather than the pars defect itself, contributes to multilevel degeneration.

The discrepancy between our findings and earlier reports may be explained by altered spinal biomechanics. Spondylolisthesis results in sagittal imbalance and increased shear forces[6,11]. To maintain an upright posture, patients often exhibit compensatory mechanisms, such as increased lumbar lordosis or pelvic tilt changes[9,11]. We hypothesize that this compensatory hyperextension places excessive stress on the posterior column and annulus fibrosus of the cranial adjacent segments, accelerating degeneration as observed in our IS and LDH groups. This supports the view that adjacent level degeneration is more prevalent in spondylolisthesis, particularly in younger cohorts[6].

Consequently, this has significant implications for clinical practice. During surgical planning, the condition of the intervertebral discs is crucial for deciding between direct repair and segmental fusion[5,10,17]. Preoperative MRI is essential for assessing disc abnormalities at both the affected and adjacent segments[18,19]. As stated by Dai[5] the feasibility of direct repair is not necessarily limited by the patient's age, provided that the adjacent intervertebral disc remains healthy. Our study reinforces this view by showing that disc health is more a factor of mechanical environment than chronological age, thus informing the selection of the most appropriate surgical intervention."

Study Limitations

This study has several limitations that should be acknowledged. First, the retrospective design and relatively small sample size may limit the generalizability of our findings and the statistical power to detect subtle differences. Second, objective spinopelvic radiographic parameters such as pelvic incidence, sacral slope, and lumbar lordosis were not evaluated. Since our interpretation includes a biomechanical hypothesis, the absence of these parameters limits direct validation of sagittal balance-related mechanisms.

Additionally, our assessment was based solely on morphological changes on MRI, and clinical outcome measures (e.g., visual analog scale or Oswestry disability index scores) were not included.

Finally, although the control group consisted of asymptomatic individuals with normal MRIs, complete matching for environmental and lifestyle factors is inherently limited in retrospective analyses.

CONCLUSION

Our study demonstrates that IS and L5-S1 disc herniation are associated with higher rates of IDD in the upper lumbar segments compared to healthy individuals. Although no significant correlation was found between age and degeneration at the upper levels, these findings may suggest a contribution of altered biomechanical factors beyond chronological aging. However, given the retrospective design and absence of objective spinopelvic parameters, definitive causal inferences cannot be established. These results highlight the importance of comprehensive preoperative MRI evaluation of the entire lumbar spine when planning surgical interventions such as pars repair or fusion.

Ethics

Ethics Committee Approval: The study protocol was approved by the İstanbul Medipol University of Non-Interventional Clinical Research Ethics Committee (approval no: E-10840098-202.3.02-6545, date: 05.09.2024).

Informed Consent: This study was a retrospective study. Patient consent was not required.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.K., B.O.G., Concept: B.K., B.O.G., Design: B.K., B.O.G., Data Collection or Processing: B.K., B.O.G., Analysis or Interpretation: B.K., B.O.G., Literature Search: B.K., B.O.G., Writing: B.K., B.O.G.

Conflict of Interest: No conflict of interest was declared by the authors.

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CLINICAL RELATIONSHIP BETWEEN CURVE LOCATION AND BODY IMAGE, QUALITY OF LIFE, AND DEPRESSION LEVELS IN PATIENTS WITH ADOLESCENT IDIOPATIC SCOLIOSIS

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ABSTRACT

Objective: Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity that may negatively affect adolescents' psychosocial well-being. Increasing evidence suggests that radiographic severity alone does not fully explain the impact of scoliosis on health-related quality of life (HRQoL). However, the extent to which curve magnitude and location influence domain-specific HRQoL outcomes remains unclear.

Materials and Methods: This cross-sectional study included 65 adolescents with AIS who were evaluated at a university hospital outpatient clinic. Participants completed the validated Turkish version of the scoliosis research society-22 (SRS-22) questionnaire. Standing posteroanterior full-spine radiographs were used to determine Cobb angle, curve location (proximal thoracic, main thoracic, thoracolumbar/lumbar), and Risser stage. Differences among SRS-22 domains were assessed using the Friedman test, followed by Bonferroni-corrected Wilcoxon signed-rank tests. Comparisons between curve location groups were performed using the Kruskal-Wallis test. Associations between curve magnitude and SRS-22 domain scores were assessed using Spearman correlation.

Results: Self-image and mental health were the most adversely affected SRS-22 domains, whereas pain and functional activity scores were relatively preserved [Friedman $\chi^2(4)=78.18$, $p<0.001$]. No significant differences in SRS-22 total or domain scores were observed across curve location groups (all $p>0.05$). Spearman correlation analysis demonstrated no significant associations between Cobb angle magnitude and any SRS-22 domain.

Conclusion: Psychosocial domains, particularly self-image and mental health, constitute the primary burden in AIS and appear largely independent of radiographic severity and the curve pattern. These findings support a patient-centered approach to AIS management that incorporates psychosocial assessment alongside conventional radiographic evaluation.

Keywords: Adolescent idiopathic scoliosis, curve location, SRS-22

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a complex three-dimensional spinal deformity that develops in otherwise healthy adolescents during the pubertal growth spurt and affects approximately 2-4% of the general adolescent population[1]. Although many cases remain mild and clinically stable, a subset of patients experience curve progression that may lead to functional limitations, cosmetic concern, psychosocial distress. As a result, AIS has multidimensional consequences extending beyond structural spinal deformity, affecting both physical health and psychosocial well-being.

Health-related quality of life (HRQoL) has become a central outcome in AIS research, driven by increasing recognition that radiographic severity alone does not fully capture the lived experience of the condition. Among available measurement tools, the scoliosis research society-22 (SRS-22) questionnaire is one of the most widely validated instruments, assessing pain, function/activity, self-image, mental health, and satisfaction with treatment[2]. Notably, the self-image and mental health domains have been shown to correlate closely with adolescents' subjective experience of scoliosis and often demonstrate greater impairment than physical domains, even in patients with relatively modest curve magnitudes[3].

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Previous studies have examined potential determinants of HRQoL in AIS, but their findings remain inconsistent. Some investigations have reported that larger Cobb angles are associated with poorer self-image and psychological outcomes, whereas more recent evidence suggests that the association between radiographic severity and HRQoL is weak or absent[4,5]. Likewise, the influence of curve location whether proximal thoracic, main thoracic, or thoracolumbar/lumbar on HRQoL remains unclear. While thoracic curves have traditionally been considered more cosmetically deforming due to rib prominence and trunk asymmetry, empirical data on the relationship between curve topography and HRQoL have been inconclusive. These discrepancies highlight the need for further research examining the interplay between curve magnitude, curve location, and multidimensional HRQoL outcomes. In particular, clarifying whether radiological parameters predict psychosocial domains such as self-image and mental health is essential for guiding holistic clinical decision making and identifying adolescents who may require additional psychological support[6].

Therefore, the present study aims to analyze domain-specific SRS-22 scores in relation to curve magnitude and curve location in a cohort of adolescents with idiopathic scoliosis. Despite increasing attention to psychosocial outcomes in AIS, few studies have simultaneously evaluated the independent contributions of curve magnitude, curve location, and domain-specific HRQoL within a single, well-defined cohort. Existing reports commonly rely on heterogeneous severity groups, merge distinct curve patterns, or emphasize global SRS-22 scores rather than subdomain-level analysis.

The present study provides a novel contribution by isolating the effects of radiographic parameters on individual SRS-22 domains particularly self-image and mental health thereby enabling a more precise characterization of the psychosocial determinants of HRQoL in AIS. By evaluating both physical and psychosocial components of HRQoL concurrently, this study seeks to clarify whether radiographic characteristics meaningfully influence perceived health status and emotional well-being in adolescents with idiopathic scoliosis.

MATERIALS AND METHODS

This was a single-center cross-sectional observational study based on consecutively collected clinical data. Adolescents diagnosed with AIS were consecutively recruited and evaluated during routine visits to the orthopedic outpatient clinic of a university hospital. All clinical, radiographic, and patient-reported outcome data were collected at the time of presentation. This single-center, clinical study, patient data were prospectively evaluated after obtaining ethical committee approval from Ondokuz Mayıs University Clinical Research Ethics Committee (approval no: 2025/305, date: 11.06.2025). All patients and their legal guardians were informed about the study procedures, and both verbal and written consent were obtained in accordance with the Declaration of Helsinki.

Study Population

A total of 65 patients between 10 and 18 years of age were enrolled. Inclusion criteria were diagnosis of AIS with a structural curve of at least 10° measured by Cobb method; availabilty of standardized standing posteroanterior (PA) full-spine radiographs, and ability to independently complete the validated Turkish version of the SRS-22 questionnaire. Patients were excluded if they had non idiopathic scoliosis (congenital, neuromuscular, or syndromic), a history of spinal surgery or active brace treatment, incomplete radiographic data, or any cognitive/psychiatric condition that could interfere with questionnaire responses.

Radiographic Assessment

All participants underwent standardized standing PA full-spine radiography. Curve magnitude was measured using the Cobb method by two independent raters experienced in spinal deformity assessment. Based on the location of the apical vertebra, curves were classified into three categories: proximal thoracic (T1-T5), main thoracic (T6-T12; Figure 1A), and thoracolumbar/lumbar (T12-L4; Figure 1B). Double thoracic curve patterns are illustrated separately (Figure 1C). Skeletal maturity was assessed using the Risser staging system. Interobserver reliability for Cobb angle measurements was evaluated in a random subsample using intraclass correlation coefficients.

Patient-reported Outcomes

Participants completed the validated Turkish version of the SRS-22 questionnaire, which assesses HRQoL across five domains: pain, function/activity, self-image, mental health, and satisfaction with management. All questionnaires were administered and collected on the same day as the radiographic evaluation.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics (version 21; IBM Corp., Armonk, NY). Data were first examined for normality using the Shapiro-Wilk test. Because SRS-22 scores displayed non-normal distributions, non-parametric methods were employed for group comparisons.

The Kruskal-Wallis H test was used to compare SRS-22 scores across curve location groups. Within-subject differences among the five SRS-22 domains were evaluated using the Friedman test, followed by Bonferroni-corrected Wilcoxon signed-rank tests for pairwise comparisons. Relationships between curve magnitude and SRS-22 domain scores were assessed using Spearman's rank correlation coefficients. Statistical significance was set at $p<0.05$.

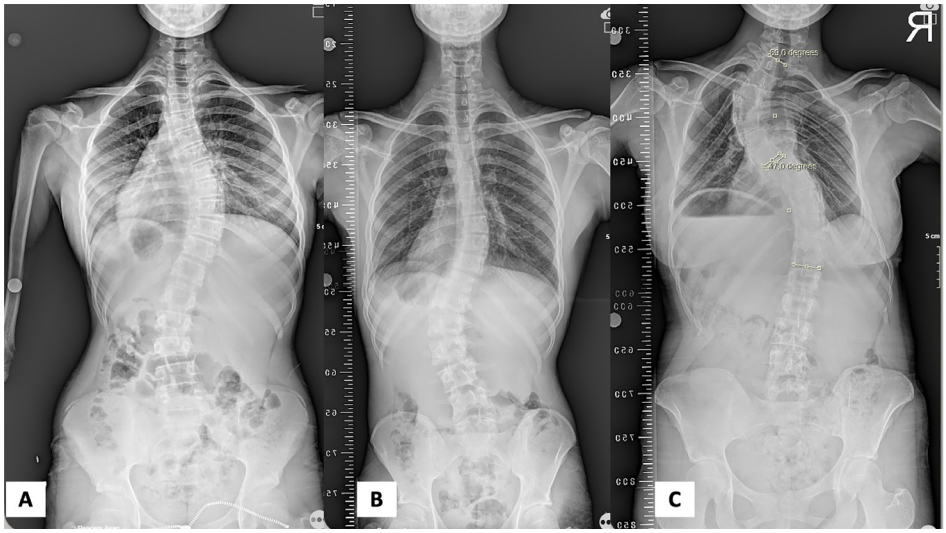

Figure 1. Representative radiographic patterns of scoliosis according to curve localization. **(A)** Main thoracic curve, **(B)** thoracolumbar curve, and **(C)** double thoracic curve

RESULTS

Participant Characteristics

The study included 65 adolescents with AIS. The mean age of the cohort was 15.01±3.47 years (range: 10-18 years). The mean Cobb angle was 24.6±17.2°. When categorized according to curve severity, 37 patients (56.9%), had mild curves (<25°), 25 patient (38.5%) had moderate curves (25-45°), and 3 patients (4.6%) had severe curves (>45°). Regarding skeletal maturity, Risser stage distribution was as follows: stage 1 in 1 patient (1.5%), stage 2 in 1 patient (1.5%), stage 3 in 9 patient (13.8%), stage 4 in 37 patient (56.9%), and stage 5 in 17 patients (26.2%). The most common curve type was thoracolumbar (n=33, 50.8%), followed by main thoracic curves (n=26, 40.0%) and proximal thoracic curves (n=6, 9.2%) (Table 1).

Table 1. Demographic and clinical characteristics of the study cohort

Variable	Value
Age, years (mean ± SD)	15.01±3.47
Gender	n (%)
Female	44 (67.7%)
Male	21 (32.3%)
Curve type	n (%)
Proximal thoracic	6 (10.8%)
Main thoracic	26 (38.5%)
Thoracolumbar/lumbar	33 (50.8%)
Risser stage	
0-1	1 (1.5%)
2-3	10 (15.4%)
4-5	54 (83.1%)

SD: Standard deviation

Differences Across SRS-22 Subscale Scores

The Friedman test demonstrated significant differences across the five SRS-22 subdomains [$\chi^2(4, n=65)=78.18$, $p<0.001$], indicating heterogeneous perceptions of HRQoL within the cohort.

Post-hoc pairwise analyses with Bonferroni correction showed that self-image scores were significantly lower than pain ($p<0.001$), function/activity ($p<0.001$), and satisfaction with treatment ($p=0.011$). Mental health scores were significantly lower than pain ($p=0.001$) and function/activity ($p<0.001$). Satisfaction with treatment was significantly lower compared with pain ($p=0.039$) and function/activity ($p=0.001$). No significant differences were found between pain and function/activity ($p=1$), or between self-image and mental health ($p=0.229$).

These results demonstrate that psychosocial domains (self-image and mental health) were more impaired than physical domains. Descriptive statistics for all subdomains are presented Table 2.

SRS-22 Scores by Curve Localization

Kruskal-Wallis tests revealed no significant differences across the three curve location groups for the SRS-22 scores or any of the subdomains (all $p>0.05$). This suggests that curve location (proximal thoracic vs. main thoracic vs. thoracolumbar/lumbar) did not significantly influence perceived HRQoL. Curve group comparisons are provided in Table 3.

Correlations Between Curve Magnitude and SRS-22 Subdomains

Spearman correlation analysis revealed no significant associations between Cobb angle magnitude and SRS-22 domain scores. Detailed correlation results are presented in Table 4.

Table 2. SRS-22 domain scores and descriptive statistics

	Mean ± SD	Median (minimum-maximum)	p-value
Pain	4.03±0.75	4.20 (1.60-5.00)	<0.001
Self-image	3.22±0.77	3.20 (1.00-4.80)	
Function/activity	4.13±0.74	4.20 (2.00-5.00)	
Mental health	3.50±0.71	3.40 (1.80-4.80)	
Treatment satisfaction	3.60±0.85	3.50 (1.50-5.00)	

Overall between-domain comparion was performed using the Friedman test, SD: Standard deviation

Table 3. Comparison of SRS-22 domain scores across curve location groups

Domain	Proximal thoracic (n=7)	Main thoracic (n=25)	Thoracolumbar (n=33)	p-value
Pain	22.07	31.32	36.59	0.149
Function	31.21	29.48	36.05	0.402
Self-image	27.86	29.88	36.45	0.313
Mental health	33.71	37.80	29.21	0.226
Satisfaction	36.29	29.38	35.05	0.456

Kruskall-Wallis test, SRS-22: Scoliosis research society-22

Table 4. Correlation between Cobb angle and SRS-22 domain scores

Variable	Spearman's ρ	p-value
Pain	-0.111	0.380
Function	-0.170	0.177
Self-image	-0.169	0.179
Mental health	-0.121	0.339
Treatment satisfaction	-0.225	0.071

Spearman rank correlation test (two-tailed), SRS-22: Scoliosis research society-22

Influence of Demographic Variables

Age and sex were not significantly associated with either SRS-22 total scores or with the psychosocial domains of self-image and mental health (all p>0.05). These findings indicate that HRQoL outcomes were largely independent of demographic characteristics in this cohort.

Clinical Interpretation and Implications

Overall, the lowest SRS-22 scores were observed in the self-image and mental health domains. Neither curve magnitude nor curve location significantly influenced HRQoL. Psychosocial factors, rather than radiographic severity or anatomical curve pattern, appear to play a stronger role in shaping adolescents' perceived well-being.

DISCUSSION

This study examined the extent to which radiographic parameters specifically curve magnitude and curve location are associated with HRQoL in AIS. Our results demonstrated that the psychosocial domains of the SRS-22, particularly self-image and mental health, were the most adversely affected components, whereas pain and function scores remained relatively preserved. Importantly, neither curve magnitude nor curve location emerged as significant determinants of HRQoL, and no demographic variables showed meaningful associations with patient-reported outcomes. These findings support the growing body of evidence suggesting that psychosocial morbidity in AIS is only modestly correlated with the underlying radiographic deformity.

Our findings are consistent with previous studies indicating that AIS disproportionately affects body image and emotional well-being. Torén and Diarbakerli[4] reported significantly lower SRS-22 self-image and mental health scores among adolescents with AIS compared with healthy controls, despite similar functional capacity. Similarly, Sanders et al.[7] demonstrated that adolescents with AIS frequently experience emotional distress and altered body perception independent of curve severity. Parent et al.[8] further reported that psychosocial domains, particularly self-image, show greater variability than physical domains across severity strata, suggesting that these outcomes are more strongly influenced by subjective perception than by radiographic metrics.

This relationship is further supported by studies directly evaluating body image disturbances in AIS. Auerbach et al.[9] validated the body image disturbance questionnaire-short form (BIDQ-S) as a sensitive instrument for detecting body image disturbance and reported strong correlations with psychological distress. Likewise, brace-related investigations by Pezham et al.[10] demonstrated that perceived deformity, rather than curve magnitude, was the primary determinant of stress levels during conservative management. Collectively, these studies indicate that the clinical burden of AIS is often mediated through psychosocial pathways rather than through biomechanical impairment alone.

Although thoracic curves may theoretically produce greater cosmetic deformity due to rib prominence and shoulder asymmetry, our findings demonstrated no significant differences in SRS-22 outcomes between proximal thoracic, main thoracic, and thoracolumbar/lumbar curve patterns. This observation aligns with recent research challenging the traditional assumption that curve topography directly influences psychosocial burden. Belli et al.[11] reported no significant effect of curve location on self-image or mental health after adjusting for demographic and psychological variables. Similarly, Horne et al.[12] concluded that curve pattern does not independently determine HRQoL once global trunk asymmetry is considered.

Evidence from aesthetic assessment instruments such as the Walter Reed visual assessment scale (WRVAS) and trunk appearance perception scale (TAPS) suggest that patients perceive spinal deformity holistic manner. Features such as trunk shift, waist asymmetry, and shoulder appear to correlate more strongly with patient-reported outcomes than with the anatomical apex of curvature[13,14]. This holistic perception of deformity may explain why curve location exerted minimal influence on HRQoL in our cohort.

Another central finding of this study was the absence of significant correlations between Cobb angle and domain-specific SRS-22 scores. This observation is consistent with several studies demonstrating that radiographic severity is a relatively poor predictor of psychosocial morbidity in AIS. Cheung et al.[15] reported that curve magnitude accounted for only a small proportion of variance in HRQoL scores, while Parent et al.'s[8] systematic review similarly concluded that radiographic indicators correlate only modestly with psychosocial outcomes. Berliner et al.[16] emphasized that psychosocial scores may vary widely among patients with comparable Cobb angles, highlighting the role of perceptual and contextual factors. Likewise, Hresko et al.[17] demonstrated that subjective deformity perception is a stronger determinant of body-image distress than objective radiographic severity.

Importantly, Belli et al.[11] showed that even mild scoliosis (<25°) can significantly impair self-image, and Turkish studies by Çolak et al.[18] and Çubukçu and Bilir[19] demonstrated stronger associations between perceived deformity and HRQoL than between Cobb angle and HRQoL. Taken together, these findings substantiate our conclusion that radiographic severity carries limited prognostic value for psychosocial outcomes.

Neither age nor sex demonstrated a significant relationship with HRQoL in our cohort. D'Agata et al.[20] similarly reported that emotional indicators in AIS reflect individual perception of deformity rather than chronological age. Sanders et al.[7] found that approximately one-third of AIS patients exhibit clinically significant psychological distress, primarily associated with perceived deformity rather than demographic characteristics.

These findings have several implications for clinical practice. First, radiographic parameters alone should not be used to infer psychosocial burden, as adolescents with relatively mild curves may experience substantial emotional distress, whereas others with more pronounced deformities may demonstrate adequate coping. Second, incorporating routine psychosocial screening into AIS assessment using instruments such as the SRS-22, BIDQ-S, WRVAS, or TAPS may facilitate earlier identification of vulnerable patients. Third, multidisciplinary management strategies, including psychological counseling, body-image interventions, and peer support programs, may be beneficial for patients experiencing significant emotional distress. Finally, clinical decision-making should integrate both objective radiographic risk and patient-reported outcomes, acknowledging that these domains do not always align.

Study Limitations

This study has several limitations. First, the cross-sectional design does not allow conclusions regarding causal relationships between radiographic parameters and HRQoL outcomes. Second, the sample size was moderate and derived from a single center, which may limit the generalizability of the findings. Third, AIS is a three-dimensional deformity; however, only the coronal Cobb angle was evaluated in this study, while other deformity parameters such as axial rotation, thoracic kyphosis, and trunk balance were not analyzed. Finally, most patients in our cohort were in Risser stages 4-5, indicating skeletal maturity. Therefore, the findings may not fully represent psychosocial outcomes in skeletally immature AIS patients.

CONCLUSION

In summary, psychosocial domains particularly self-image and mental health were the most adversely affected HRQoL components in adolescents with idiopathic scoliosis. Radiographic parameters such as curve magnitude and curve location, as well as demographic characteristics, demonstrated minimal impact on patient-reported outcomes. These findings highlight the critical importance of integrating psychosocial evaluation into AIS management and underscore the limited value of radiographic severity as a surrogate marker for adolescents' lived experience of scoliosis. A novel contribution of this study is its domain-specific approach, which isolates the independent effects of curve magnitude and curve location on each SRS-22 domain rather than relying on global HRQoL scores. By demonstrating that psychosocial impairment persists irrespective of radiographic characteristics, this work provides evidence that AIS care should shift toward patient-centered models prioritizing body image perception and emotional well-being.

Ethics

Ethics Committee Approval: This single-center, clinical study, patient data were prospectively evaluated after obtaining ethical committee approval from Ondokuz Mayıs University Clinical Research Ethics Committee (approval no: 2025/305, date: 11.06.2025).

Informed Consent: Written and verbal consent was obtained from all participants.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: B.A., A.A., H.S.C., Concept: B.N.Ö.E., A.U., H.S.C., Design: B.N.Ö.E., A.U., H.S.C., Data Collection or Processing: B.N.Ö.E., B.A., A.A., H.S.C., Analysis or Interpretation: B.N.Ö.E., Literature Search: B.N.Ö.E., A.U., H.S.C., Writing: B.N.Ö.E., H.S.C.

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ORIGINAL ARTICLE

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COMPARISON OF CLINICAL, LABORATORY, AND RADIOLOGICAL CHARACTERISTICS OF SPONDYLODISCITIS ACCORDING TO ETIOLOGY: A 10-YEAR SINGLE-CENTER RETROSPECTIVE STUDY

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ABSTRACT

Objective: This study aimed to compare the clinical, laboratory, and radiological characteristics of spondylodiscitis caused by pyogenic microorganisms, *Brucella* spp., and *Mycobacterium tuberculosis*.

Materials and Methods: Patients diagnosed with spondylodiscitis at a single-center between January 2014 and December 2024 were retrospectively reviewed. Contrast-enhanced magnetic resonance imaging (MRI) was performed in all cases during the diagnostic evaluation. Patients were categorized into three groups according to etiology: pyogenic spondylodiscitis (PSD), brucellar spondylodiscitis (BSD), and tuberculous spondylodiscitis (TSD). The diagnosis was established based on clinical presentation, laboratory findings, and MRI features and supported by microbiological and/or histopathological confirmation when available.

Results: A total of 122 patients were included: 81 (66.4%) with PSD, 29 (23.8%) with BSD, and 12 (9.8%) with TSD. The mean age was significantly higher in the PSD group (p=0.009). Motor neurological deficits were more frequently observed in patients with TSD (p<0.001). Pre-treatment and follow-up C-reactive protein levels were significantly higher in the PSD group than those in the other groups (p<0.05). Lumbar involvement was the most common site across all groups. Abscess formation was observed most frequently in PSD, and paravertebral abscesses were the predominant type. Patients who underwent surgical treatment achieved high rates of clinical and laboratory remission. Antibiotic therapy was continued for at least six weeks in those who achieved remission.

Conclusion: Clinical presentation, inflammatory response, and neurological involvement in spondylodiscitis vary according to the causative pathogen. Recognition of these etiology-related differences may facilitate earlier diagnosis and guide appropriate treatment strategies, thereby improving infection control and reducing the risk of neurological complications.

Keywords: Spondylodiscitis, pyogenic, Brucella, tuberculosis, spinal infections

INTRODUCTION

Spondylodiscitis is an infection involving the vertebral bodies and the intervertebral disc space and may lead to substantial morbidity when diagnosis and treatment are delayed[1]. The clinical presentation is frequently non-specific and commonly includes back or thoracic pain, fever, and general malaise[2]. Because of these non-specific symptoms, diagnosis may be delayed, particularly in elderly individuals and patients with multiple comorbidities, increasing the risk of neurological complications[3].

Pyogenic microorganisms are the most frequent causative agents of spondylodiscitis; however, specific pathogens such as *Brucella* spp. and *Mycobacterium tuberculosis* also contribute significantly to the disease burden[4-6]. The clinical course and radiological features of the infection may vary depending on the causative organism. Pyogenic spondylodiscitis (PSD) generally presents with an acute clinical course and a marked inflammatory response. In contrast, tuberculous spondylodiscitis (TSD) often develops insidiously and may lead to delayed diagnosis and a higher rate of neurological deficits. Brucellar spondylodiscitis (BSD) is particularly relevant in endemic regions, where serological tests play a key role in the diagnostic process[6-8].

Management of spondylodiscitis requires a multidisciplinary approach involving infectious disease specialists, radiologists, and spine surgeons. Early identification of the causative organism is essential for selecting appropriate antimicrobial therapy, determining surgical indications, and preventing neurological deterioration. Nevertheless, studies directly comparing the clinical, laboratory, and radiological

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characteristics of different etiological forms of spondylodiscitis remain relatively limited. Country-specific data are particularly valuable in regions where infections such as brucellosis remain endemic. Magnetic resonance imaging (MRI) is currently considered the primary imaging modality for the diagnosis of spondylodiscitis and for evaluating the extent of infection and associated complications[3,9].

The present study aimed to compare the clinical, laboratory, and radiological features of pyogenic, brucellar, and TSD in patients treated at a single-center over a 10-year period and to evaluate how etiological differences influence the clinical management of this disease.

MATERIALS AND METHODS

Study Design and Patient Selection

This retrospective observational study evaluated patients who were diagnosed with spondylodiscitis and followed at a single-center between January 2014 and December 2024. Ethical approval was obtained from the Scientific Research Ethics Committee of University of Health Sciences Türkiye, Erzurum Faculty of Medicine (approval no: 2026/01-29, date: 14.01.2026).

Contrast-enhanced MRI was performed in all patients during the diagnostic evaluation, and radiological assessment was based on these images.

Patients aged 18 years or older with a diagnosis of spondylodiscitis based on clinical findings, laboratory parameters, and radiological evidence were eligible for inclusion. A minimum follow-up period of six months was required. Patients with incomplete clinical data, missing radiological imaging, or insufficient follow-up were excluded from the study.

Diagnostic Criteria and Etiological Classification

The diagnosis of spondylodiscitis was established through a combined evaluation of clinical findings (vertebral pain, fever, weight loss), laboratory parameters [elevated C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR)], and contrast-enhanced MRI findings. Etiological diagnosis was supported by microbiological and/or histopathological confirmation when available.

Patients were classified into three groups according to the etiological agent:

- **PSD:** Diagnosis was based on compatible clinical and radiological findings together with the isolation of pyogenic bacteria from blood cultures, tissue cultures, or surgical specimens, or on a favorable clinical and laboratory response to antibiotic therapy.
- **BSD:** Patients with a serum tube agglutination test titer ⩾1:160 and/or positive Coombs anti-*Brucella* test, in conjunction with clinical and radiological findings consistent with spondylodiscitis, were classified as BSD. Culture positivity, when present, was considered confirmatory.
- **TSD:** Diagnosis was established based on positive *Mycobacterium tuberculosis* culture results, histopathological evidence of granulomatous inflammation, or a favorable clinical and radiological response to antituberculous therapy.

Clinical and Demographic Data

Patient data including age, sex, comorbidities (hypertension, diabetes mellitus, cardiovascular diseases), history of previous spinal surgery, and presenting symptoms (vertebral pain, fever, weight loss) were recorded. Neurological status was evaluated based on clinical examination, with particular attention to the presence of motor deficits.

Laboratory Evaluation

Laboratory parameters measured before treatment and during follow-up were retrospectively reviewed for all patients. Evaluated parameters included CRP, ESR, and white blood cell (WBC) count. CRP values were comparatively analyzed at baseline, at the first month, and at the third month of treatment.

Radiological Evaluation

All patients underwent contrast-enhanced MRI at the time of diagnosis. MRI findings were evaluated for vertebral body and intervertebral disc involvement consistent with spondylodiscitis, bone marrow edema, signal changes within the disc space, and the presence of associated epidural, paravertebral, or psoas abscesses. Computed tomography was used when necessary for a more detailed assessment of bony destruction (Figure 1). The level of involvement was classified as cervical, thoracic, or lumbar.

Microbiological Assessment

Results of blood cultures and cultures obtained from biopsy or intraoperative tissue specimens were recorded. Isolated microorganisms were classified according to etiology. Serological test results were considered for brucellar cases, while culture and histopathological findings were evaluated for tuberculous cases.

Surgical Treatment and Antibiotic Management

Surgical intervention was considered in patients presenting with progressive neurological deficit, spinal instability, failure of conservative treatment, advanced vertebral destruction, or epidural or paravertebral abscess formation.

The choice of surgical approach was determined individually according to the patient's clinical status, the level of involvement, and the suspected etiological agent.

Spinal instrumentation was performed when mechanical instability was present or when stabilization was required after decompression. Previous studies have demonstrated that active infection does not represent an absolute contraindication to spinal stabilization.

In patients requiring surgical treatment, the timing of surgery was determined according to clinical and radiological findings. Patients presenting with neurological deficits, epidural abscess,

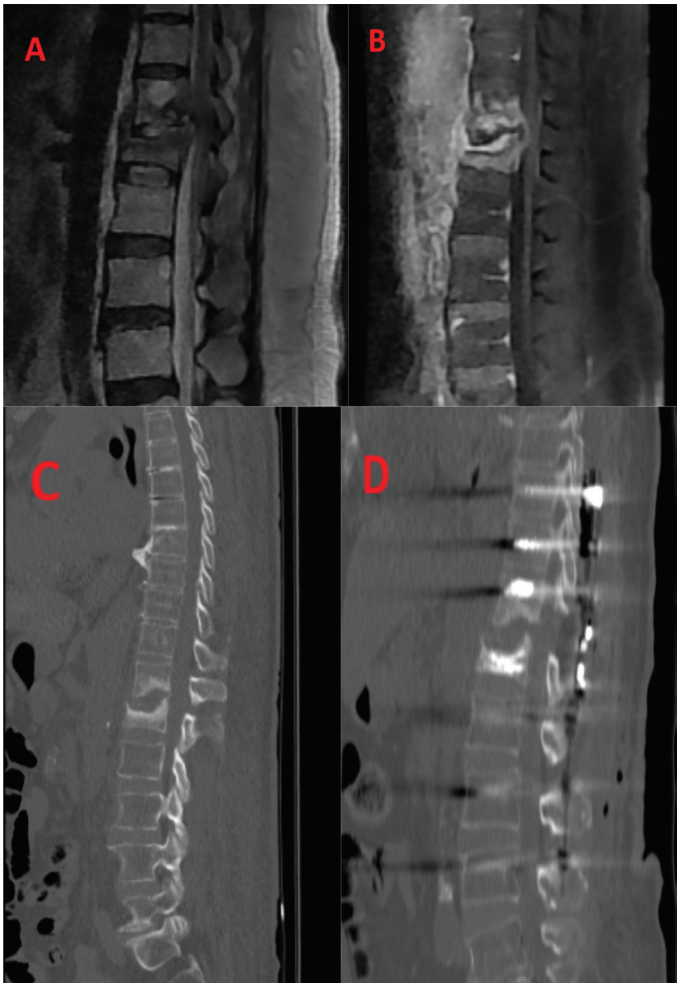

Figure 1. (**A**) Preoperative MRI demonstrating destructive spondylodiscitis at the T12-L1 level with epidural canal invasion in a patient presenting with neurological deficit. (**B**) Preoperative contrast-enhanced MRI of the same patient showing enhancement consistent with infectious involvement. (**C**) Preoperative CT image demonstrating bony destruction at the T12-L1 level. (**D**) Postoperative imaging of the same patient after surgical treatment showing debridement, posterior stabilization, and vertebroplasty performed for infection control and spinal stability. MRI: Magnetic resonance imaging, CT: Computed tomography

severe vertebral destruction, or spinal instability underwent surgical intervention at the time of diagnosis. Patients who developed clinical or radiological progression during conservative treatment underwent surgery during the follow-up period.

Whenever possible, tissue samples were obtained before the initiation of antibiotic therapy. Percutaneous or open biopsy was performed for microbiological culture and antibiogram analysis. Antibiotic treatment was adjusted according to microbiological results when available. In patients with severe clinical signs of infection, empirical antibiotic therapy was started after biopsy and later modified according to culture findings.

Treatment adequacy was evaluated based on clinical improvement, reduction of inflammatory markers, and stabilization of radiological findings.

All patients initially received etiology-specific intravenous antibiotic therapy, followed by oral treatment depending on clinical response and laboratory parameters. In patients who achieved clinical and laboratory remission, antibiotic therapy was continued for at least six weeks.

Statistical Analysis

Statistical analyses were performed using SPSS software. Continuous variables were expressed as mean ± standard deviation, and categorical variables as numbers and percentages. Group comparisons were conducted using analysis of variance or the Kruskal-Wallis test for continuous variables, and the chi-square test or Fisher's exact test for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Characteristics

A total of 122 patients were included in the study. Of these, 81 patients (66.4%) were diagnosed with PSD, 29 patients (23.8%) with BSD, and 12 patients (9.8%) with TSD. The mean age was significantly higher in the PSD group compared with the other groups (p=0.009). There was no statistically significant difference in sex distribution among the groups (p=0.240).

Evaluation of comorbidities revealed that hypertension and cardiovascular disease were significantly more frequent in the PSD group (p=0.028 and p=0.047, respectively). A history of previous spinal surgery was also significantly more common in the PSD group compared with the other groups (p=0.001).

The most common presenting symptom was vertebral pain, observed in 95.9% of all patients. Weight loss and motor neurological deficits were significantly more frequent in patients with TSD (p=0.006 and p<0.001, respectively) (Table 1).

Laboratory Findings

Pre-treatment CRP and ESR levels were significantly higher in the PSD group compared with the other groups. CRP levels in the PSD group remained higher at both the first and third months of treatment. WBC counts were generally similar among the groups (Table 2).

Radiological Findings

Radiological evaluation revealed that lumbar vertebral involvement was the most common localization across all groups (49.2%). Abscess formation was detected in 55.7% of the patients. Abscesses were more frequently observed in the PSD group, with paravertebral abscess being the most common abscess type (Table 3).

Microbiological Findings

In the PSD group, *Staphylococcus aureus* was the most frequently isolated pathogen, followed by Gram-negative bacteria. In the majority of patients diagnosed with BSD, the diagnosis was established based on serological tests, while culture

positivity was detected in a limited number of cases. In the TSD group, a substantial proportion of patients demonstrated culture positivity for *Mycobacterium tuberculosis*. Overall, microbiological findings highlighted differences in diagnostic approaches according to the etiological agent (Table 4).

Surgical Treatment and Clinical Outcomes

In patients who underwent surgical treatment, effective pain control was achieved in the early postoperative period, allowing early mobilization. No cases of infection control failure or implant-related complications were observed in patients who received spinal instrumentation.

Clinical remission was defined as marked improvement or resolution of vertebral pain, normalization of body temperature, and normalization of inflammatory markers (CRP and ESR). In patients who met these criteria, antibiotic therapy was completed for a minimum duration of six weeks. Clinical and laboratory remission rates were high among surgically treated patients (Table 5).

Table 1. Demographic and clinical characteristics of patients according to etiology

Characteristic	PSD (n=81)	BSD (n=29)	TSD (n=12)	Total (n=122)	p-value
Age, mean ± SD (years)	60.8±12.9	52.2±13.7	49.3±19.4	57.6±14.6	0.009
Male sex, n (%)	40 (49.4)	19 (65.5)	5 (41.7)	64 (52.5)	0.240
Hypertension, n (%)	25 (30.9)	2 (6.9)	2 (16.7)	29 (23.8)	0.028
Diabetes mellitus, n (%)	21 (25.9)	3 (10.3)	4 (33.3)	28 (23.0)	0.154
Cardiovascular disease, n (%)	11 (13.6)	0	0	11 (9.0)	0.047
History of spinal surgery, n (%)	27 (33.3)	1 (3.4)	0	28 (23.0)	0.001
Vertebral pain, n (%)	79 (97.5)	27 (93.1)	11 (91.7)	117 (95.9)	0.433
Fever, n (%)	31 (38.3)	15 (51.7)	6 (50.0)	52 (42.6)	0.391
Weight loss, n (%)	10 (12.3)	7 (24.1)	6 (50.0)	23 (18.9)	0.006
Motor neurological deficit, n (%)	3 (3.7)	0	4 (33.3)	7 (5.7)	<0.001

PSD: Pyogenic spondylodiscitis, BSD: Brucellar spondylodiscitis, TSD: Tuberculous spondylodiscitis, SD: Standard deviation

Table 2. Laboratory findings according to etiology

Laboratory parameter	PSD	BSD	TSD	Total	p-value
Pre-treatment CRP (mg/L), mean ± SD	88.0±79.9	42.2±32.8	68.4±73.8	75.2±73.1	0.036
CRP at 1 month (mg/L), mean ± SD	40.4±45.2	15.1±18.7	38.7±42.5	34.3±41.4	0.007
CRP at 3 months (mg/L), mean ± SD	21.6±31.8	9.1±12.9	19.6±23.9	18.5±28.0	0.045
Pre-treatment ESR (mm/h), mean ± SD	67.3±33.5	48.9±30.3	61.6±32.4	62.3±33.3	0.048
Pre-treatment WBC ($\times 10^9$/L), mean ± SD	Similar among groups	Similar among groups	Similar among groups	-	>0.05

PSD: Pyogenic spondylodiscitis, BSD: Brucellar spondylodiscitis, TSD: Tuberculous spondylodiscitis, CRP: C-reactive protein, WBC: White blood cell, SD: Standard deviation

Table 3. Radiological findings according to etiology

Radiological finding	PSD n (%)	BSD n (%)	TSD n (%)	Total n (%)
Lumbar involvement	44 (54.3)	13 (44.8)	3 (25.0)	60 (49.2)
Thoracic involvement	15 (18.5)	9 (31.0)	5 (41.7)	29 (23.8)
Abscess presence	54 (66.7)	8 (27.6)	6 (50.0)	72 (55.7)
Paravertebral abscess	39 (48.1)	6 (20.7)	2 (16.7)	47 (39.3)

PSD: Pyogenic spondylodiscitis, BSD: Brucellar spondylodiscitis, TSD: Tuberculous spondylodiscitis

Table 4. Microbiological findings according to etiology

Microorganism	PSD n (%)	BSD n (%)	TSD n (%)	Total n (%)
Staphylococcus aureus	24 (29.7)	-	-	24 (19.7)
Escherichia coli	6 (7.4)	-	-	6 (4.9)
Mycobacterium tuberculosis	-	-	8 (66.7)	8 (6.6)
Brucella spp.	-	2 (6.9)	-	2 (1.6)

PSD: Pyogenic spondylodiscitis, BSD: Brucellar spondylodiscitis, TSD: Tuberculous spondylodiscitis

Table 5. Surgical treatment and clinical outcomes

Parameter	Surgically treated (n=48)	Conservatively treated (n=74)	p-value
Motor neurological deficit, n (%)	6 (12.5)	1 (1.4)	<0.001
Presence of abscess, n (%)	39 (81.3)	33 (44.6)	<0.001
Instrumentation, n (%)	31 (64.6)	-	-
Antibiotic duration ⩾6 weeks, n (%)	44 (91.7)	60 (81.1)	0.048
Clinical remission, n (%)	43 (89.6)	63 (85.1)	0.412
Treatment failure/recurrence, n (%)	5 (10.4)	11 (14.9)	0.356

DISCUSSION

The findings of this study demonstrate that the clinical presentation and laboratory characteristics of spondylodiscitis vary considerably according to the causative pathogen. PSD was more common in older patients and was more frequently associated with comorbid conditions such as hypertension and cardiovascular disease. These observations are consistent with previous studies reporting that degenerative changes, previous surgical procedures, and systemic diseases increase susceptibility to pyogenic spinal infections[10].

In addition, inflammatory markers such as CRP and ESR were significantly higher in patients with PSD. This finding likely reflects the more aggressive inflammatory response typically associated with acute bacterial infections. The higher frequency of previous spinal surgery in the pyogenic group may also indicate the role of postoperative infections as an important etiological factor.

Patients with TSD demonstrated higher rates of weight loss and neurological deficits. The insidious course of spinal tuberculosis often results in delayed diagnosis, allowing progressive vertebral destruction and increasing the likelihood of neurological complications[7,11]. These results highlight the importance of considering tuberculosis in the differential diagnosis of patients presenting with persistent back pain, particularly in regions where the disease remains prevalent.

In the BSD group, serological testing played a central role in diagnosis. Culture positivity was relatively limited, which is consistent with previous reports emphasizing the diagnostic value of serological tests in brucellosis[6,8,12,13]. Although the clinical course of brucellar infection is generally milder compared with other forms of spondylodiscitis, delayed diagnosis may still lead to serious complications.

Radiological findings in our cohort showed that lumbar involvement was the most common localization regardless of etiology. This observation has also been reported in previous studies evaluating spinal infections[5,14]. Abscess formation occurred more frequently in pyogenic cases, suggesting a more aggressive inflammatory process. The presence of abscesses is also an important factor influencing the decision for surgical intervention.

The results of this study emphasize the importance of an etiology-based approach in the management of spondylodiscitis. Tuberculous infections require careful neurological monitoring and early recognition of surgical indications due to their progressive nature. In brucellar infections, conservative treatment with appropriate antibiotic therapy is often sufficient when diagnosis is established early. In contrast, pyogenic infections frequently require rapid diagnosis and targeted antimicrobial therapy, and surgical treatment may be necessary when abscess formation or neurological compromise occurs.

In our cohort, surgically treated patients achieved favorable outcomes with effective infection control. The absence of implant-related complications in instrumented patients supports previous studies suggesting that spinal stabilization can be safely performed even in the presence of active infection[15-17]. In addition, continuation of antibiotic therapy for at least six weeks after clinical remission appears to contribute significantly to treatment success[18].

Although the presence of motor neurological deficits and abscess formation was higher in patients who underwent surgical treatment, the similarity of clinical remission rates compared with patients managed conservatively indicates that surgical treatment is an effective and safe option when appropriately indicated[19]. Nevertheless, conservative management was also effective in selected patients without neurological deficits or mechanical instability. Careful clinical and laboratory monitoring allowed adequate infection control in these cases without the need for surgical intervention[20].

Study Limitations

This study has several limitations. Its retrospective design and single-center setting may limit the generalizability of the findings. In addition, diagnostic approaches and treatment strategies may have changed over the 10-year study period. Culture negativity in some patients, particularly in pyogenic and brucellar infections, also limited the microbiological evaluation. Despite these limitations, the inclusion of a relatively large patient cohort and the comparative evaluation of different etiological groups represent important strengths of this study.

CONCLUSION

Spondylodiscitis is a complex spinal infection characterized by variable clinical course, inflammatory response, and neurological involvement depending on the etiological agent. While inflammatory markers are more pronounced in PSD, weight loss and neurological deficits are more frequently observed in tuberculous cases. In BSD, serological testing plays

a key role in diagnosis. In patients who underwent surgical treatment and achieved clinical and laboratory remission, successful infection control can be achieved with etiology-specific antibiotic therapy administered for at least six weeks. Early recognition of these etiology-specific differences is critical for selecting appropriate treatment strategies and preventing potential neurological complications.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Scientific Research Ethics Committee of University of Health Sciences Türkiye, Erzurum Faculty of Medicine (approval no: 2026/01-29, date: 14.01.2026).
Informed Consent: Retrospective observational study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: N.P., B.P., Concept: N.P., B.P., Design: N.P., B.P., Data Collection or Processing: N.P., B.P., Analysis or Interpretation: N.P., B.P., Literature Search: N.P., B.P., Writing: N.P., B.P.
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LANGERHANS CELL HISTIOCYTOSIS OF THE SPINE: T12 VERTEBRAL DESTRUCTION AND SPINAL CORD COMPRESSION IN A 49-YEAR-OLD ADULT: A CASE REPORT

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ABSTRACT

Langerhans cell histiocytosis (LCH) is a rare clonal disorder that predominantly affects children, while adult spinal involvement is uncommon. We report a 49-year-old woman presenting with thoracic back pain and progressive lower extremity weakness. Imaging revealed a destructive lytic lesion of the T12 vertebra with epidural extension causing spinal cord compression, initially suggestive of infection or metastasis. Histopathological examination confirmed LCH. The patient underwent posterior decompression, instrumentation, and T12 hemicorpectomy, resulting in rapid neurological improvement. This case highlights the diagnostic challenge of adult spinal LCH and the importance of timely surgical management in the presence of neurological compromise.

Keywords: Langerhans cell histiocytosis, eosinophilic granuloma, spinal cord compression

INTRODUCTION

Langerhans cell histiocytosis (LCH) is a rare disease characterized by the clonal proliferation of Langerhans cells[1]. It is widely variable in the clinical manifestation; it may manifest as a single bone lesion or as a multisystemic disorder that may be fatal[2]. Generally, LCH affects children under the age of 15, with an incidence of approximately 8.9 per million in this age group. In contrast, its occurrence in adults is much rarer, with an estimated incidence of 0.07 per million annually[3].

The symptoms of LCH are diverse and depend primarily on the organ system involved. LCH could be unifocal or multifocal. When the bone is affected, it is known as eosinophilic granuloma[4]. In the skeletal system, the most commonly involved parts are the skull, followed by the femur, mandible, pelvis, and spine[5]. Lung involvement is the most common presentation in LCH, seen in over half (51%) of such cases, bone (38%) and skin (7%)[6]. Spinal involvement in adult LCH is relatively rare, and epidural extension is particularly uncommon[7]. In adults, LCH presents as a multisystem disease in approximately 69% of cases, while 31% exhibit single-system involvement[6].

Treatment of LCH varies according to disease extent and location and may include conservative management, local or surgical interventions, and systemic therapy[8]. Because spinal LCH can mimic infection or metastatic disease, diagnosis is often challenging. Herein, we report a 49-year-old woman with T12 vertebral LCH initially suspected to be an inflammatory or metastatic lesion, underscoring the diagnostic complexity of this rare condition.

CASE PRESENTATION

Written informed consent was obtained from the patient. A 49-year-old woman presented with a five-month history of lower thoracic back pain and progressive left lower extremity weakness, accompanied by gait disturbance for one month. Her medical history included hypertension and hypothyroidism.

Physical examination revealed lower thoracic tenderness and grade 4 motor weakness in the left lower limb. Laboratory findings showed a white blood cell count of 4.55×10^9/L, C-reactive protein level of 19 mg/dL, and erythrocyte sedimentation rate of 60 mm/h, without fever or evidence of systemic infection.

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Radiological Findings

Magnetic resonance imaging showed a pathological fracture of the T12 vertebra with approximately 40% height loss, posterior element destruction, and an epidural mass occupying the left T11-T12 neural foramen, resulting in spinal cord displacement and canal stenosis. These findings initially suggested infectious spondylitis.

Contrast-enhanced computed tomography (CT) revealed a 33×23 mm lytic lesion in the left T12 vertebral body extending to the posterior elements and paravertebral region, with destruction of the posterior 12th rib. Fluorodeoxyglucose-positron emission tomography (FDG-PET)/CT demonstrated a solitary hypermetabolic lesion without additional involvement; therefore, no systemic treatment was administered (Figure 1).

Biopsy and Histopathological Findings

A preoperative biopsy of the T12 vertebra was obtained using a 16-G tru-cut needle. Histopathological examination revealed histiocyte-like cells with reniform nuclei and multinucleated giant cells within an eosinophil-rich inflammatory stroma. The lesional cells showed immunohistochemical positivity for S-100 and CD1a, consistent with LCH. Intraoperative biopsy confirmed the same findings (Figure 2).

Surgical Procedure

The patient was positioned prone under general anesthesia, and intraoperative neuromonitoring was used throughout the procedure. A midline posterior approach from T10 to L2 was performed after fluoroscopic level confirmation. Intraoperatively, extensive destruction of the left T12 vertebral body, pedicle, and lamina with exposure of the spinal canal was observed , and marginal excision of the soft-tissue mass was carried out.

Pedicle screws were placed at T10, T11, T12 (right side only), L1, and L2 using a freehand technique under fluoroscopic guidance. Left T12 hemicorpectomy and laminectomy were

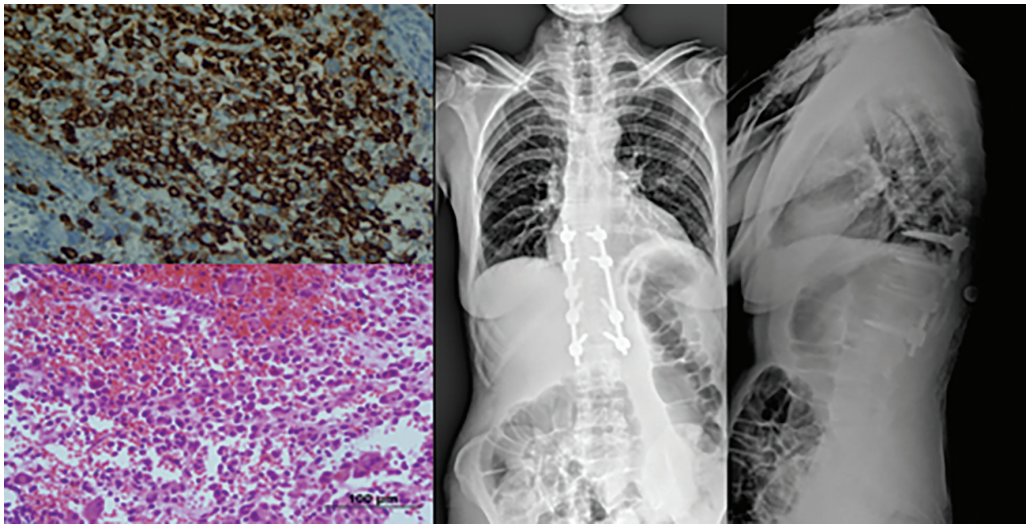

Figure 1. Axial magnetic resonance imaging demonstrating a lytic lesion involving the left side of the T12 vertebral body and posterior elements, with associated epidural and paravertebral soft-tissue extension causing spinal canal compromise. Axial contrast-enhanced computed tomography shows a lytic lesion in the left half of the T12 vertebral body extending to the posterior elements and paravertebral region, with destruction of the posterior portion of the 12th rib. Axial FDG-PET/CT demonstrates a hypermetabolic lytic lesion involving the left T12 vertebra and adjacent posterior rib arch. FDG-PET/CT: Fluorodeoxyglucose-positron emission tomography/computed tomography

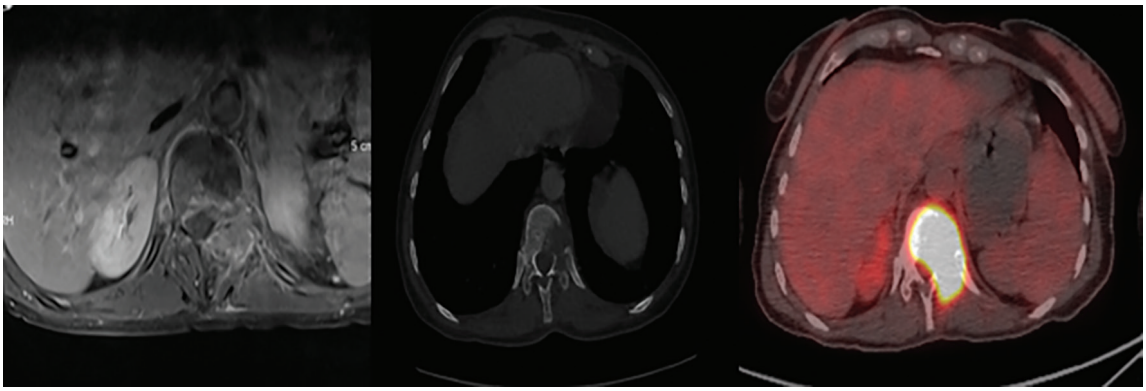

Figure 2. Left: histopathological section of the biopsy demonstrating histiocyte-like cells with eccentric reniform nuclei and multinucleated giant cells, consistent with Langerhans cell histiocytosis. Right: postoperative anteroposterior and lateral thoracolumbar spine radiographs showing posterior spinal instrumentation and fusion spanning from T10 to L2

performed to achieve spinal cord decompression, followed by posterior stabilization with bilateral rods and autologous bone grafting. Final neuromonitoring signals remained unchanged. Postoperative radiographs demonstrated satisfactory alignment and fixation (Figure 2).

The patient was followed for 8 months postoperatively, with no complications observed.

DISCUSSION

LCH is an uncommon disorder in adults and rarely presents with vertebral destruction or spinal cord compression. In their 2025 systematic review, Abdulla et al.[9] identified LCH in 74 patients. This diagnostic difficulty was evident in our patient, whose imaging findings-including a lytic vertebral lesion, paravertebral soft-tissue extension, and rib destruction-initially raised concern for an infectious or metastatic process.

Several radiologic clues may help differentiate LCH from infection or malignancy. Preservation of the intervertebral disc space, a well-defined lytic lesion, and the absence of additional FDG-avid lesions on PET/CT favor LCH over spondylodiscitis or metastatic disease[9]. However, in advanced cases with posterior element destruction or extensive soft-tissue components, as in our patient, the imaging characteristics may become less specific, making histopathological confirmation essential.

Management of adult spinal LCH remains variable due to its rarity. Otsuki et al.[10] achieved successful treatment in four patients using posterior instrumentation alone, without the need for curettage or bone grafting, and in one additional patient with the addition of chemotherapy. Sapkas et al.[11] were concerned about the extraosseous extension and performed excision and bone grafting. While conservative treatment or limited local interventions may be adequate for stable, unifocal lesions without neurological compromise, surgical intervention is recommended in the presence of instability or cord compression[11]. Our patient required posterior decompression and T12 hemicorpectomy due to extensive bone destruction and epidural compression. Surgical stabilization enabled immediate neural decompression and adequate tissue procurement for diagnosis.

Most adults with solitary osseous LCH have favorable outcomes following complete resection, curettage, or just posterior stabilisation[12]. Nonetheless, long-term follow-up is essential, as recurrence or progression to multisystem disease, although infrequent, has been reported[13]. This case underscores the importance of considering LCH in the differential diagnosis of destructive thoracic vertebral lesions in adults. It highlights the role of timely biopsy and surgical management to prevent irreversible neurological deterioration.

CONCLUSION

Adult spinal LCH is rare and may mimic infectious or metastatic disease, causing diagnostic delay. This case emphasizes the importance of considering LCH in destructive vertebral lesions and confirms the role of histopathology. Early surgical intervention is recommended in cases with spinal instability or neurological compromise.

Ethics

Informed Consent: Written informed consent was obtained from the patient.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.A., N.A., F.E., H.S.C., Concept: B.A., A.A., Design: B.A., A.A., Y.S.B., Data Collection or Processing: B.A., N.A., F.E., H.S.C., Analysis or Interpretation: B.A., N.A., A.A., Y.S.B., Literature Search: B.A., A.A., N.D., Writing: B.A., A.A., N.D.

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