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JOURNAL OF TURKISH SPINAL SURGERY

EDITORIAL

Dear Colleagues,

In this, the first issue, of our 2025 professional journal, you will find seven clinical studies and one case report. I continue to feel humbled and privileged to be the person responsible for disseminating this information to you. As always, I hope you will review everything carefully, and incorporate any findings that you find useful into your practices.

In the first study, the authors investigated "Psychological Burdens in Lumbar Spinal Stenosis: the Underrated Influence of Pre-operative Depression and Anxiety on Surgical Outcomes and Quality of Life." The second study examines "Risk Factors Contributing to Symptomatic Adjacent Segment Disease Following Long-Segment Posterior Instrumentation with Pelvic Screws in Degenerative Spine Disease: a Retrospective Cohort Analysis." In the third study, one can read about "Single-Session Multilevel Vertebroplasty and Kyphoplasty: Evaluation of Safety and Efficacy in the Treatment of Spinal Compression Fractures." The authors of the fourth article studied the "Effectiveness of Halo Traction in the Treatment of Patients with Severe Rigid Scoliosis." The authors of the fifth study reported their experiences when investigating the "Effectiveness of Cervical Disc Arthroplasty in Cervical Vertigo." The sixth study discussed "Evaluating Incidental Findings in Cervical MRI Scans: the Prevalence and Clinical Relevance of Incidental Findings", while in the seventh, the authors wrote about "The Impact of Blood Transfusion on Outcomes in Posterior Lumbar Fusion Surgery." The eighth study is a report on "Sudden Severe Neurological Deficit in Scheuermann's Disease: a Case Report and Literature Review."

I hope you found this issue thought provoking and informative. My primary objective is unwavering. I intend to provide you with the most current and innovative information possible so that we remain at the forefront of our profession. This is only possible if we are aware of and implement the most current research and practices available.

I wish all our Turkish spinal surgeons and their families a healthy, peaceful, and prosperous New Year.

With kindest regards,

Editor in Chief
Metin Özalay, M.D.

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ORIGINAL ARTICLE
1

PSYCHOLOGICAL BURDENS IN LUMBAR SPINAL STENOSIS: THE UNDERRATED INFLUENCE OF PRE-OPERATIVE DEPRESSION AND ANXIETY ON SURGICAL OUTCOMES AND QUALITY OF LIFE

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ABSTRACT

Objective: This study investigated the impact of pre-operative anxiety and depression on health-related quality of life (H-RQOL) after surgery for lumbar spinal stenosis (LSS) surgery.

Materials and Methods: We reviewed 152 consecutive patients with single-level LSS who underwent laminectomy or laminectomy with fusion. With the use of pre-operative Hospital Anxiety and Depression Scale to evaluate H-RQOL, patients were divided into (A+)/(A-) or (D+)/(D-) according to the positivity of anxiety or depression. H-RQOL was assessed pre-operatively and post-operatively using Oswestry Low Back Pain Disability Questionnaire (ODI) and visual analogue scale (VAS).

Results: (A+) and (D+) had higher pre-operative ODI scores and pre-operative VAS scores (D+). Had higher pre-operative ODI and VAS scores than (D-). (A+) Had higher pre-operative ODI and VAS scores than (A-). Post-operative ODI and VAS scores were higher in (D+). There was no significant difference between the post-operative ODI and VAS scores in (A+).

Conclusion: Pre-operative depression, independent of anxiety, reduces the effectiveness of LSS surgery and negatively impacts post-operative quality of life.

Keywords: Health-related quality of life, Hospital Anxiety and Depression Scale, lumbar spinal stenosis

INTRODUCTION

Lumbar spinal stenosis (LSS) is a degenerative condition of the lumbar spine characterized by motor and sensory impairments, often accompanied by gait disturbances and neuropathic pain due to spinal cord compression. Affecting over 103 million adults worldwide, LSS is a leading cause of severe pain, mobility limitations, and the most common indication for spinal surgery in adults[1]. The condition typically manifests as pain in the lower back, buttocks, and legs, which worsens with activities such as standing or walking and improves with forward flexion, sitting, or lying down. This pain results from a narrowing of the spinal canal, compressing nerves and blood vessels[2].

The impact of LSS extends beyond physical symptoms, significantly impairing activities of daily living (ADLs) and health-related quality of life (H-RQOL) in a rapidly aging population, where maintaining quality of life is increasingly

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essential[3,4]. Various surgical procedures, including laminotomy, decompression, and minimally invasive approaches, aim to alleviate symptoms and improve H-RQOL. However, the outcomes of these surgeries are influenced by multiple factors, including mental health conditions such as depression and anxiety[5].

Mental health disorders are highly prevalent among individuals with chronic pain[6,7]. Depression, in particular, is associated with lower H-RQOL, reduced ADLs, and increased mortality rates[8,9]. Studies have demonstrated that mental health significantly impacts recovery from spine surgeries, including both lumbar and cervical procedures. Despite these findings, limited research has explored the specific relationship between pre-operative depression and anxiety and their effects on H-RQOL in LSS patients undergoing surgical treatment.

Psychological distress, including anxiety and depression, can often be masked by the physical symptoms of back pain. The Hospital Anxiety and Depression Scale (HADS), developed in 1983, is a validated tool designed to assess emotional well-being by focusing solely on psychological symptoms, excluding physical factors such as fatigue or sleep disturbances. This specificity makes HADS particularly useful in conditions like LSS, where physical symptoms might otherwise confound mental health assessments[10,11].

The reliability of HADS in evaluating mental health among spinal patients has been established in numerous studies[12,13]. While there is a growing body of research examining the psychological effects of lumbar surgery[14-17], gaps remain in understanding how different surgical approaches for LSS influence anxiety and depression. This study aims to address these gaps by evaluating the interaction between mental health and surgical outcomes in LSS patients, thereby contributing to a more comprehensive understanding of the psychological dimensions of surgical care.

MATERIALS AND METHODS

Patient Selection

The study was approved by the İstanbul Medipol University of Non-interventional Clinical Research Ethics Committee (decision number: 413, date: 18.04.2024). All patients provided written informed consent for the procedures performed. We retrospectively analyzed data from 179 patients with a single level LSS who underwent surgery at our institution between March 2017 and March 2023. The diagnosis of LSS was made by expert neurosurgeons using both neurological examination and magnetic resonance imaging studies. Patients were divided into those who underwent only laminectomy and those who underwent fixation-fusion surgery. Exclusion criteria for the study included patients under 18 years of age, those with radiculopathy or myelopathy symptoms resulting from lumbar disc herniation, infection, neoplasm, or rheumatologic diseases, and those who had undergone previous spinal surgery. Patients with multiple levels of LSS were excluded from the study because the option of only laminectomy in patients with multiple levels of LSS was thought to impair stabilization. Out of the 179 patients initially included in the study, 27 were excluded due to age or inability to be reached through communication channels. Finally, the study reviewed 152 patients (Figure 1).

At our institution, surgical strategies for LSS are as follows: 1) Patients with a single level LSS, without >5 mm motion on flexion-extension lateral radiographs and without accompanying listhesis, are operated on only for decompression. Only laminotomy is performed, preserving as much stability as possible without touching the facet joints of the patients. 2) Short level fixation and posterior fusion surgery is performed in single level LSS patients with >5 mm movement on flexion-extension lateral radiographs. 3) Fixation and fusion surgery is performed in symptomatic LSS patients with stenosis at more than one level by decompressing the symptomatic stenosis areas with laminectomy[18].

We retrospectively reviewed the medical records of our patients. We analyzed several factors that could affect their outcomes, including demographic information such as age, gender, body mass index (BMI). Furthermore, we examined details about their condition, such as the duration of their symptoms and their medical history, including diabetes and smoking. We also evaluated their medication use, with a specific focus on anti-depressants and anti-anxiety drugs. Finally, we evaluated the possibility of major post-surgery complications, such as infections at the surgical site (presence of pus draining from the incision or a positive culture test within 30 days of surgery), the need for a second surgery due to epidural hematoma (post-operative 7 days), and any significant neurological deficits (>2 grades of muscle weakness in post-operative one month).

Evaluation of Pre-operative Depression and Anxiety

HADS stands for HADS. It's a questionnaire used to evaluate a patient's emotional state in the week leading up to surgery.

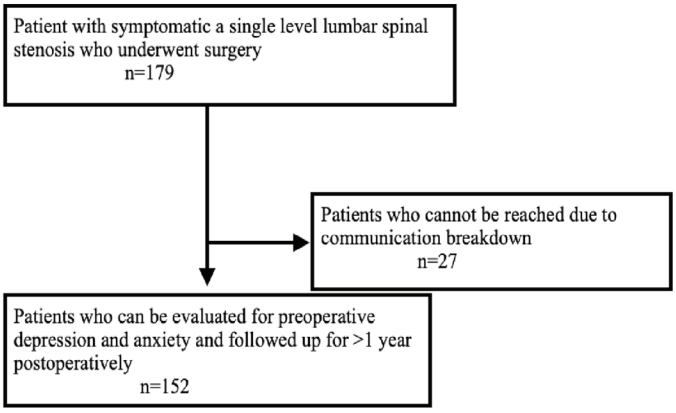

Figure 1. Flowchart of the study population and the patients who completed the outcome measure

The HADS has 14 questions, split into two sections: 7 for depression (D) and 7 for anxiety (A). Each question is scored from 0 (no impairment) to 3 (severe impairment). Higher scores indicate a greater likelihood of depression or anxiety. A score of 0 reflects no signs of depression or anxiety, while a maximum score of 21 indicates severe symptoms. Scores of 8 or higher in either subscale identify individuals as likely having depression or anxiety. These are signified as (D+) for depression and (A+) for anxiety. Scores below 8 [(D-) or (A-)] suggest no depression or anxiety[12].

Clinical Outcome Measures

Patients' H-RQOL was evaluated pre-operatively (within 7 days before surgery) and post-operatively (at least 1 year after surgery) using the Oswestry Low Back Pain Disability Questionnaire (ODI)[19] and the visual analogue scale (VAS) [20]. Post-operative clinical outcomes were assessed using questionnaires administered during the most recent follow-up visit.

Statistical Analysis

To analyze the data and identify any important relationships between the variables, researchers employed statistical tests. For continuous data, such as age or pain scores, the Mann-Whitney U test was used to compare the groups. Categorical data, like presence or absence of a certain condition, was analyzed using the chi-square test. However, this test relies on a minimum number of participants in each category. When this wasn't the case, Fisher's exact test provided a more reliable alternative. Additionally, a One-Way analysis of variance was conducted for subgroup analysis to compare means across multiple groups. All statistical analyses were performed using IBM SPSS Statistics version 23. A finding was considered statistically significant if the probability of it occurring by random chance was less than 5% (p-value <0.05). This threshold helps ensure the observed differences are unlikely due to chance and reflect a true relationship between the variables.

RESULTS

A total of 152 patients were included in this study (Table 1). The patients' ages ranged from 50 to 82 years, with a mean age of 64.03 years [standard deviation (SD 6.77)]. Males comprised 52% of all patients (n=79), while females accounted for 48% (n=73). The mean follow-up period was 16.93 months (SD 3.70), with a range from 12 to 24 months. Among these patients, 64 (42.1%) underwent decompression only, while 88 (57.9%) underwent both decompression and fixation. Regarding pre-operative clinical scores, the mean ODI was 37.63 (SD 13.11) with a range from 10 to 60. The mean pre-operative VAS score was 5.34 (SD 1.96) with scores ranging from 1 to 10. Post-operative outcomes showed an improvement, with the mean ODI score decreasing to 17.96 (SD 15.28), ranging from 0 to 60. The mean post-operative VAS score also decreased to 2.86 (SD 2.02), with scores ranging from 0 to 10 (Table 1) (Figure 2).

When comparing the (A-) and (A+) groups, no significant difference was found in age (p=0.119) or the mean BMI (p=0.105). However, a significantly lower proportion of females was observed in the (A+) group compared to the (A-) group (p=0.046). Additionally, pre-operative ODI and VAS scores were significantly higher in the (A+) group compared to the (A-) group (p<0.05 for both). There was no statistically significant difference in post-operative ODI scores (p=0.082), and post-operative VAS scores (p=0.064) between the two groups (p=0.064). Other factors such as smoking history, diabetes mellitus prevalence, and the proportion of surgeries involving laminectomy or fusion did not differ significantly between the groups (Table 2). When comparing the (D-) and (D+) groups, no significant differences were found in age (p=0.849), mean BMI (p=0.105), or the follow-up period (p=0.919). However, pre-operative ODI and VAS scores were significantly higher in the (D+) group compared to the (D-) group (p<0.05 for both). Post-operative ODI and VAS scores also remained significantly higher in the (D+) group (p<0.05 for both). Additionally, no significant differences were observed between the groups in terms of smoking history, diabetes mellitus prevalence, or the proportion of surgeries involving laminectomy or fusion (Table 3) (Figure 3).

Clinical Outcomes

The subgroup analysis presented in Table 4 aimed to identify whether depression (D) or anxiety (A) had a more significant impact on the pre-operative and post-operative clinical parameters. The analysis revealed that both anxiety and depression significantly affected pre-operative ODI and VAS scores. Specifically, patients with anxiety [(A+) or depression (D+)] had significantly higher pre-operative ODI and VAS scores

Table 1. Characteristic features of the 152 patients included in the study

Variable	Value [n (%)/M ± SD (min.-max.)]
Sex	
Male	79 (52%)
Female	73 (48%)
Age	64.03±6.77 (50-82)
Follow-up (month)	16.9 ±3.70 (12-24)
Surgery	
Decompression	64 (42.1%)
Decompression+fixation	88 (57.9%)
Pre-operative ODI	37.63±13.11 (10-60)
Pre-operative VAS	5.34±1.96 (1-10)
Post-operative ODI	17.96±15.28 (0-60)
Post-operative VAS	2.86±2.02 (0-10)

ODI: Oswestry Low Back Pain Disability Questionnaire, VAS: Visual analogu scale, SD: Standard deviation, M: Mean, min.-max.: Minimum-maximum, *p<0.05: Statistically significant

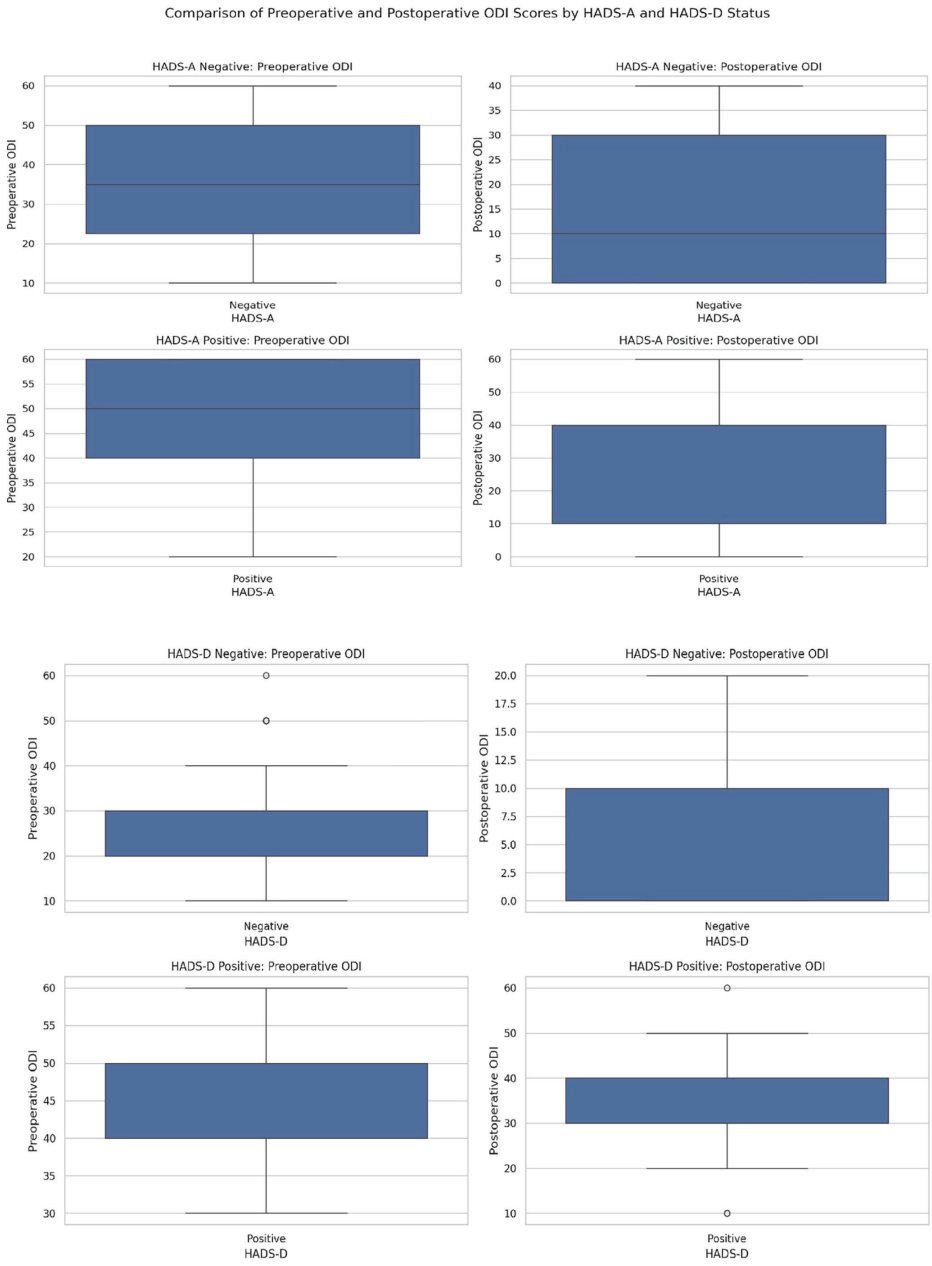

Figure 2. Box plot showing pre-and post-operative ODI results according to A and D
ODI: Oswestry Low Back Pain Disability Questionnaire, HADS: Hospital Anxiety and Depression Scale

compared to those without these conditions [(A-)/(D-)] ($p<0.05$ for all comparisons). However, when comparing post-operative outcomes, depression (D+) had a more consistent impact, with significantly higher post-operative ODI and VAS scores observed in the (D+) group, regardless of anxiety status ($p<0.05$ for most comparisons). In contrast, anxiety (A+) alone did not consistently result in significantly different post-operative scores unless accompanied by depression (Table 4). Patients with neither anxiety nor depression [(A-)/(D-)] had significantly lower pre-operative ODI scores compared to all other groups ($p<0.05$).

Those with anxiety but no depression [(A+)/(D-)] had significantly higher pre-operative ODI scores compared to the (A-)/(D-) group ($p<0.05$). The comparison between patients with depression but no anxiety [(A-)/(D+)] and those with both anxiety and depression [(A+)/(D+)] showed no statistically significant difference ($p=0.142$). The (A-)/(D-) group had significantly lower pre-operative VAS scores compared to all other groups ($p<0.05$). There was no significant difference between the (A+)/(D-) group and the (A-)/(D+) group ($p=0.790$). The (A+)/(D+) group had significantly higher pre-operative VAS scores compared to the (A-)/(D-) group ($p<0.05$). The post-operative ODI scores showed that patients without anxiety or depression [(A-)/(D-)] had significantly lower scores compared to the (A-)/(D+) and (A+)/(D+) groups ($p<0.05$). There was no significant difference

Table 2. Comparison of A (-) and A (+) patients

Variable	(A-)	(A +)	p-value
No of patients (%)	120 (78.9)	32 (21.1)	
Female, n (%)	63 (41.4)	10 (6.6)	0.046
Male, n (%)	57 (37.5)	22 (14.5)	
Age [M±SD (min.-max.)]	64.5±6.83 (50-82)	62.4±6.35 (53-73)	0.119
Follow-up (month) [M±SD (min.-max.)]	16.9±3.71 (12-24)	16.9±3.71 (12-24)	0.919
Pre-operative ODI (M±SD)	35.0±12.04	46.7±12.73	<0.05*
Pre-operative VAS (M±SD)	5.14±1.92	6.03±1.95	<0.05*
Post-operative ODI (M±SD)	16.53±13.67	22.94±19.31	0.082
Post-operative VAS (M±SD)	2.55±1.65	3.94±2.55	0.064
Mean BMI (kg/m^2) (SD)	23.7 (4.2)	25.8 (4.6)	0.105
Smoking history, %	60	50	0.676
Diabetes mellitus, %	33.3	40.6	0.568
Anti-depressant or anoxialytic use, %	1.6	3.1	0.743
Surgery with laminectomy, %	36.6	15.6	0.124
Surgery with fusion, %	63.3	84.3	0.238

*Comparative analysis was conducted using Fisher's exact test or Student's t-test. ODI: Oswestry Low Back Pain Disability Questionnaire, VAS: Visual Analogue Scale, SD: Standard deviation, BMI: Body mass index, M: Mean, min.-max.: Minimum-maximum, *p<0.05: Statistically significant, A: Hospital Anxiety and Depression Scale for Anxiety

Table 3. Comparison of D (-) and D (+) patients

Variable	(D-)	(D+)	p-value
No of patients (%)	86 (56.6)	66 (43.4)	
Female, n (%)	49 (32.2)	24 (15.8)	0.097
Male, n (%)	37 (24.3)	42 (27.6)	
Age [M±SD (min.-max.)]	64.1±6.81 (50-82)	62.6±6.50 (51-80)	0.024
Follow-up (month) [M±SD (min.-max.)]	16.9±3.59 (12-24)	17.0±3.87 (12-24)	0.849
Pre-operative ODI (M±SD)	29.7±11.02	47.61±7.61	<0.05*
Pre-operative VAS (M±SD)	4.92±1.86	5.87±1.96	<0.05*
Post-operative ODI (M±SD)	6.2±5.97	32.84±9.34	<0.05*
Post-operative VAS (M±SD)	1.81±1.34	4.1±1.83	<0.05*
Mean BMI (kg/m^2) (SD)	24.8	25.4	0.359
Smoking history, %	65.1	66.6	0.765
Diabetes mellitus, %	37.2	33.3	0.864
Anti-depressant or anoxialytic use, %	3.4	3.0	0.876
Surgery with laminectomy, %	34.8	30.3	0.852
Surgery with fusion, %	65.1	69.9	0.736

*Comparative analysis was conducted using Fisher's exact test or Student' t-test. ODI: Oswestry Low Back Pain Disability Questionnaire, VAS: Visual Analogue Scale, SD: Standard deviation, BMI: Body mass index, M: Mean, min.-max.: Minimum-maximum, *p<0.05: Statistically significant, D: Hospital Anxiety and Depression Scale for Depression

in post-operative ODI scores between the (A-)/(D-) and (A+)/(D-) groups (p=0.441). The post-operative VAS scores were significantly lower in the (A-)/(D-) group compared to both the (A-)/(D+) and (A+)/(D+) groups (p<0.05). No significant difference was found between the (A+)/(D-) and (A-)/(D-) groups (p=0.764) (Figure 4).

DISCUSSION

This research aimed to explore the influence of pre-operative depression and anxiety on post-operative quality of life in individuals undergoing surgery for lumbar stenosis. The findings reveal that patients with pre-operative depression reported poorer quality of life and greater levels of pain

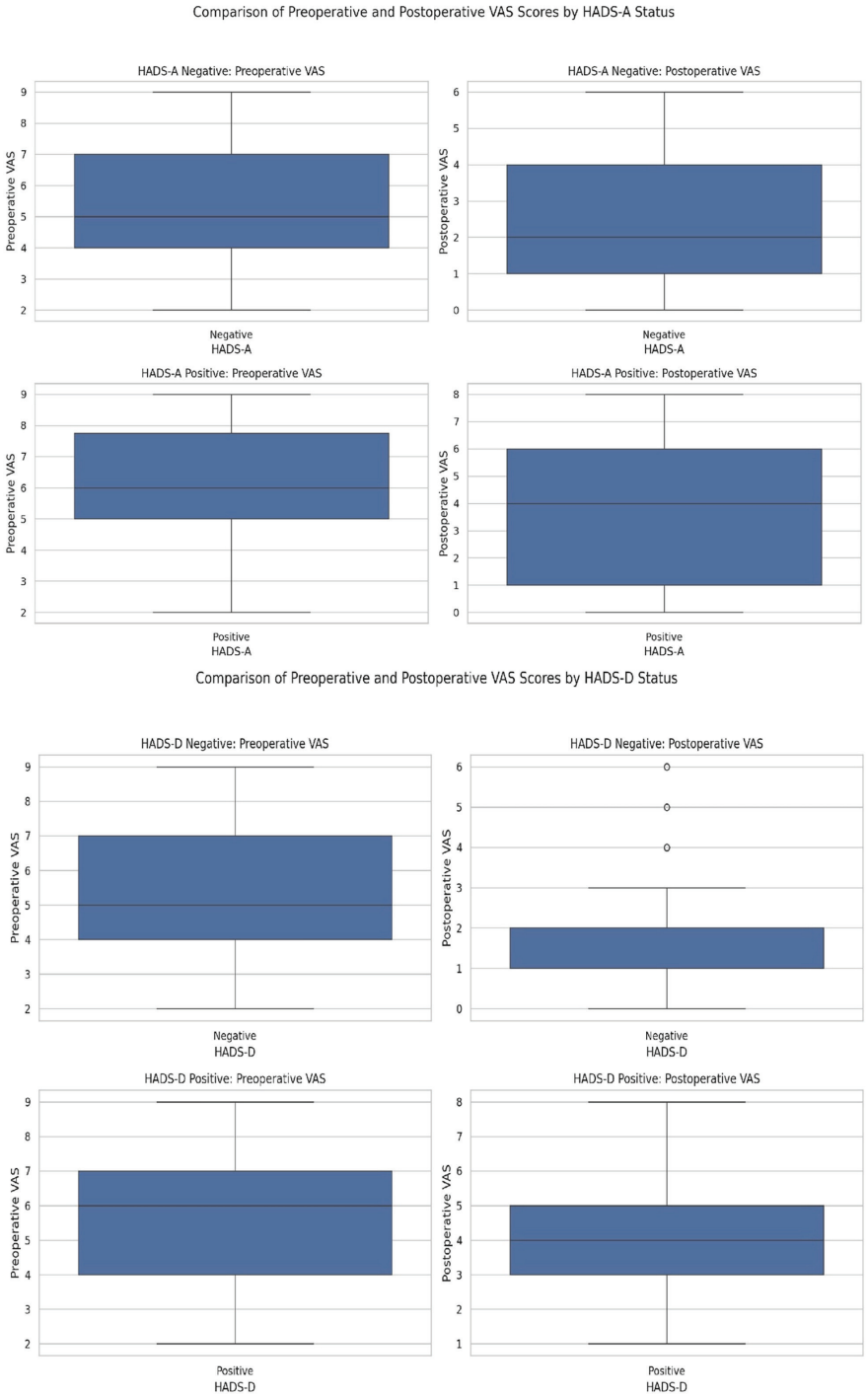

Figure 3. Box plot showing pre-and post-operative VAS results according to A and D
VAS: Visual analogue scale, HADS: The Hospital Anxiety and Depression Scale

before surgery compared to those without depression. When evaluating quality of life using different assessment tools, it was observed that ODI scores were notably higher in patients with depression, while VAS scores-used to gauge pain-were significantly lower in patients without depression.

Regarding anxiety, the data showed that ODI scores were considerably elevated in patients experiencing pre-operative anxiety, whereas their VAS scores were comparable to those of patients without anxiety. This observation indicates that anxiety impacts perceived functional disability (measured by ODI) more than perceived pain intensity (measured by VAS). The disparity in scoring outcomes may stem from the ODI's focus on daily functional activities, as opposed to the VAS's emphasis on pain levels. These results suggest that chronic lumbar pain might be more strongly associated with depression than with anxiety.

Table 4. Changes of subgroups in pre-operative and post-operative parameters

Pre-operative ODI	**(A+)/(D-)**	**(A-)/(D+)**	**(A+)/(D+)**
A (-) D (-)	<0.05*	<0.05*	<0.05*
A (+) D (-)		0.134	<0.05*
A (-) D (+)			0.142
Pre-operative VAS	(A+)/(D-)	(A-)/(D+)	(A+)/(D+)
A (-) D (-)	<0.05*	<0.05*	<0.05*
A (+) D (-)		0.790	<0.05*
A (-) D (+)			0.614
Post-operative ODI	(A+)/(D-)	(A-)/(D+)	(A+)/(D+)
A (-) D (-)	0.441	<0.05*	<0.05*
A (+) D (-)		<0.05*	<0.05*
A (-) D (+)			0.765
Post-operative VAS	(A+)/(D-)	(A-)/(D+)	(A+)/(D+)
A (-) D (-)	0.764	<0.05*	<0.05*
A (+) D (-)		<0.05*	<0.05*
A (-) D (+)			0.735

*Comparative analysis was conducted using Fisher's exact test or Student's t-test or ANOVA. ODI: Oswestry Low Back Pain Disability Questionnaire, VAS: Visual Analogue Scale, SD: Standart deviation, M: Mean, min.-max.: Minimum-maximum, *p<0.05: Statistically significant, A: Hospital Anxiety and Depression Scale for Anxiety, D: Hospital Anxiety and Depression Scale for Depression, ANOVA: Analysis of variance

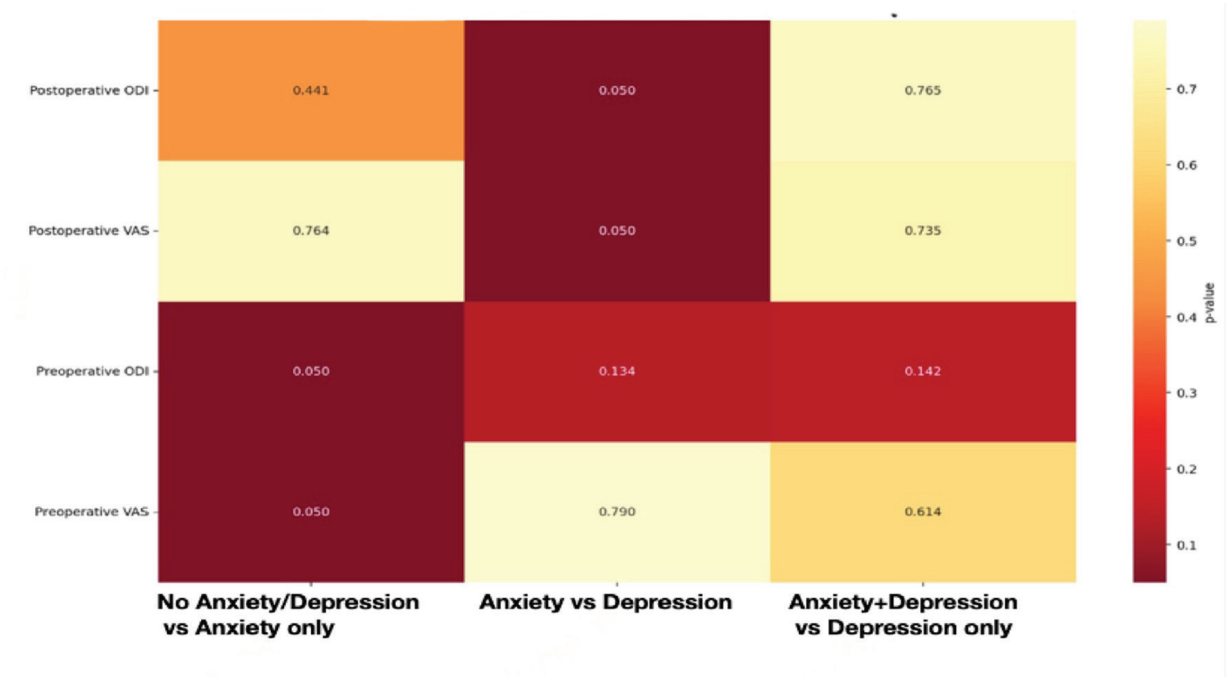

Figure 4. Heatmap of pre-operative and post-operative outcomes by anxiety and depression groups
ODI: Oswestry Low Back Pain Disability Questionnaire, VAS: Visual Analogue Scale

Significant improvements in both ODI and VAS scores were recorded across all patients, regardless of the surgical technique performed or the presence of pre-operative anxiety or depression. These outcomes suggest that the surgical interventions effectively reduced perceived disability and pain, affirming the appropriateness of the surgical indications.

However, long-term post-operative follow-ups demonstrated that patients with pre-operative anxiety and depression continued to exhibit significantly lower quality of life compared to those without these psychological conditions. This highlights the enduring impact of mental health on recovery and overall well-being. It is worth noting that this analysis relies exclusively on objective measurements and does not account for subjective patient feedback.

Despite the considerable improvement in H-RQOL following surgery, patients with depression or anxiety still showed a significant reduction in quality of life compared to those without these conditions. While the surgery itself was beneficial, it did not achieve optimal quality of life outcomes in these individuals, indicating that psychological distress substantially hampers recovery. It is evident that lumbar pain alone cannot fully explain these findings. Our analysis underscores the notable role of psychological factors in influencing pain perception and quality of life.

Previous studies have suggested that the impact of depression on outcomes in lumbar stenosis surgery ranges from mild to moderate[21]. This study, however, identified a substantial relationship between depression and diminished post-operative quality of life. This aligns with existing literature, underscoring depression as a critical determinant of surgical outcomes. It reinforces the necessity of carefully evaluating the need for surgery, particularly given the variability in methodologies and findings across different studies.

One study identified pre-operative depression as a significant independent predictor of reduced symptom improvement following surgery for lumbar stenosis[22]. Another prospective study revealed that psychosocial challenges, such as depression and anxiety, were associated with poorer outcomes[16,17].

In the present study, depression exhibited a pronounced effect on surgical outcomes, independent of anxiety. This was particularly evident among patients with lumbar stenosis, who already endure substantial pain and functional limitations. Interestingly, while anxiety significantly influenced pre-operative quality of life-reflected in higher ODI and VAS scores in (A+) patients compared to (A-)-its effect diminished post-operatively. This suggests that anxiety symptoms may improve after surgery, reducing their negative impact on post-operative outcomes. Conversely, depression persisted as a significant factor affecting both pre-operative and post-operative ODI and VAS scores, demonstrating its lasting adverse effects on quality of life. Although surgical interventions provided benefits, patients with depression consistently reported poorer outcomes compared to their counterparts without depression, thus impacting overall surgical efficacy.

Study Limitations

This study has several limitations that should be acknowledged to provide a clearer understanding of the findings. First, the retrospective design of the study introduces inherent challenges, such as potential selection bias and the inability to establish causality between variables. Retrospective analyses rely on pre-existing data, which may lack the granularity needed to address specific research questions comprehensively.

Second, while no statistically significant differences in surgical methods were observed between patient groups, other unexamined factors could have influenced the post-operative outcomes. For instance, variables such as the duration and severity of symptoms, the extent of radiographic abnormalities, and comorbid conditions were not included in the analysis. Incorporating these predictive factors could have provided a more nuanced understanding of their influence on surgical results.

Third, the reliance on subjective measures such as the HADS, ODI, and VAS poses a limitation. These tools are influenced by individual patient perceptions and external factors, potentially leading to variability in the data. While HADS is a valuable instrument for assessing mood disorders, using more comprehensive evaluations or conducting a numerical comparison of anxiety and depression severity could have offered deeper insights into how these psychological conditions impact surgical outcomes.

Additionally, the study's cohort size and follow-up duration may limit the generalizability of the findings. A larger sample size and extended follow-up periods would enable more robust statistical analyses and help identify longer-term trends in surgical and psychological outcomes.

Lastly, the study did not address the potential interplay between physical and psychological factors in influencing recovery. For example, how radiographic findings correlate with mood disorders or how symptom severity might amplify psychological distress remains unexplored. Addressing these gaps in future research could significantly enhance the understanding of the multifaceted nature of recovery in LSS patients.

In conclusion, these limitations should be carefully considered when interpreting the results of this study. Future investigations should aim to include larger patient cohorts, longer follow-up durations, and additional predictive factors such as symptom severity, duration, and radiographic characteristics to provide a more comprehensive understanding of the variables influencing surgical outcomes in LSS.

CONCLUSION

This study underscores the significant impact of pre-operative depression and anxiety on post-operative outcomes in patients with lumbar stenosis, highlighting the need for comprehensive psychological assessment and management in surgical candidates. Additionally, pre-operative depression, independent of anxiety, significantly reduces the effectiveness of LSS surgery and negatively impacts post-operative quality of life in patients.

Ethics

Ethics Committee Approval: The study was approved by the İstanbul Medipol University of Non-interventional Clinical Research Ethics Committee (decision number: 413, date: 18.04.2024).

Informed Consent: All patients provided written informed consent.

Footnotes

Authorship Contributions

Surgical and Medical Practices: E.U., H.Ş.Ç., A.Y.Y., Concept: S.İ.A., H.C.Ç., Design: H.Ş.Ç., S.İ.A., M.V.A., Data Collection or

Processing: H.C.Ç., A.H.Y., Analysis or Interpretation: E.U., A.Y.Y., Literature Search: H.C.Ç., A.H.Y., Writing: E.U., M.V.A.

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

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ORIGINAL ARTICLE
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RISK FACTORS CONTRIBUTING TO SYMPTOMATIC ADJACENT SEGMENT DISEASE FOLLOWING LONG-SEGMENT POSTERIOR INSTRUMENTATION WITH PELVIC SCREWS IN DEGENERATIVE SPINE DISEASE: A RETROSPECTIVE COHORT ANALYSIS

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ABSTRACT

Objective: Adjacent segment disease (ASD) is a complication commonly associated with spinal instrumentation; it usually requires further surgery and deteriorates the quality of life of patients. Although many studies have been conducted regarding the risk factors of ASD in short-segment surgeries, the literature regarding long-segment posterior instrumentation with pelvic screws and transforaminal lumbar interbody fusion is limited. Therefore, this study evaluated the incidence, cause, and outcome of ASD in such cases.

Materials and Methods: This retrospective study included 127 patients who underwent long-segment posterior instrumentation between January 2010 and December 2017. Among them, 15 developed symptomatic ASD requiring revision surgery. The diagnostic criteria encompassed >20% intervertebral disc height reduction, >5° angulation on flexion-extension X-rays, >3 mm sagittal translation, and facet joint degeneration.

Results: The overall revision rate was 11%. The median follow-up duration was 107 months, with mean of 114±23 months. There were 9 females and 6 males in the ASD cohort, with a mean age of 65.7±5.3 years, compared with a mean age of 62.9±7.6 years for non-ASD patients. The most common level for ASD to occur was T9-10 ($p<0.05$). Advanced age, degenerative changes, and the absence of vertebroplasty or cemented screws had a significant contribution.

Conclusion: ASD is a significant complication of long-segment posterior instrumentation. The strategy for identifying high-risk patients, particularly by modifiable factors like age >65, smoking, and determination of the upper instrumented vertebra, has important implications for prevention. Prophylactic vertebroplasty and use of cemented screws may reduce ASD risk.

Keywords: Spine, lumbar vertebrae, sakrum, spinal fusion

INTRODUCTION

Long-segment posterior spinal instrumentation is a standard surgical technique that pertains specifically to the treatment of degenerative spinal disorders. Although this surgical technique was effective in the acquisition of both stability and fusion of the spine, it usually presented several complications[1]. The most frequent complication was the occurrence of adjacent segment disease (ASD), which is characterized by degeneration in the segments adjacent to the fused segments[2]. ASD generally presents itself as painful instability and, in many instances, requires additional surgery.

ASD significantly impacts the patient outcome, an impact that is manifested as a reduction of quality of life. Further, the necessity of secondary surgical procedures raises the healthcare expenditure. The risk factors known to contribute to the development of ASD are many; they include advanced age, pre-existing degenerative changes, and extension and length of the fusion[3]. Thus, the question of whether ASD represents an inevitable consequence of long-segment fusion or can be avoided by surgical technique remains controversial despite the available literature. Although many studies have demonstrated various risk factors for ASD after one- or two-level spinal surgeries, clinical research related to the outcomes and risk factors of long-segment spinal fixation with pelvic

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screws combined with transforaminal lumbar interbody fusion is still very rare[4-6].

This retrospective study determines the incidence of, risk factors governing, and clinical outcome for ASD in patients undergoing long-segment posterior spinal instrumentation. More precisely, it looks into the added benefit provided by a number of newer surgical techniques-upper instrumented vertebra (UIV) selection, vertebroplasty at the proximal levels of instrumentation, and cement-augmented screw application-in mitigating ASD risk. This study is designed to better the long-term outcomes for patients and reduce the incidence of this difficult complication by pinpointing modifiable risk factors and implementing appropriate preventive measures.

MATERIALS AND METHODS

Study Population Selection

This series retrospectively studied those patients who underwent long-segment posterior spinal instrumentation combined with transforaminal lumbar interbody fusion between January 2010 and December 2017. The spine center represents a catchment area of about fifteen million people and carries out more than 150 spinal deformity surgeries annually. The participants all provided their informed consent, and this study has been approved by the Institutional Review Board at our institution. The study was approved by the İstanbul Yeni Yüzyıl University of Local Ethics Committee (approval number: 2024/10-1346, date: 15.10.2024). A total of 127 patients were involved; however, only 15 symptomatic ASD patients who underwent revision surgery comprised the series. The T8 was measured as UIV in 2 participants, T9 in 55, T10 in 46, L1 in 11, and L2 in 13. In this study, interest lay in proximal ASD, taking into consideration the fact that all the subjects underwent sacral and iliac fixation to perform the needed spinopelvic stabilization. In those patients who received vertebroplasty, treatments were performed in the most proximal two instrumented vertebrae and the vertebra above the level of instrumentation (Figure 1). Data were collected regarding demographic information, the surgical methods utilized, and radiographic follow-through.

The criteria for diagnosing symptomatic ASD were appearance of new patterns of pain after the surgery, which were related to patient symptoms, and correlated with radiological evidence of adjacent segment degeneration. Radiographic assessment included standing AP and lateral spine radiographs taken pre-operatively, post-operatively, and during the follow-up period. Dynamic flexion-extension radiographs were included in the pre-operative examination. The investigations also included magnetic resonance imaging (MRI) and computed tomography scans, which were taken pre-operatively and at the final follow-up.

Inclusion Criteria

Patients with long-segment posterior spinal instrumentation-e.g., a minimum of 5 levels for primary degenerative spinal pathologies, where the UIV are at L2 or proximal, with fixation using sacral and iliac screws. The presence of adequate imaging for pre-operative and post-operative radiographic evaluation. Patients received at least one MRI study in the post-operative period.

Exclusion Criteria

Patients presenting with spinal infection, neoplasm, or trauma. Patients with severe neurological deficits post-operatively.

Radiographic Assessment

Standardized radiographic criteria for the development of ASD included dynamic lateral flexion-extension X-ray and standing AP and lateral spine X-ray. Standardized pre-operative and

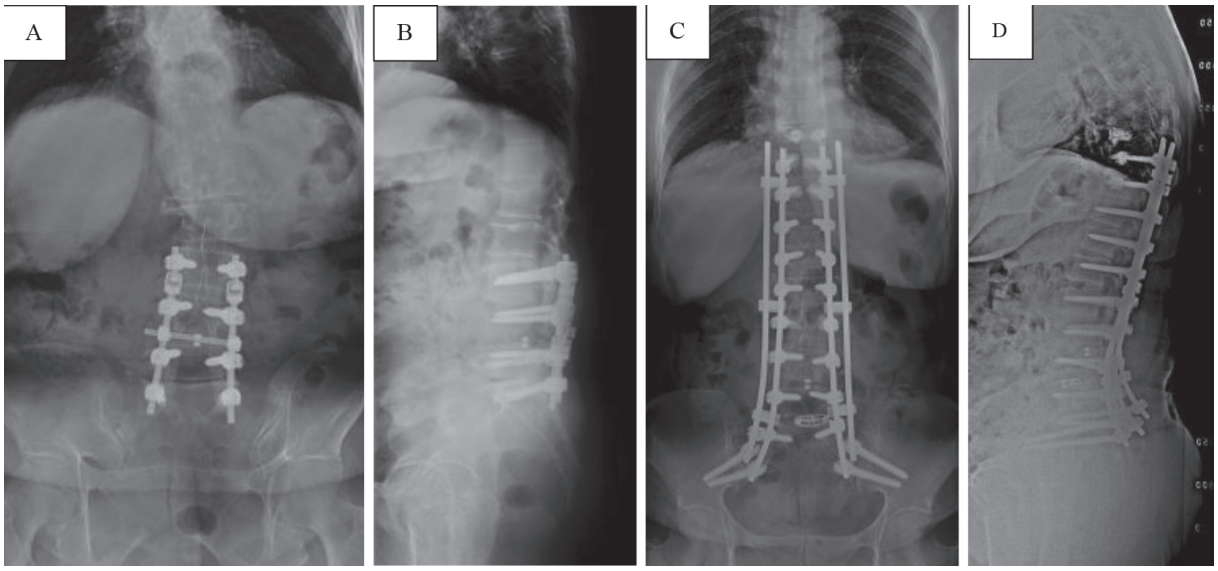


Figure 1. Pre-operative (A, B) and post-operative (C, D) X-rays of T10-iliac posterior instrumentation case with the use of cemented screws and vertebroplasty

immediate post-operative X-ray were obtained. X-rays were also performed at each follow-up. MRI were taken in all patients pre-operatively and last follow-up. The following parameters were measured to detect radiographic evidence of ASD:

• Disc height reduction: Decrease of more than 20% in intervertebral disc height at the adjacent segment compared to the immediate post-operative X-ray[7].

• Degenerative changes in the facet joints: According to Weishaupt classification[8], increase by one or more grades was considered the development of ASD.

• Anterior and/or posterior osteophyte formation: New formation or marked growth of osteophytes (more than 3 mm) at the adjacent level was accepted as a sign of ASD[9].

• Sclerosis or subchondral bone changes, thickening and hardening or cystic, may be seen in vertebral endplates adjacent to the fusion.

• Range of motion evaluation: Assessed using dynamic flexion-extension X-rays to detect hypermobility (defined as an angular motion increase of more than 5° compared to the pre-operative measurements) at the adjacent segment[10].

• Adjacent segment instability: A translation of >3 mm on dynamic sagittal lateral X-ray is considered instability[9].

In particular, all radiographic assessments were made separately by two blinded spine surgeon, and a consensus of ASD diagnosis was attained. In the case of any detection of disagreement, then an independent third assessment was performed by radiologist.

Surgical Intervention

In all instances in this series, long-segment posterior spinal instrumentation with pelvic screw fixation was carried out. All the surgeries were done through a standard midline posterior approach under general anesthesia. Multilevel decompression with fusion was carried out as per the pathology, and transforaminal lumbar interbody fusion was added if necessary for additional segmental stabilization.

Surgeries consisted of extension of instrumentation proximally to the degenerated segment. Laminectomy with decompression was performed in 12 of 15 ASD patients due to radiologically obvious hypertrophic ligamentum flavum, stenosis, and facet hypertrophy causing compression of the spinal cord.

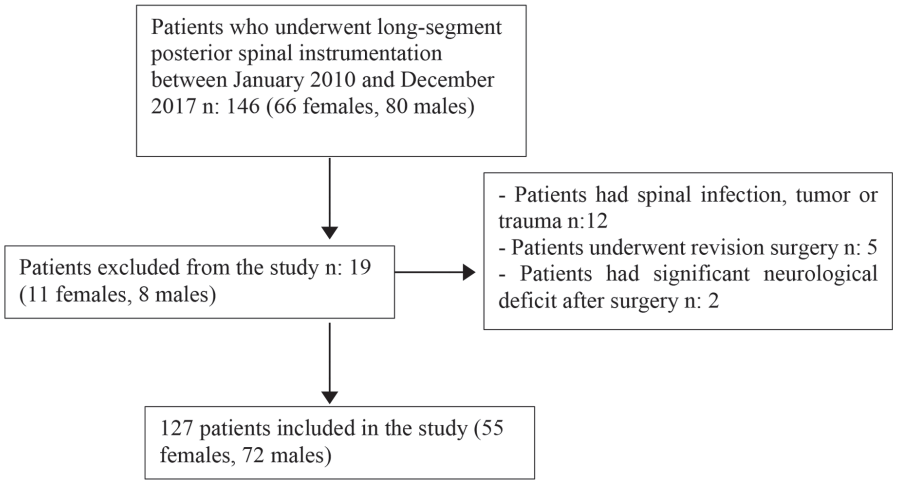
Extension of instrumentation proximally was undertaken in the presence of radiological evidence of instability of the adjacent segment, degeneration, or extension of deformity. Vertebroplasty and cemented screw was performed in selected cases to avoid ASD.

The follow-up was done according to a routine monitoring schedule at 1 month, 6 months, and a year, with standing anteroposterior and lateral X-ray, for the study of the stability of the adjacent segments.

RESULTS

This series includes 127 patients who underwent long-segment posterior spinal instrumentation (Table 1). In follow-up, symptomatic ASD developed in 15 patients (11.8%), while the remaining 112 patients (88.2%) did not have any signs of ASD. The cohort consisted of 72 males (56.7%) and 55 females (43.3%). The mean age for the entire patient population was 63.2±7.4 years. Comparatively, marked differences were registered for ASD and non-ASD patients. Patients from the ASD group were older at 65.7±5.3 years compared to those from the non-ASD group, who were younger at 62.9±7.6 years. Although this difference did indicate a trend for the possible risk factor of older age in the development of ASD, it did not attain statistical significance at p=0.14. It was thus noted that a larger number of patients over 65 years were well represented in the ASD group, thus making age an important factor to be considered while assessing the risk for ASD. The range of follow-up was from 73 to 155 months, with a median of 107 months and an average of 114±23 months. The mean BMI for all patients was 28.7±4.1. The mean BMI for the ASD group was 29.2±4.5 and

Table 1. Flowchart of the study group



for the non-ASD group was 28.5±4.0. However, this was not statistically significant (p=0.21). Diabetes mellitus: 33.1%, that is, 42 patients of the overall cohort had DM. In the ASD group, 40% which constitutes 6 patients, were diagnosed to have DM, while 32.1%, that is, 36 patients, had DM in the non-ASD group. DM was not statistically different between the groups (p=0.45). However, smoking was higher in the ASD group. Though 43.3% of all the patients were smokers, comprising 55 patients, this was as high as 66.7% among the ASD group, comprising 10 patients as opposed to 40.2%, comprising 45 patients in the non-ASD group. The difference was statistically significant, (p=0.03*), implying that smoking may thus have contributed to the development of ASD as shown in Table 2.

In the radiographic measurements, there were no significant differences between groups regarding sagittal vertical axis; C7 plumb line-central sacral vertical line, sacral slope, lumbar lordosis, pelvic tilt, and coronal Cobb angle during pre-operation and at the final follow-up (Table 3).

Of the ASD patients in the ASD group, the majority were located at the T9-10 level with a total of 9 patients; 4 presented ASD at T8-9; 1 presented at T12-L1 and 1 at L1-L2. All patients had only proximal ASD. All the cases of ASD were treated as cases of symptomatic degeneration by reoperation to extend the instrumentation. In 12 patients, radiologically evident hypertrophic ligamentum flavum with adjacent segment stenosis and facet hypertrophy causing spinal cord compression was seen, hence, laminectomy with decompression was performed to relieve the compression (Table 4). Risk factor analysis revealed that advanced age strongly correlated with pre-existing degenerative spinal changes (Table 5). In ASD, patients with fusions extending to T10 had a significantly higher incidence as compared to others (p<0.05).

Vertebroplasty was utilized markedly less in the ASD group compared with the non-ASD group (p<0.05). The use of cemented screws was noted to be applied with considerably lower frequency within the ASD cohort compared to those with no ASD status in all cases at (p<0.05).

Statistical Analysis

Data analysis was conducted using SPSS software. The distribution of continuous variables were tested by Shapiro-Wilk. Normally distributed variables were described as mean ± standard deviation, and non-normally distributed variables as median. Besides, the results of categorical variables, including presence of upper level vertebroplasty and cemented screws, were expressed as frequency and percentage.

Comparisons for subjects with ASD versus subjects without ASD were done using the following tests:

Table 2. Demographic characteristics

Characteristics	All patients (n=127)	ASD group (n=15)	Non-ASD group (n=112)	p-value
Age (mean ± SD)	63.2±7.4	65.7±5.3	62.9±7.6	0.14
Gender (male/female)	72/55	6/9	66/46	0.22
BMI (mean ± SD)	28.7±4.1	29.2±4.5	28.5±4.0	0.21
Diabetes mellitus (%)	42 (33.1%)	6 (40%)	36 (32.1%)	0.45
Smoking (%)	55 (43.3%)	10 (66.7%)	45 (40.2%)	0.03*

ASD: Adjacent segment disease, SD: Standard deviation, BMI: Body mass index

Table 3. Radiographic analysis between groups in terms of SS, LL, PT, and coronal Cobb angle

Parameter	T10 group (n=9)	T9 group (n=4)	L1 group (n=1)	L2 group (n=1)	p-value
SVA pre-op	78.4 (-25-137)	70.2 (-30-140)	75.8 (-20-135)	73.0 (-28-130)	0.5842
SVA final follow-up	59.3 (-9-158)	61.2 (-12-155)	58.8 (-10-160)	62.5 (-11-162)	0.5920
C7PL-CSVL pre-op	14.2 (0-90)	15.0 (1-92)	13.5 (0-88)	14.8 (1-89)	0.2153
C7PL-CSVL final follow-up	9.2 (0-39)	10.0 (0-42)	8.5 (0-37)	9.8 (0-40)	0.7684
Pre-op LL	33.8±19.5	34.5±18.2	32.6±15.0	31.9±14.5	0.680
Last follow-up LL	36.2±13.4	37.0±12.5	39.1±10.9	38.6±10.4	0.230
Pre-op PI	44.1±10.2	45.7±11.0	47.9±9.9	49.0±10.5	0.045
Last follow-up PI	47.4±13.8	47.9±13.4	49.6±8.8	50.2±8.3	0.490
Pre-op PT	18.8±8.7	20.2±8.6	22.4±9.1	22.9±9.3	0.090
Last follow-up PT	15.5±10.1	15.0±6.5	16.1±6.0	15.8±6.2	0.980
Pre-op SS	25.9±9.1	26.5±9.0	27.1±8.9	27.4±9.1	0.740
Last follow-up SS	31.9±10.2	32.7±10.0	34.1±7.8	34.6±7.9	0.200
Pre-op Cobb	10.9±5.1	10.3±5.4	9.5±5.1	10.0±5.3	0.330
Last follow-up Cobb	4.8±2.4	5.1±2.6	5.3±2.8	5.6±2.7	0.190

SVA: Sagittal vertical axis, C7PL-CSVL: C7 plumb line-central sacral vertical line, SS: Sacral slope, LL: Lumbar lordosis, PT: Pelvic tilt

Table 4. Surgical technique of 1st operation, time to 2nd operation and surgical detail of 2nd operation

Case	Sex	Age	1st operation	Time to 2nd operation (months)	2nd operation
1	F	75	TLIF L4-5, L5-S1 (T9-iliac screws)	23	Instrumentation
2	M	72	TLIF L4-5 (T10-iliac screws)	24	Instrumentation
3	F	69	TLIF L3-4, 4-5 (T9-iliac screws)	26	Instrumentation+laminectomy
4	F	68	TLIF L4-5 (T10-iliac screws)	30	Instrumentation+laminectomy
5	M	71	TLIF L3-4, L5-S1 (T9-iliac screws)	32	Instrumentation+laminectomy
6	F	57	TLIF L4-5 (L1-iliac screws)	33	Instrumentation+laminectomy
7	M	60	TLIF L5-S1 (T10-iliac screws)	35	Instrumentation+laminectomy
8	F	61	TLIF L3-4 (T10-iliac screws)	33	Instrumentation+laminectomy
9	F	72	TLIF L4-5 (L2-iliac screws)	38	Instrumentation+laminectomy
10	M	55	TLIF L4-5 (T10-iliac screws)	40	Instrumentation+laminectomy
11	F	68	TLIF L4-5, L5-S1 (T10-iliac screws)	41	Instrumentation+laminectomy
12	M	61	TLIF L3-4 (T9-iliac screws)	42	Instrumentation+laminectomy
13	F	68	TLIF L5-S1 (T10-iliac screws)	36	Instrumentation
14	M	67	TLIF L4-5 (T10-iliac screws)	27	Instrumentation+laminectomy
15	F	71	TLIF L4-5, L5-S1 (T10-iliac screws)	29	Instrumentation+laminectomy

TLIF: Transforaminal lumbar interbody fusion, F: Female, M: Male

Table 5. Risk factors for ASD development

Risk factors	ASD group (n=15)	Non-ASD group (n=112)	p-value	Odds ratio	95% CI
Age (>65)	10 (66.7%)	28 (25.0%)	0.01*	3.50	1.35-9.08
Pre-operative degenerative changes	12 (80.0%)	40 (35.7%)	<0.01**	4.67	1.70-12.82
Vertebroplasty	3 (20.0%)	56 (50.0%)	0.02*	0.28	0.08-0.93
Cemented screw use	4 (26.7%)	60 (53.6%)	0.03*	0.33	0.10-1.00

*p<0.05 and **p<0.01 indicate significant differences, ASD: Adjacent segment disease, CI: Confidence interval

Independent Samples t-test: This is used to compare the mean of normally distributed continuous variables between groups.

The Mann-Whitney U test was performed for follow-up duration-a continuous variable with a non-normal distribution.

Chi-square (χ^2) test: In comparisons of categorically distributed variables, including proportion of patients with vertebroplasty or cemented screw placement in ASD versus non-ASD subjects. Fisher's exact test if expected count in contingency table for categorical variables were less than 5.

Multivariate logistic regression analysis was done to elucidate predictive factors in the development of ASD based on the following independent variables: Age, pre-existing degenerative spinal changes, the use of vertebroplasty, and cemented screws. The Hosmer-Lemeshow test was used to evaluate the goodness-of-fit for this regression model.

A probability value less than 0.05 was taken as the level of significance. The adjusted odds ratios and 95% confidence intervals of each risk factor involved were measured in the logistic regression analysis.

DISCUSSION

We therefore conducted the study to determine the incidence, risk factors, and outcome of symptomatic ASD after long-segment posterior spinal instrumentation with pelvic screws in patients with degenerative spine disease. In the series, the incidence of ASD was 11.8%, showing a high clinical impact of the complication. Advanced age, smoking, pre-operative degenerative spinal changes, and selection of the UIV were critical risk factors for ASD. The use of cemented screws and vertebroplasty also seemed to play a protective role against ASD. Based on our observation of a considerable incidence of ASD in the surgical cases performed during the initial years commencing from 2010, targeted prevention strategies were implemented. These included the performance of vertebroplasty on the non-instrumented vertebra adjacent to the proximal end of instrumentation and usage of cemented screws. As we initiated these, the rates of ASD began to dramatically decline; as such, we made them a standard for all cases beyond 2015. Beside, based on the authors' experience, adequate bending of

the rod at the UIV may potentially reduce the risk of ASD. That would be one way intrinsically to decrease mechanical stress at the junction between instrumented and non-instrumented segments while maintaining the biomechanical essence of the spinal column.

We thus studied our cases retrospectively and compared the two groups in an attempt to measure the impact of this prevention on the rate of ASD. These findings add to the literature in targeting the risk factors that influence ASD and, once again, highlight how important careful pre-operative planning and surgical strategy are in avoiding this complication.

Kimura et al.[1] studied the risk of ASD and distal junctional failure in patients who underwent long-segment spinal fusion ending at L5. They concluded that there was an increased risk of ASD and distal junctional failure for those patients, especially when the UIV were at the thoracic levels of T7-T10. Thus, our investigation demonstrated that the precise extent of the proximal end of spinal fusion significantly contributed to the creation of ASD and pointed out that advanced age and pre-operative degenerative changes were important risk factors. These findings stress the importance of segment selection in the process of surgical planning.

Ma et al.[3] performed a study to determine the risk factors related to post-operative ASD after multi-level posterior lumbar interbody fusion. They found that one of the pre-operative factors was a Pfirrmann grade ⩾3, high pelvic incidence, and an increased number of decompressed levels were the only significant determinants in ASD development. They reported the protective effect of cemented screws and vertebroplasty in reducing the risk of ASD. Such findings have brought into view the importance of addressing modifiable risk factors in the prevention of ASD.

Pinto et al.[11] pointed out the main contribution of the surgical methodology itself, such as the type of interbody fusion, the extension of the fusion construct, and sagittal alignment restoration, to the development of ASD. They also realized how cardinal the determinants are because of the surgical approach and anatomical dissection.

Glattes et al.[12] evaluated the incidence and consequence of proximal junctional kyphosis in adults following extended posterior spine fusion. The incidence of ASD was 26%. Interestingly, development of ASD did not result in any adverse consequence in terms of SRS-24 scores or sagittal alignment, and did not identify any patient or radiographic variable that could predispose to it. Pehlivanoğlu et al.[13] report that the most common causes of revision surgery following the surgical treatment of adult spinal deformity are severe sagittal malalignment and proximal junctional kyphosis. They stressed that these situations can be prevented by not missing the proximal fusion levels to the thoracolumbar junction rather than T10 and not using PMMA-augmented screws in patients with osteoporosis during surgical planning. In this framework, our research designates the importance of accurate surgical planning, with an especial focus on the role of the UIV and techniques such as cement-augmented screws in reducing ASD and further need for revision surgery.

Puvanesarajah et al.[14] investigated factors associated with revision surgery after long-segment fusion for adult spinal deformity in elderly patients. In this respect, it was discovered that osteoporosis drastically enhanced the risk of revision surgeries while bone morphogenetic protein application had a protective effect. Other critical factors affecting the outcomes could be smoking and instrumentation failure. Similarly, in our study, ASD was more frequent among patients who smoked.

Quinn et al.[15] emphasised that ASD may occur in all types of spine surgery; the consequence of a constellation of post-operative mechanical factors superimposed upon natural aging of the spine. Such technical contributors to ASD highlighted from the authors are represented by laminectomy adjacent to a fusion and also a failure to restore appropriate segmental lordosis. It also provided that ASD is often prone to significantly impact functional outcome and usually requires surgical revision in cases of severe refractory back pain or neurological deficit. As evolution in newer concepts took place, such as minimally invasive techniques and motion preservation, it has clearly failed to show any reduction in the incidence of ASD. Conclusively, their findings highlight the importance of restoration of global, regional, and segmental alignment, in addition to decompression and stabilization, while planning surgery for the treatment of ASD.

The research has certain limitations that need to be acknowledged. First, without the pre-operative DEXA studies of the bone density, there is every possibility that the associated factors of osteoporosis may have underestimated the definition of ASD. Secondly, the nature of the study was retrospective. Thus, the conclusions regarding causality are limited due to reliance on previously collected data, which is subject to various biases: selection and recall biases. Lastly, the number of symptomatic ASD patients was small, and this may limit the generalisability of the results.

CONCLUSION

ASD following long-segment posterior spinal instrumentation in adult degenerative spines is a common complication with significant clinical and quality-of-life implications. Evaluating high-risk patients based on factors such as age >65, smoking, pre-operative degenerative changes, and the selection of the fusion levels may help mitigate this risk. The use of cemented screws and prophylactic vertebroplasty are effective surgical techniques for reducing the risk of ASD. Further research is needed to develop surgical techniques and preventive strategies aimed at reducing ASD incidence and improving long-term patient outcomes.

Ethics

Ethics Committee Approval: The study was approved by the İstanbul Yeni Yüzyıl University of Local Ethics Committee (approval number: 2024/10-1346, date: 15.10.2024).

Informed Consent: Informed consent was obtained from all participants in this study.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: Y.K., M.N.E., Concept: Y.K., M.N.E., Design: Y.K., M.N.E., Data Collection or Processing: Y.K., Analysis or Interpretation: Y.K., M.N.E., Literature Search: Y.K., M.N.E., Writing: Y.K., M.N.E.

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SINGLE-SESSION MULTILEVEL VERTEBROPLASTY AND KYPHOPLASTY: EVALUATION OF SAFETY AND EFFICACY IN THE TREATMENT OF SPINAL COMPRESSION FRACTURES

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ABSTRACT

Objective: Single-session multi-level vertebroplasty (VP) and kyphoplasty (KP) are minimally invasive techniques for spinal compression fracture treatment.This study aimed to retrospectively evaluate the safety and clinical efficacy of three or more KP/VP procedures performed in a single session.

Materials and Methods: Between 2017 and 2024, clinical data from 13 patients who underwent single-session multilevel (>3 levels) KP/VP for spinal compression fractures were retrospectively analyzed. Pain severity was assessed pre-operatively and post-operatively using the Visual Analogue Scale (VAS), while functional recovery was evaluated using the Oswestry Disability Index (ODI). The procedure-related complication rates, including cement leakage, were also analyzed and categorized according to clinical significance.

Results: A significant reduction in pain levels was observed based on VAS scores ($p<0.05$). The mean pre-operative VAS score was 8.38±1.26, which decreased to 5.15±1.72 in the early post-operative period and further to 2.15±1.14 in the late post-operative period. Similarly, the mean pre-operative ODI score was 70.72±11.65, which decreased to 33.56±10.4* in the late post-operative period ($p<0.05$). The complication rate related to the procedure remained minimal, with a cement leakage rate of 18%.

Conclusion: Single-session multi-level KP and VP are reliable and effective treatment methods for spinal compression fractures, and they can significantly reduce pain and achieve functional improvement with a low complication rate. This approach has been implemented in a limited number of centers worldwide and has a high clinical success rate.

Keywords: Multilevel vertebroplasty, multilevel kyphoplasty, spinal compression fractures, minimally invasive techniques

INTRODUCTION

Back pain is a common problem that affects millions of people worldwide and significantly reduces quality of life. The source of the pain may be collapsed or fractured vertebrae in the spine. Various factors can lead to vertebral collapse or fractures. Aging-related bone mass loss, muscle loss, and the development of kyphotic deformities in the spine can render vertebrae more vulnerable to trauma, increasing the risk of fractures[1].

Multilevel vertebral compression fractures are a serious issue caused by the collapse of multiple spinal bones. This condition can result in chronic pain, loss of mobility, and a significant decrease in quality of life[2]. Patients may struggle to perform daily activities and even become dependent on others[3].

Painkillers, muscle relaxants, physical therapy, and orthopedic braces are conservative treatment methods that can be beneficial in many cases. Particularly in patients with mild to moderate compression fractures, these methods are effective

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in alleviating symptoms and promoting recovery without the need for surgical intervention[4].

Vertebroplasty (VP) and kyphoplasty (KP) are procedures used to treat vertebral compression fractures. VP is a minimally invasive procedure aimed at alleviating fracture-related pain, reducing opioid dependency, and enabling patients to resume daily activities[5].

VP can be performed under local or general anesthesia. It provides rapid pain relief and biomechanical stability, slowing the progression of kyphosis by preventing vertebral collapse. It involves injecting a special cement mixture into the fractured bone (VP) or inserting a balloon into the fractured bone to create a cavity, followed by filling it with cement (KP)[6]. Procedures such as VP or KP carry a risk of cement leakage, which can lead to serious complications. The spread of cement outside the vertebral fractures may cause nerve damage, paralysis, or even death.

Therefore, performing VP or KP on more than four levels in a single session has been a controversial topic among surgeons. Due to potential complications such as cement leakage, many authors recommend limiting VP or KP to no more than three levels in a single session[7].

Because of the increased risk of leakage and potential complications in such procedures, surgeons often prefer to treat fewer levels. Barr et al.[8] reported that single-level percutaneous kyphoplasty (PKP) is more effective than multilevel PKP. According to some studies, injections should be limited to six levels in a single session due to the higher risk of leakage and complications[9].

Other studies suggest that percutaneous vertebroplasty (PVP) performed on a single fracture level and multiple fracture levels is equally effective and safe[10]. However, this may vary depending on the individual characteristics of the patient, fracture pattern, and other health factors.

In this study, we retrospectively analyzed the efficacy and safety of KP or VP procedures performed on more than three levels in selected patients. This analysis aims to help surgeons better understand the challenges and risks associated with these procedures and guide future treatment planning.

MATERIALS AND METHODS

Between January 2017 and February 2024, this study included a total of 13 patients who underwent multilevel VP or KP procedures. All patients presented with common symptoms of back and lumbar pain. Of the patients, 5 were male (38.5%) and 8 were female (61.5%). The mean age of the patients was 66 years (±14.97), with a range of 22 to 88 years (Table 1). All patients experienced pain that affected their daily lives, highlighting the necessity and effectiveness of the procedure. Upon examining the performed procedures, VP or KP was performed on 8 patients at 4 levels, 2 patients at 6 levels, 1 patient at 7 levels, and 2 patients at 8 levels, totaling 67 vertebrae treated (38 thoracic and 29 lumbar levels) (Table 2).

Patients included in the study had stable compression fractures that did not cause radiological neural compression. Patients with fractures involving more than 3 levels and causing pain were included in the study. VP or KP cases that did not meet these criteria were excluded.

Additionally, 4 patients underwent VP, 6 patients KP, and 3 patients a combination of VP and KP (Table 3). These different approaches were determined based on the individual needs of the patients and the characteristics of the fractures. A comprehensive evaluation method was employed to determine the effectiveness and safety of the procedure. Pre-and post-

Table 1. Patient demographics and procedures

Category	Value
Total patients	13
Male patients	5 (38.5%)
Female patients	8 (61.5%)
Mean age (years)	66 (±14.97)
Age range	22-88

This table summarizes the demographic distribution of the study's 13 patients, including their gender (61.5% female) and age range (22 to 88 years). The table highlights the diversity of patient demographics and underscores the range of cases included in the analysis

Table 2. Levels treated and vertebra distribution

Levels treated	Number of patients	Total vertebrae treated
4 levels	8	32
6 levels	2	12
7 levels	1	7
8 levels	2	16

The distribution of vertebral levels treated shows that the majority of patients (61.5%) underwent procedures at 4 levels, with a total of 67 vertebrae treated across thoracic and lumbar regions. This table emphasizes the multilevel treatment strategy adopted in this study

Table 3. Distribution of surgery types

Surgical type	Frequency	Percent (%)	Valid percent (%)	Cumulative percent (%)
Vertebraplasty	4	30.8	30.8	30.8
Kyphoplasty	6	46.2	46.2	76.9
Vertebraplasty+kyphoplasty	3	23.1	23.1	100.0
Total	**13**	**100.0**	**100.0**	**100.0**

This table categorizes patients based on the surgical approach used: kyphoplasty (46.2%), vertebroplasty (30.8%), and a combination of both techniques (23.1%). Kyphoplasty emerged as the most frequently performed procedure in this cohort

procedure X-rays were used to assess the healing status of the fractures and identify any potential complications. Ethical approval for the study was obtained from the Ordu University Non-interventional Research Ethics Committee (approval number: 2024/154, date: 24.10.2024).

Statistical Analysis

Pain levels were assessed using the Visual Analogue Scale (VAS) pre-operatively, in the early post-operative period, and in the late post-operative period. Functional status was measured using the Oswestry Disability Index (ODI), with scores recorded pre-operatively, in the early post-operative period, and in the late post-operative period.

The statistical analysis was conducted as follows:

- Paired t-test; was applied to compare differences in pre-operative and post-operative VAS and ODI scores.
- Shapiro-Wilk normality test; was used to assess the normality of data distributions for VAS and ODI scores.

A p-value of <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics, version 26.0.

Monitoring Complications

Complications during surgery were continuously monitored under fluoroscopy, with special attention paid to cement leakage into the foramen or spinal canal. If any concern arose, the procedure was halted, and reevaluation was performed. Post-operatively, patients were neurologically assessed immediately upon waking in the operating room and compared with their pre-operative condition.

Follow-up Period

Patients were evaluated in early and late post-operative periods, specifically at the 3rd month. During these follow-ups, VAS and ODI scores were reassessed along with the identification of potential complications.

RESULTS

In this retrospective study, 13 patients who underwent KP/VP procedures were analyzed in detail. Regarding gender distribution, female patients constituted 61.5% (n=8), while male patients accounted for 38.5% (n=5). No significant differences were observed in treatment outcomes between genders. The mean age of the patients was recorded as 63.38 (±14.97) years, with an age range between 22 and 77 years.

During the early post-operative period, patients were regularly monitored, and their recovery processes were evaluated at the third month using short-tau inversion recovery (STIR)-sequenced whole spinal magnetic resonance imaging (MRI) (Figures 1, 2). During follow-up, two patients passed away in the late period; however, it was concluded that these deaths were not directly related to the treatment. No severe complications, such as cement embolism, fat embolism, or pulmonary embolism (PE), were observed during or after the procedure. Only one patient reported temporary shortness of breath, which showed no abnormalities on radiological examination and resolved spontaneously.

Cement Leakage Analysis

In total, 67 vertebrae were injected, and cement leakage was detected in 12 levels (18%). Of these leakages, 4 (5.97%) extended into the disc space, 5 (8.95%) into the paravertebral area, and 3 (4.47%) into the epidural space (Table 4). All these leakages were considered clinically insignificant, and no complications, such as radicular compression or canal stenosis, were observed in any patient.

Pain and Functional Outcomes

A significant reduction in pain levels was recorded:

VAS Scores: The mean pre-operative VAS score was 8.38 (±1.26), which decreased to 5.15 (±1.72) early post-operatively and further to 2.15 (±1.14) late post-operatively. This reduction

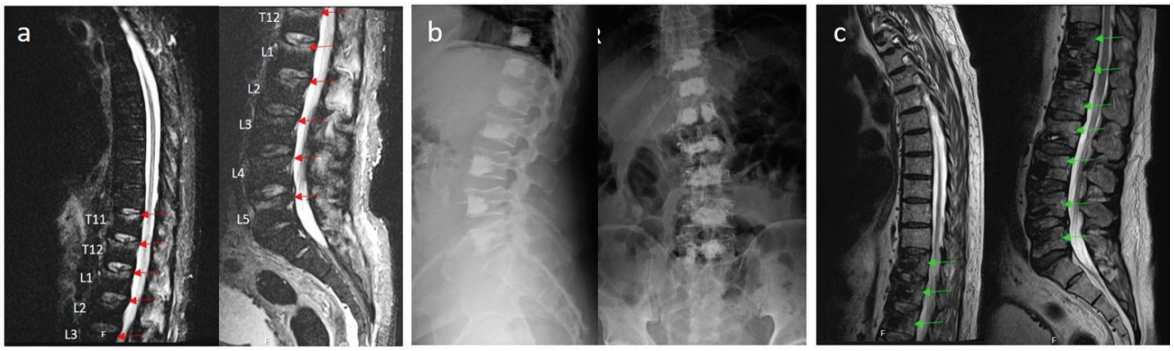

Figure 1. A 27 years old male patient with a history of prolonged steroid use and no evidence of trauma presented with persistent back pain lasting for one week. A whole-spine MRI revealed multilevel vertebral body compression fractures with acute compression and edema observed on STIR sequences. These were treated with single-session multilevel KP. (a) Pre-operative STIR-sequenced MRI images show acute compression fractures at seven levels (T11-L5) marked with red arrows. (b) Post-operative X-ray images display cement fillings without any cement leakage into the spinal canal. (c) Post-operative STIR-sequenced MRI images demonstrate cement fillings covering all edematous areas, indicated by green arrows

MRI: Magnetic resonance imaging, STIR: Short-tau inversion recovery, KP: Kyphoplasty

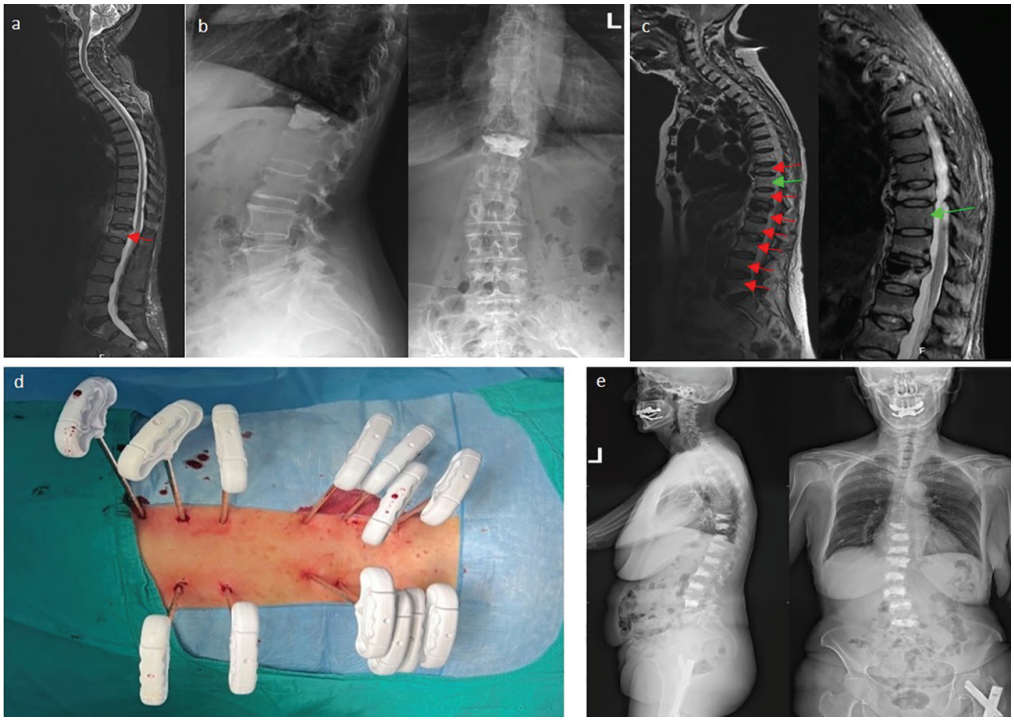

Figure 2. A 70-year-old female patient with a history of an L1 traumatic compression fracture treated with vertebroplasty and osteoporotic bone T-score levels presented with spontaneous acute back pain. (a) Initial pre-operative STIR-sequenced MRI images indicating an acute compression fracture at the L1 level. (b) Post-operative X-ray images after the first surgery, showing that the T12 vertebra was treated with vertebroplasty while the other vertebrae remained intact. (c) Whole-spine STIR-sequenced MRI images obtained after the onset of new back pain. Red arrows indicate newly developed multilevel compression fractures, while the green arrow highlights the intact T11 vertebral body. (d) Intraoperative multilevel single-session procedures. (e) Post-operative X-ray images, demonstrating that all fractured levels were filled with cement. Although the T11 vertebra had not collapsed, it was included in the treatment with vertebroplasty to prevent a high likelihood of fractures between the T10 and T12 vertebrae following KP

STIR: Short-tau inversion recovery, MRI: Magnetic resonance imaging

Table 4. Cement leakage distribution

Leakage location	Number of levels	Percentage (%)
Disc space	4	5.97%
Paravertebral area	5	8.95%
Epidural space	3	4.47%

Cement leakage was observed in 18% of the treated levels, categorized into disc space (5.97%), paravertebral area (8.95%), and epidural space (4.47%). Despite leakage in these areas, no clinically significant complications, such as radicular compression, were reported

was statistically significant ($p<0.001$) as confirmed by paired t-test analysis. A 6.51-point reduction was observed in the late post-operative period (Table 5).

Functional improvement was also evident:

ODI Scores: The mean pre-operative ODI score was ±11.65 (70.72%), which decreased to ±11.37 (52.33%) early post-operatively and further to ±10.43 (33.56%) late post-operatively. This difference was statistically significant ($p<0.001$) and reflects a notable improvement in patients' daily functional capacities (Table 5).

Statistical Confirmation

Statistical analysis revealed that all comparisons yielded statistically significant results with a p-value of <0.05. The Shapiro-Wilk normality test confirmed that pre-operative and post-operative VAS scores followed a normal distribution, while post-operative ODI scores did not. Paired t-tests demonstrated statistically significant differences in both VAS and ODI scores across pre-operative and post-operative periods, validating the effectiveness of the procedures.

DISCUSSION

This study demonstrates that VP and KP procedures performed on three or more levels in a single session provide high safety and efficacy in the treatment of spinal compression fractures. Minimally invasive procedures such as VP and KP are well-known methods for the rapid relief of pain caused by

Table 5. Summary statistics and paired t-test results

Measure	Mean	Median	SD	Range	Minimum	Maximum	t-value	p-value
Preop VAS	8.38	8.47	1.26	3.77	7.00	10.77	-	-
Postop VAS	5.15	5.50	1.72	4.75	4.00	8.75	7.08	<0.001
Late postop VAS	2.15	1.75	1.14	3.46	-0.46	3.00	-	-
Preop oswestry	70.72	67.50	11.65	20.83	54.17	75.00	-	-
Early postop oswestry	52.33	53.00	11.37	20.00	40.00	60.00	9.52	<0.001
Late postop oswestry	33.56	32.00	10.43	30.18	17.81	47.99	18.03	<0.001

This table presents the pain (VAS) and functional (ODI) outcomes of the procedures, showing significant improvements post-operatively. Pre-operative VAS scores averaged 8.38, decreasing to 2.15 in the late post-operative period. Similarly, ODI scores improved from 70.72% pre-operatively to 33.56% in the late post-operative period, reflecting enhanced patient mobility and pain relief. Paired t-tests confirmed significant improvements in both scores, validating the clinical efficacy of the procedures with p-values <0.001
SD: Standard deviation, VAS: Visual Analogue Scale, ODI: Oswestry Disability Index

Table 6. Complications table

Complication type	Number of cases	Percentage (%)	Comments
Cement leakage	12	18%	Clinically insignificant in all cases
Disc space	4	5.97%	No radicular compression or canal stenosis
Paravertebral area	5	8.95%	No clinical symptoms
Epidural space	3	4.47%	No neurological deficits observed
Pulmonary embolism	0	0%	Not observed
Fat embolism	0	0%	Not observed
Temporary shortness of breath	1	<1%	Resolved spontaneously without intervention

Cement leakage was the most common complication, occurring in 12 levels (18%), predominantly in the paravertebral area (8.95%). However, these leakages were clinically insignificant, with no cases of pulmonary embolism or severe systemic complications reported

compression fractures. However, multi-level applications are less frequently used, and data in this area remain limited. Our study bridges this gap by focusing specifically on the clinical efficacy of multi-level applications and confirms the significant pain relief and functional improvement achieved, as evidenced by VAS and ODI scores.

Although VP is an effective minimally invasive method for treating vertebral fractures, like all medical procedures, it carries some complications. Most complications are transient and vary in severity. Mild complications typically present as temporary pain increase and hypotension. Moderate complications include infections and cement leakage. Lastly, severe complications can include cement extravasation into the vasculature, PE, cardiac perforation, and cerebral vessel occlusion, all of which pose life-threatening risks[11].

This risk is one of the most common complications. According to Wang et al.[12] (2012) meta-analysis, the cement leakage rates in VP range from 2.1% to 26%. Other studies report an overall leakage rate of 41.7% for cement injected into vertebral fractures[13]. In our study, the cement leakage rate was recorded as 12 levels (18%), predominantly in the paravertebral area (8.95%), but no serious systemic complications such as PE were observed (Table 6). This underscores the importance of careful measures during the procedure and the appropriate viscosity of the cement injected.

Similarly, the study byChen et al.[14] (2021) found that the use of high-viscosity cement resulted in lower leakage rates. This systematic review and network meta-analysis aimed to compare cement leakage rates after VP with high- and low-viscosity cements, as well as after KP. However, some differences were observed across studies.

Likewise, Wang et al.[15] (2022) study focused on comparing the clinical outcomes and complications of high- versus low-viscosity bone cement in patients with osteoporotic vertebral compression fractures treated with PVP or PKP. Similar findings were reported in this study[14].

Rare complications following VP, such as infections, epidural hematoma[16], fat embolism[17], cardiac damage[18], arterial or renal embolism[19], and intradural cement leakage[20], have been documented in the literature. Fortunately, none of these complications were observed in our study. Awareness of these risks and taking preventive measures are critical for minimizing complications and optimizing treatment outcomes. Preventive measures include employing an experienced team, ensuring the correct cement viscosity, using imaging techniques, low-pressure injection, and careful patient monitoring.

Cement injection is one of the most critical stages of VP. Proper preparation and administration of the cement mixture directly impact the success of the procedure and the risk of complications[21]. High-viscosity cements may resist flow

more easily, require higher injection pressures, and potentially increase leakage risk. Conversely, low-viscosity cements may flow more easily but are associated with increased leakage risk if not properly controlled. Rapid injection can lead to undesired cement extravasation and increase the risk of PE[21], while delayed injection can cause the cement to harden within the working channels, resulting in procedural failure. Therefore, cement injection must be performed at the correct timing and speed.

In VP, excessive cement injection into the vertebral body increases the risk of leakage and complications. Studies suggest using as much cement as possible without causing leakage[22]. However, excessive cement volumes may lead to leakage and other complications. Some studies report that the amount of cement injected is not associated with leakage but significantly increases the incidence of adjacent fractures[23]. In this study, the volume of cement injected into the vertebral body was maintained between 4 and 9 cc. Cement injection was performed gradually and carefully under fluoroscopic guidance, ensuring no signs of complications. If rare complications were detected during the procedure, the operation was terminated. Based on our experience, as long as these principles are followed, multi-level procedures can be performed as safely as single-level procedures.

Efficacy and Advantages of the Procedure

In this study, VP was performed on patients presenting with complaints of back and lumbar pain. Pre- and post-operative assessments showed a significant reduction in pain in all groups. The pre-operative VAS scores averaged ±26.1 (8.38), which decreased to ±14.1 (2.15) post-operatively ($p<0.001$, paired t-test). This marked reduction demonstrates the effectiveness of multi-level procedures in reducing pain. Our results not only showed a reduction in pain but also significantly improved patients' limitations in daily activities, as evidenced by the ODI. Pre-operative ODI scores averaged ±11.65 (70.72%), which decreased to ±43.10 (33.56%) post-operativel ($p<0.001$, paired t-test). These findings align with results reported in the literature[24], clearly demonstrating that patients were able to perform daily activities more easily and comfortably after the procedure.

Single-session multi-level VP and KP offer distinct advantages such as shorter recovery times, reduced hospital stays, and enhanced patient satisfaction. The significant reductions in VAS and ODI scores in our study align with the findings of Zidan et al.[25] (2018), who reported accelerated clinical recovery with multi-level minimally invasive techniques.

Although the literature on multi-level VP and KP is limited, existing data demonstrate the high clinical efficacy of these procedures, especially in elderly patients and cases with multiple compression fractures[25].

One advantage of the procedure is its ability to stabilize the spine, particularly in preventing kyphosis associated with multiple fractures[26]. This technique may be play a significant role in treating vertebral fractures and correcting spinal deformities. Proper stabilization of the spine helps patients maintain postural balance and mobility. Additionally, achieving stabilization can reduce pain associated with vertebral fractures and enhance the patient's quality of life[8].

The results of our study demonstrate that multi-level VP/ KP is an effective and safe method for significantly reducing pain and improving mobility and quality of life in patients with compression fractures. Furthermore, it suggests that this method may be effective in managing chronic pain in such patients. This technique can also provide long-term biomechanical stability.

A study by Cosar et al.[27] found that KP causes fewer complications compared to VP. This is attributed to the volume of cement injected into the cavity created by the balloon during KP, making it the preferred method.

Detailed pre-operative planning and careful execution during the operation can help avoid potential complications, such as cement leakage and PE, or minimize their effects. Additionally, the experience of the surgical team and the use of appropriate techniques contribute to the successful completion of the operation and optimize the patient's recovery process.

Study Limitations

One of the primary limitations of our study is the relatively small sample size. Larger prospective studies could provide a clearer understanding of the long-term efficacy and safety of multi-level VP and KP. Moreover, the retrospective design may introduce some inaccuracies, which could limit the generalizability of the results. Future randomized controlled trials can help better understand the outcomes of this treatment strategy in different patient groups.

CONCLUSION

Single-session multi-level VP and KP applications offer a reliable and effective option in the treatment of spinal compression fractures. Our study demonstrates that these procedures may be play a significant role in improving patients' quality of life and reducing pain. Future prospective studies involving larger patient groups could strengthen these findings and further establish the place of these methods in clinical practice.

Ethics

Ethics Committee Approval: Ethical approval for the study was obtained from the Ordu University Non-Interventional Research Ethics Committee (approval number: 2024/154, date: 24.10.2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.H., A.T.B., H.Ö., F.E., U.Ö., M.Y.A., T.Ö., A.F.Ö., Concept: A.F.Ö., Design: M.H., A.T.B., T.Ö., A.F.Ö., Data Collection or Processing: M.H., H.Ö., F.E., B.K., Analysis or

Interpretation: H.Ö., U.Ö., B.K., Literature Search: M.H., M.Y.A., Writing: M.H., B.K.

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ORIGINAL ARTICLE
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EFFECTIVENESS OF HALO TRACTION IN THE TREATMENT OF PATIENTS WITH SEVERE RIGID SCOLIOSIS

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ABSTRACT

Objective: Halo traction reduces surgical risks in the treatment of severe rigid scoliosis. The aim of this study was to demonstrate the effectiveness of halo traction in the treatment of these patients.

Materials and Methods: Patients with severe rigid scoliosis who underwent halo traction before surgery were retrospectively evaluated. The halo traction gradually increased, and a total weight of 50% of the body weight was applied. The major coronal curvature (Cobb angle), thoracic kyphosis (TK) and length between T1 and L5 in the coronal plane were evaluated before halo traction, at 3 weeks under traction, and before surgery.

Results: Five patients (mean age: 12.8 years) were evaluated. Before halo traction, the mean major Cobb angle was 112°, TK was 78.6°, and the length between T1 and L5 was 261 mm. The average traction duration was 43 days. It was determined that there was a statistically significant improvement in the major Cobb angle, TK, and the length between T1 and L5 between the patients' baseline and 3rd week and presurgery measurements. It was observed that 85% of the total Cobb angle and TK were completely corrected, and 84% of the length between T1 and L5 was obtained after 3 weeks of halo traction.

Conclusion: Approximately 85% of the correction is achieved after the first three weeks of halo traction application. There was no significant improvement after this period. Thus, halo traction for 3 weeks may be considered sufficient.

Keywords: Halo traction, scoliosis, thoracic kyphosis.

INTRODUCTION

The management of severe, rigid scoliosis in children presents significant challenges because surgical correction carries a significant risk of neurological injury[1,2]. This can be caused by direct trauma to the spinal cord or indirectly by overstretching or compromising its vascular supply. It is essential to ensure that such catastrophic complications are avoided, as these injuries can lead to permanent dysfunction and long-term disability. Therefore, careful pre-operative planning and adjunctive treatments are essential to minimise these risks while achieving the desired spinal correction[3].

Traditional techniques, including posterior spinal fusion, anterior release or osteotomies may be insufficient or carry high risks in patients with severe curvature and reduced flexibility[4]. To minimise this risk, surgeons have used various methods to achieve a partial correction in the size of the major curve prior to definitive surgery, including halo-femoral, halo-pelvic and halo-gravity traction (HGT). Traction methods such as halo-tibial and halo-femoral provide serious corrections but require long-term bed rest. Halo gravity traction allows mobilization and patient compliance is better[5,6].

Halo traction, a method initially developed for cervical spine injuries, has since been adapted for scoliosis management, particularly in cases of severe and rigid deformities[7]. By applying controlled, continuous longitudinal traction to the spine, halo traction facilitates gradual correction over time, allowing for increased curve flexibility, reduction in rib prominence, and better overall balance of the spine. This pre-operative treatment modality can enhance the safety and effectiveness of subsequent definitive surgical intervention, often improving outcomes in a patient population at high risk for complications[8,9].

The aim of our study is to investigate whether pre-operative halo traction in rigid curves corrects coronal and sagittal balance and for how long it should be used.

MATERIALS AND METHODS

Five patients with severe rigid scoliosis who applied to the scoliosis outpatient clinic in Department of Orthopedics and

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Traumatology, İstanbul University, İstanbul Faculty of Medicine, and underwent halo traction application were evaluated retrospectively. The ethics committee was approved the study protocol (approval number: 2024/1892, date: 15/11/2024) in line with the principles of the Declaration of Helsinki. Patient consent form was added protocol. Halo traction was applied according to the previously described protocol[10]. Halo traction was applied to the patients under general anesthesia in the operating room. Four to six halo pins were placed and tightened to 6-to 8-inch pounds depending on the patient's size and skull bone density. Usually, the pins were checked for looseness and tightened every 24-48 hours. Traction was started after checking that the pins were in the safe zone with cranial computed tomography scan. Two kilograms was applied on the first day. In the following days, the weight was increased by 2 kilograms every day until it reached half of the body weight (Figure 1).

Neurologic checks were performed 8.00 am, 04.00 pm, 00.00 am. Daily cranial nerve and upper/lower extremity neurologic examinations were performed. The patient underwent posterior fusion in the operating room and the halo traction was removed. Before starting traction, at the 3rd week of traction application and before fusion surgery, long cassette antero-posterior and lateral radiographs were taken. In radiological evaluations, major coronal curvature degree, thoracic kyphosis (TK) curvature degree (T4-12) and T1-L5 length were evaluated.

In the measurements, the degree of coronal curvature and TK was determined by the Cobb method, and the T1-L5 length was determined according to the length of the line drawn from the midpoint of both corpuses on the antero-posterior radiograph (Figure 2-4). Halo traction was applied to the patients for 6 weeks. Halo-traction related complications were noted in each case.

Figure 1. Application of halo traction for severe scoliosis

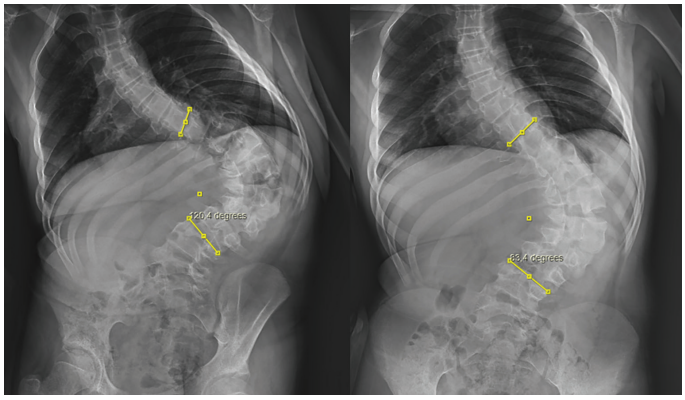

Figure 2. Thirteen year old male patient, change in Cobb angle at 3rd week follow-up (from 120 to 83 degrees)

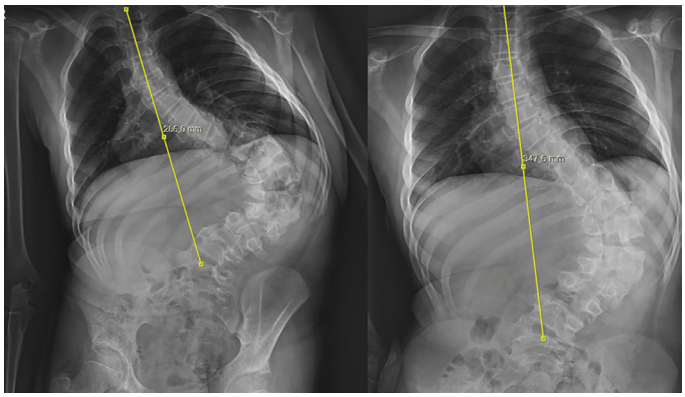

Figure 3. Thirteen year-old male patient, lengthening between T1-L5 at 3rd week follow-up (from 286 to 347.6 mm)

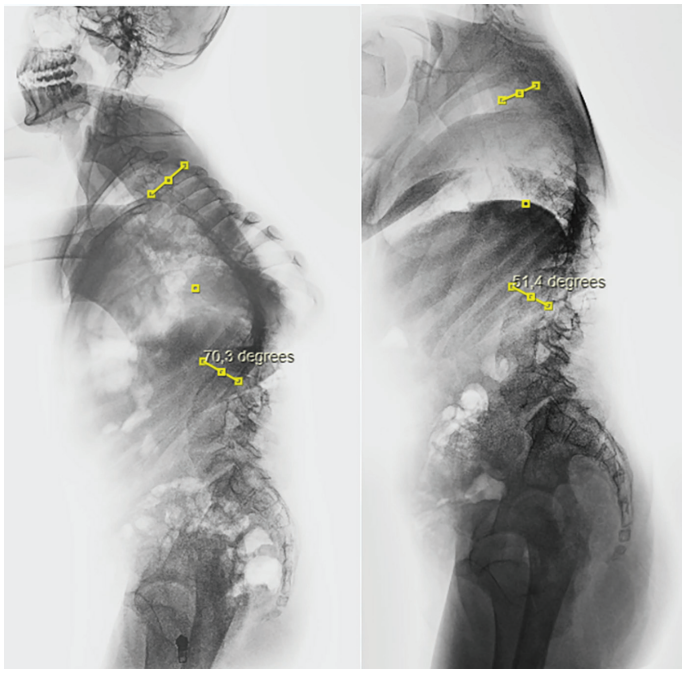

Figure 4. Correction of thoracic kyphosis at 3rd week follw-up (from 70 to 51 degrees)

Statistical Analysis

SPSS v.27 software (MacOs, IBM Corp., Armonk, NY,USA) was performed for analysis. Shapiro Wilk test was used for analysis the distribution of variables. The nonparametric tests were performed due to skewed distribution. Descriptive statistics were presented as mean (standard deviation), minimum, and maximum values. Friedman test was used to present the difference between the baseline, 3rd week after treatment, and before surgery values for within-group analysis. When a significant difference was found in the within-group analysis, Wilcoxon's signed ranks test was used to analyze pairwise comparisons. Confidence interval was 95% and p-value <0.05 was considered significant.

RESULTS

A total of five pediatric patients (3 female, 2 male) with rigid severe scoliosis, with a mean age of 12.8 years, were retrospectively evaluated. Pre-halo traction measurements showed an average major coronal curve of 112 (92-140) degrees, an average TK of 78.6 (24-108) degrees, and a mean spinal length between T1 and L5 of 261 (234-294) mm (Table 1). Halo traction was applied for an average duration of 43 days, during which traction force was gradually increased to reach 50% of each patient's body weight.

In the radiological evaluation at the end of the 3rd week, major coronal curve angle reduced to 86.4 (64-105) degrees, TK reduced to 52.4 (17-75) degrees and mean spinal length between T1-L5 in the coronal plane increased to 315.4 (285-346) mm. However, in the evaluation of the patients at the and of the traction treatment (before surgery) mean major coronal curve was 82 (72-103) degrees, TK was similar to the 3rd week of halo traction treatment and mean spinal length between T1-L5 in the coronal plane was 326.2 (298-358) mm (Table 1).

In the evaluation at the end of the halo traction treatment, it was seen that 85% of the correction in the Cobb angle in the coronal plane, all of the TK correction, and 84% of the length between T1-L5 were obtained after 3 weeks of traction (Figure 5).

Only one patient experienced a pin tract infection, which was effectively treated with oral antibiotics. No neurological complications were reported during or after the traction period.

DISCUSSION

The results of this study support the role of halo traction as an effective preoperative adjunctive therapy in the treatment of pediatric patients with severe, rigid scoliosis. Surgical correction of such deformities is often associated with risks, including neurological injury and significant complications due to the rigidity and severity of the curves. As demonstrated in this retrospective analysis, halo traction provides significant benefits in terms of curve flexibility and reduction, thereby reducing these risks and facilitating safer and more effective surgical procedures.

Previous studies have demonstrated that HGT is an effective adjunct in the treatment of severe spinal deformities in pediatric patients. Reported correction rates for the major curves following HGT range from 12% to 35% in the coronal plane and 17% to 35% in the sagittal plane[11]. In our study, we observed a coronal curve correction rate of 26.7% and a sagittal curve correction rate of 33.3%, aligning with these previous findings. These results further support the role of HGT in achieving significant curve correction in pediatric patients with severe and rigid spinal deformities.

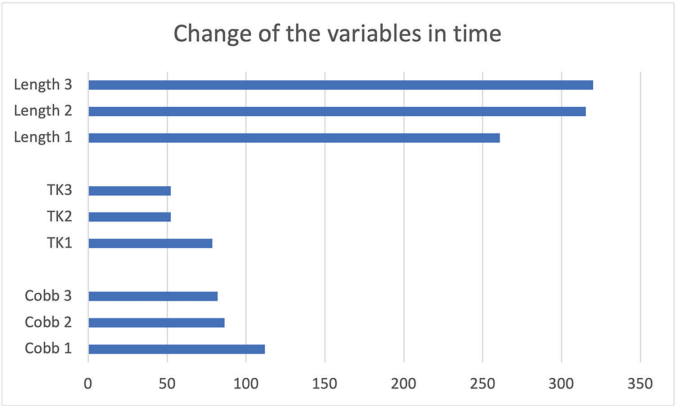

Figure 5. Change of the variables in time
1: Baseline, 2: After 3 weeks of halo traction, 3: Presurgery, TK: Thoracic kyphosis

Table 1. Within-group assessment of the variables at 3 different times

	Baseline	After 3rd week	Pre-surgery	p[a]	p[b]
Cobb angle mean (SD)	112.0 (20.4)	86.4 (17.6)	82.0 (17.1)	0.016*	3rd w-baseline: 0.043** Presurg-baseline: 0.043** Presurg-3rd w: 0.197
TK mean (SD)	78.6 (32.4)	52.4 (22.3)	52.4 (22.2)	0.015*	3rd w-baseline: 0.043** Presurg-baseline: 0.043** Presurg-3rd w: 1,000
Length mean (SD)	261.0 (26.1)	315.4 (26.3)	326.0 (26.1)	0.007*	3rd w-baseline: 0.043** Presurg-baseline: 0.043** Presurg-3rd w: 0.043**

*p[a]<0.05 is significant for within-group analysis (Friedman test), **p[b]<0.05 is significant for pairwise comparisons of the variables (Wilcoxon test).
TK: Thoracic kyphosis, SD: Standard deviation, 3rd w: After 3rd week of halo traction application, Presurg: Presurgery

In the current literature, there is still no consensus on the optimum duration of traction. Watanabe et al.[9] reported that 84.7% of major curve correction occurred within 3 weeks, while Park et al.[12] observed 96% of correction within 4 weeks. In a study conducted by Hwang et al.[13] on 59 patients, they found a 28.2% improvement in Cobb's angle in the first week, 34% in the second week, 33.8% in the third week and 32.2% in the fourth week with pre-operative halo traction. They also argued that the effectiveness of halo traction decreased after the third week. In a study conducted by Koptan et al.[14], they argued that halo traction is a safe method and that maximum correction can be achieved with continuous traction and that the complication rate is minimal for tractions up to 50% of body weight and that 2 weeks of traction is sufficient.

In a study conducted by Wang et al.[15] with 62 patients with a Cobb angle over 120 degrees, it was revealed that the complication rate decreased with halo traction in a 2-year follow-up and that it could reduce the Cobb angle by up to 50% in 4-6 weeks of use. In a study conducted by Rocos et al.[16] with 42 patients and an average of 42 days of halo use, 72 mm of extension was detected in the first 3 weeks and they argued that halo traction should be used for at least 4 weeks. Yamin et al.[17] argued that the spinal cord is sensitive to traction in severe rigid curves and that pre-operative halo traction application is effective in preventing neurological complications, and they recommended anterior release and halo traction in the first stage and posterior instrumentation in the second stage in curves with a Cobb angle of over 80 degrees and less than 20% flexibility. Park et al.[12] argued that halo traction should not be applied for more than 3 weeks. Otherwise, it was stated that complications such as osteopenia, infection and loosening of pin roots would occur. Sponseller et al.[8] argued that osteotomy and complication rates were lower when halo traction was applied.

The findings highlight that after an average of 43 days of halo traction, there was a marked improvement in the major coronal curve, TK, and spinal length. However, 85% of the total Cobb angle correction and 84% of the increase in spinal length between T1 and L5 were achieved within the first three weeks of traction. The rapid and substantial correction within this period suggests that further prolongation of halo traction beyond three weeks may not yield significant additional benefits. This supports the conclusion that three weeks is the optimal duration for halo traction, balancing efficacy with patient comfort and safety.

Moreover, the absence of neurological complications in this study aligns with existing literature that advocates for the safety of halo traction when applied with gradual increments of force, reaching up to 50% of the patient's body weight. The only complication reported-a pin tract infection-was managed effectively with oral antibiotics, reinforcing the relatively low morbidity associated with the procedure when performed under appropriate clinical protocols. This study underscores the utility of halo traction in reducing surgical complexity by pre-operatively decreasing the severity of the spinal deformity. By improving both coronal and sagittal plane alignment, halo traction enhances the overall flexibility of the spine, potentially reducing the extent of surgical dissection and instrumentation required for definitive correction. These improvements in spinal alignment contribute to more favorable postoperative outcomes and a lower likelihood of complications.

Considering the limitations of the study, the small number of patients included in the study seems to be a potential limitation. In addition, the patient population included different diagnoses and the heterogenity of the curve pattern and flexibility of curve was another limitation. Furthermore, there is no comparison with a control group to assess the efficacy of preoperative HGT.

CONCLUSION

In conclusion, halo traction is a valuable tool in terms of both coronal and sagittal plane deformities and also trunk length in the management of pediatric patients with severe, rigid scoliosis. The significant correction achieved within the first three weeks of traction suggests that this is an optimal timeframe for its use prior to surgical intervention. Future studies with larger cohorts and longer follow-up periods are recommended to further validate these findings and refine protocols for the application of halo traction in this patient population.

Ethics

Ethics Committee Approval: The study was approved by the İstanbul University of Local Ethics Committee (approval number: 2024/1892, date: 15/11/2024).

Informed Consent: Retrospective study.

Footnotes

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

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EFFECTIVENESS OF CERVICAL DISC ARTHROPLASTY IN CERVICAL VERTIGO

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ABSTRACT

Objective: Cervical vertigo (CV) is commonly observed in cervical degenerative disc disease (CDDD) but is often overlooked. The current study aimed to investigate the efficacy of cervical disc arthroplasty (CDA) in CV for single-level CDDD.

Materials and Methods: Between 2014 and 2021, we retrospectively analyzed patients with chronic neck and arm pain due to single-level CDDD on CV. All patients with CV underwent a detailed diagnostic work-up to investigate the cause of vertigo, and patients with vertigo due to etiologies other than CDDD were excluded. CV was analyzed pre-operatively and post-operatively using the CV evaluation scale (CVES); higher CVES scores reflected fewer vertigo complaints. The intensity of dizziness and neck pain was assessed using the Visual Analogue Scale (VAS).

Results: A total of 50 patients who had CDDD with CV and underwent CDA were included in the study. The mean age of the patients was 48±8 years, and 58% were female. The vertigo and neck pain VAS scores significantly decreased 3 months post-operatively (6-4.6) and at the last follow-up period (3.8-3.0) compared with pre-operatively (6.8-5.6) (p<0.001). CVES scores showed a significant increase 3 months post-operatively (22.8) and at the last follow-up period (23.4) compared with pre-operatively (16.2) (p<0.001). The clinical scores showed more improvement in the upper cervical region than in the lower cervical region (p<0.001).

Conclusion: CDDD single-level CDA is more effective in relieving cervicogenic dizziness symptoms at higher levels than at lower levels.

Keywords: Cervical vertigo, cervical disc degeneration, neck pain, cervical disc arthroplasty, cervical disc herniation

INTRODUCTION

Cervical vertigo (CV) is not classified as a standalone disease; rather, it is a symptom that may arise from various conditions with diverse underlying causes. Vertigo is defined as a hallucination of movement or disorientation in space that is thought to be caused by faulty sensory inputs (visual, vestibular, and proprioceptive) or disturbances in the central integration and modulation of this sensory information[1]. CV is defined as dizziness and imbalance associated with neck and arm pain in patients with cervical pathology.Vertigo is defined as "a non-specific sensation caused by abnormal afferent activity in the neck, altered orientation in space and impaired balance"[2]. Vertigo in adults is a common complaint in clinical practice, affecting approximately 20-30% of the general population, with 80% of these cases requiring medical intervention[3-5]. The diagnosis and treatment of vertigo can be challenging for vestibular rehabilitation specialists and spinal surgeons. CV may be a rare cause of vertigo, or it may be one of the main causes[6]. Cervical degenerative disease, also known as spondylosis, is currently acknowledged as the leading cause of CV[7]. Patients with chronic neck pain may often present with vertigo symptoms[8]. Anterior cervical surgery may reduce vertigo, neck pain, and neurological symptoms[9]. Mechanoreceptors, such as Ruffini bodies in degenerative discs, play a significant role in the pathogenesis of dizziness. Disc degeneration leads to inflammation and causes abnormal proprioceptive inputs and dizziness. The diagnosis of this condition is difficult, and conservative treatment is usually effective. With the exception of studies on percutaneous procedures, there are limited studies in the literature on surgical interventions targeting the degenerative disc for the management of CV[4,10-12]. There is no definitive diagnostic test for CV, making its definition a subject of ongoing debate. This study the relationship between cervical disc arthroplasty (CDA), which reestablishes motion at the segment after cervical microdiscectomy, and vertigo at both upper and lower cervical levels. This study did not aim to treat vertigo directly but to investigate the effectiveness of CDA on vertigo in cervical degenerative disc disease (CDDD).

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MATERIALS AND METHODS

Ethics Statements

This study protocol was approved by the Ethics Review Board (approval number: KAEK/2021/10/267, date: 14/10/2021) of the University of Health Sciences Türkiye, Kanuni Sultan Süleyman Training and Research Hospital. All patients participating in the study provided informed consent. All procedures were performed following the principles outlined in the Declaration of Helsinki.

Between January 1, 2014, and October 1, 2021, patients who underwent single-level CDA for radiculopathy and CV were included in the study.

Inclusion Criteria

1) Age between 18-80 years, 2) patients with CDDD with chronic neck or arm pain and CV with a duration of ≥3 months, 3) CV that usually develops after neck movement, 4) the presence of sensory loss, 5) cervical MRI results indicate the presence of a herniated disc, and 6) failure to respond to non-surgical treatments for a minimum duration of six weeks.

Exclusion Criteria

1) Vertigo due to neurological, ophthalmological, and otolaryngological diseases; 2) cervical instability (>2 mm displacement or >10° rotation change compared to adjacent spinal segment); 3) multilevel disc protrusion or disc herniation (≥2 levels); and 4) disc height of <50%; 5) psychiatric disorders; 6) the use of anticholinergics, anti-depressants, sedatives, hypnotics, and antipsychotics; and 7) cardiac arrhythmias and arterial atherosclerosis disorders.

Pre-operative Evaluation

Radiological assessments included cervical X-rays, computed tomography (CT) scans, and magnetic resonance imaging (MRI). Following consultation, patients with vertigo who had neurological, ophthalmological, or ENT (ear, nose, and throat) conditions were excluded from the study. Vestibular and auditory tests and imaging were performed when necessary, in accordance with the consultation recommendations.

Surgical Procedure

The patient was fixed in a supine position, with the head slightly extended in a supin position. The surgical field was sterilized and draped. Following the identification of the correct level using the scope, a transverse incision was made in the anterior region of the neck. The anatomical layers were passed with blunt dissection, and microdiscectomy was performed at the relevant cervical level. After microdiscectomy, a polyetheretherketone (PEEK) cervical disc prosthesis of appropriate size was placed between the vertebrae. The mobility and stability of the prosthesis were evaluated under fluoroscopy and confirmed to be in the appropriate position. The surgical field and bleeding was carefully controlled. The muscle and skin tissues were closed anatomically. Post-operatively, patients wore a neck collar during activities for a maximum of two weeks.

Clinical Results

Clinical outcomes were assessed at three time points: pre-operatively (at the initial presentation), three months post-operatively, and one year post-operatively using the CV evaluation scale (CVES). The CVES, originally developed by Wang and Zhou in China in 1998, has demonstrated strong criterion validity and test-retest reliability for evaluating CV and its associated symptoms[13]. Dizziness and neck pain severity were measured using the VAS.

Statistical Analysis

Statistical analyses were conducted using SPSS 22.0 software (IBM Corp., Armonk, NY, USA). Continuous data are expressed as mean ± standard deviation, while categorical variables are shown as n (%). The Wilcoxon signed-rank test was applied to compare pre- and post-operative CVES and VAS scores. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

The study included 50 patients, consisting of 27 females and 23 males, all of whom experienced neck and arm pain accompanied by vertigo. Patient ages ranged from 35 to 72 years, with a mean age of 43±8 years. The average duration of symptoms was 8±4 months, varying between 2 and 36 months. Neck pain was present in 94% of the patients, radiculopathy in 100%, sensory symptoms in the upper extremities in 92%, abnormal gait in 23%, and vertigo of varying degrees in 100%. Neurological examination revealed grade 2 weakness in the upper extremities in 76% and grade 1 weakness in 14% of the patients. Cervical disc herniation levels were C5-6 (23 patients), C6-7 (16 patients), C4-5 (8 patients), and C3-4 (three patients). All patients underwent anterior cervical microdiscectomy and a cervical PEEK prosthesis (Figure 1).

In terms of vertigo scores, the mean vertigo score of the upper cervical segments (UCS) group was 8.1±1.3, while that of the lower cervical segments (LCS) group was 6.5±0.8 in the pre-operative period. This difference was statistically significant (p=0.012). At the three-month follow-up, the score of the UCS group decreased to 5.9±0.2, and the score of the LCS group decreased to 6.1±0.4. However, no significant difference was found between the groups (p=0.106). At 12 months, the score of the UCS group decreased to 3.3±0.2, and the score of the LCS group decreased to 3.9±0.2, and this difference was found to be significant (p<0.001).

When the neck pain VAS scores were analyzed, the mean score of the UCS group was 5.4±0.8, and that of the LCS group was 5.6±0.9 in the pre-operative period. No significant difference was found between the groups (p=0.24). At three months, the UCS group's score decreased to 4.2±0.4, while the LCS group's score was 4.6±0.8. This difference was statistically significant (p<0.001). At a 12-month follow-up, the UCS group's score

decreased to 1.9±0.8, and the LCS group's score decreased to 2.9±0.5. This difference was statistically significant (p=0.012).
Regarding CVES scores, the mean score of the UCS group was 12.5±2.8, and that of the LCS group was 17.7±1.8 in the pre-operative period. This difference was significant (p<0.001). At three months, the mean score of the UCS group was 24.3±2.1, and that of the LCS group was 22.3±3.5, a difference that was found to be significant (p<0.001). At 12 months, the CVES score of the UCS group increased to 26.1±1.6, and the score of the LCS group increased to 22.9±2.9. This difference was statistically significant (p<0.001).
The comparison of the UCS and LCS groups revealed that the UCS group showed a more significant improvement in vertigo and neck pain scores. The scores of the UCS group were significantly different from those of the down group, especially at the 12-month follow-up, thus indicating that the UCS group achieved better clinical improvement (Figure 2, Table 1).

DISCUSSION

CV is a type of vertigo originating from the cervical region; however, there is controversy over its cause[6]. There are many theories explaining the cause of vertigo in CDDD, but none of them is conclusive. Conditions include proprioceptive CV, Barré-Lièou syndrome, vertebral artery vertigo due to rotation, and CV associated with migraines. Each of these hypotheses has a different pathophysiological mechanism, diagnostic features, and optimal treatment methods. The diagnosis is based on the association of the symptoms of imbalance and vertigo with neck pain, the patient's history, physical examination findings, and vestibular function tests to exclude other vestibular disorders. Anterior fusion was performed in cases of cervical spondylosis, and a decrease in vertigo symptoms was observed in almost 80% of these patients[10]. It has been shown that anterior cervical discectomy reduces vertigo symptoms, especially in single-level upper segments[4]. In patients with CDDD who do not respond to non-surgical treatments for at least six weeks, cervical discectomy and fusion or CDA can be performed[11-14]. CV is currently described as a non-specific feeling of spatial disorientation and balance disturbance, caused by abnormal afferent signals originating from the neck[2]. Clinical research has demonstrated that individuals with cervical disc degenerative disease exhibit significant impairments in postural control[15-17]. Research has also shown that vertigo in patients with degenerative cervical radiculopathy or myelopathy can be effectively managed through anterior cervical discectomy and fusion[10,18-20].

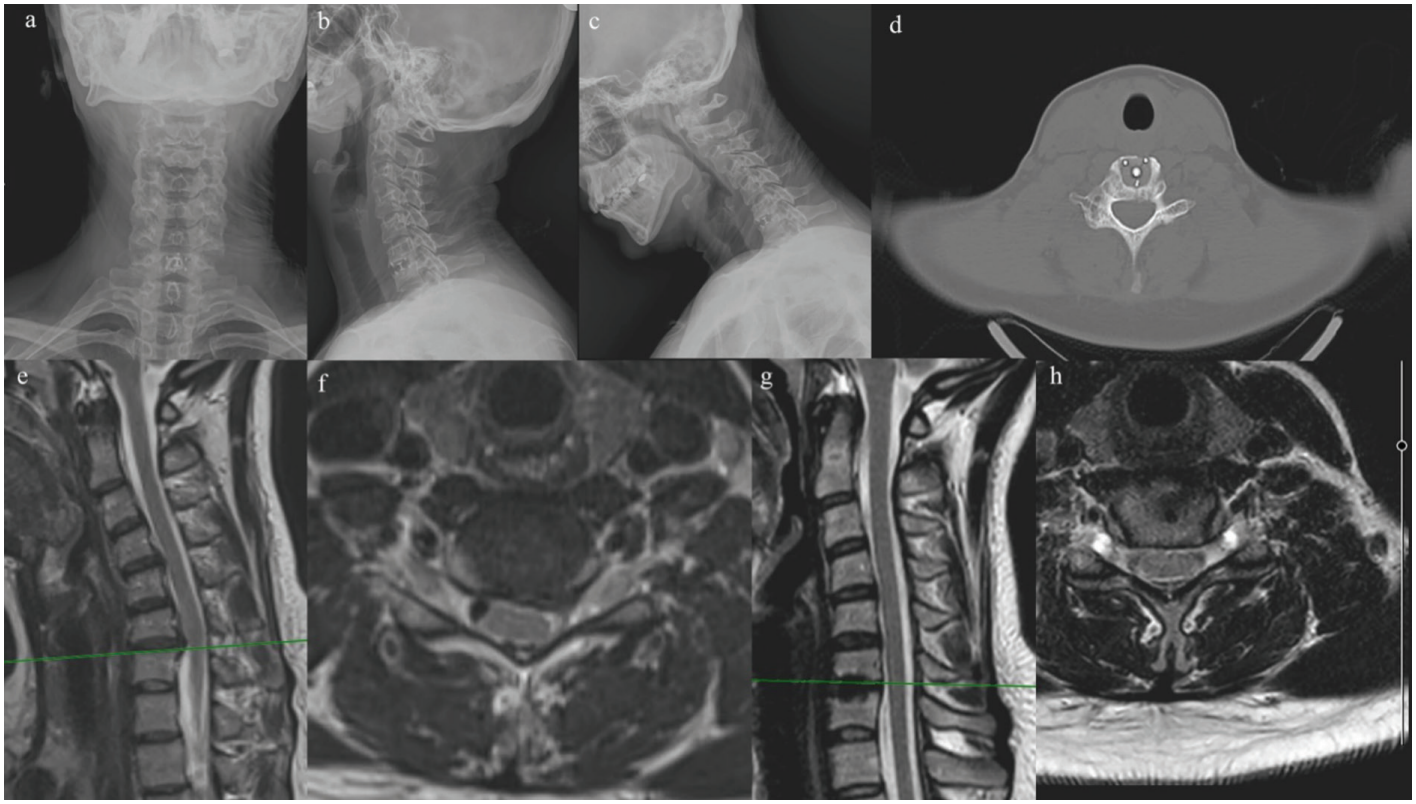

Figure 1. Radiological images of a 37-year-old female patient with left disc herniation at the C6-7 level: AP (a) flexion (b) and extension (c) positions in direct cervical radiographs. PEEK prosthesis in cervical axial plane computed tomography (d). Disc herniation at the C6-7 level causing spinal cord compression on sagittal plane MR image (e). Left paracentral disc herniation on T2 section in axial plane (f). One year later, on sagittal MR T2 sequence, hypointense changes at the C6-7 level due to PEEK prosthesis (g). Decompressed spinal cord and radix on T2 MR slice in axial plane (h)

PEEK: Polyetheretherketone, MR: Magnetic resonance

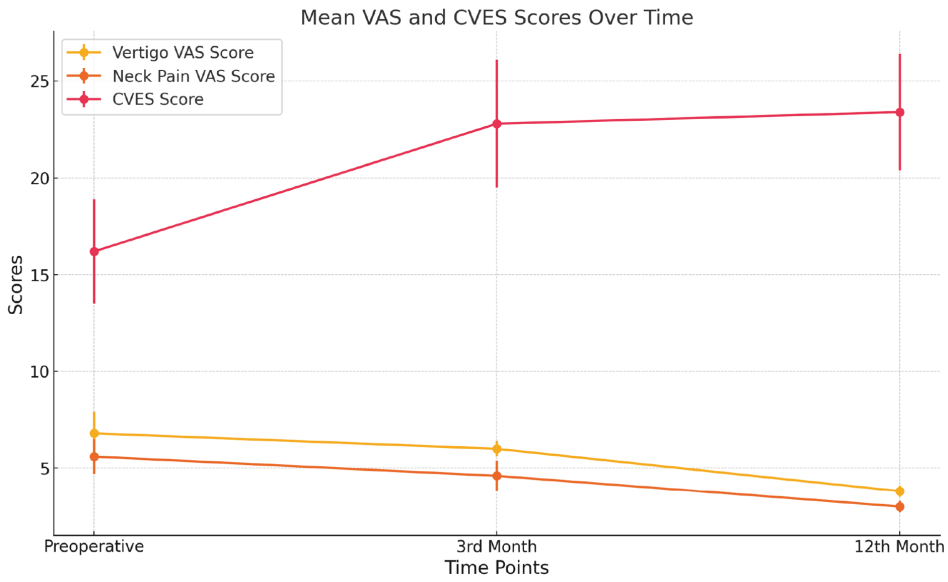

Figure 2. VAS scores for mean vertigo and neck pain and CVES at each follow-up

VAS: Visual Analogue Scale, CVES: Cervical vertigo evaluation scale

Vertigo often signifies a discrepancy between vestibular, visual, or cervical proprioceptive inputs[17]. Abnormal proprioceptive signals from Ruffini endings in degenerated cervical discs and muscle spindles in strained neck muscles send incorrect afferent information to the brain's higher centers. This mismatch with vestibular or other sensory inputs can lead to a subjective sensation of vertigo. Immunohistochemical examinations have shown that numerous free nerve endings and Ruffini bodies grow toward degenerative cervical discs[17]. Cervical intervertebral disc herniation and cervical spine instability may lead to vertebral artery spasms by affecting the cervical sympathetic nerve, which may cause CV[21]. Managing CV is challenging due to the difficulty in pinpointing the exact source of symptoms. The neck is a complex region that can contribute to dizziness through multiple mechanisms. It contains key arteries that supply blood to the brain, ganglia that regulate autonomic nervous system functions, and structures that provide proprioceptive feedback. Consequently, cervical issues related to vascular, autonomic, and proprioceptive dysfunctions can result in dizziness, each displaying distinct signs and symptoms[7].

Table 1. Distribution of clinical scores according to cervical upper and lower cervical segments

	Upper cervical segments (C3-4-5)	Lower cervical segments (LCS) (C5-6-7)	Comparison of the groups	Mean score of the groups	Pre-operative and 3rd month comparison	Pre-operative and 12 months comparison	Comparison between 3rd month and 12th month
Mean VAS score of vertigo					p<0.001	p<0.001	p<0.001
Pre-operative	8.1±1.3	6.5±0.8	p=0.012	6.8±1.1			
3rd month follow-up	5.9±0.2	6.1±0.4	p=0.106	6.0 ±0.4			
12th month follow-up	3.3±0.2	3.9±0.2	p<0.001	3.8±0.3			
Mean VAS score of neck pain					p=0.005	p=0.010	p=0.47
Pre-operative	5.4±0.8	5.6±0.9	p=0.24	5.6±0.9			
3rd month follow-up	4.2±0.4	4.6±0.8	p<0.001	4.6±0.8			
12th month follow-up	1.9±0.8	2.9±0.5	p=0.012	3.0±0.3			
Mean CVES score					p<0.001	p<0.001	p=0.35
Pre-operative	12.5±2.8	17.7±1.8	p<0.001	16.2±2.7			
3rd month follow-up	24.3±2.1	22.3±3.5	p<0.001	22.8±3.3			
12th month follow-up	26.1±1.6	22.9±2.9	p<0.001	23.4±3.0			

VAS: Visual analogue scale, CVES: Cervical vertigo evaluation scale

Previously established criteria for diagnosing CV include: 1) the presence of neck-related symptoms, 2) a history and temporal correlation between neck pain and dizziness, and 3) the exclusion of other potential causes of dizziness[22]. The sensory properties of the cervical region are vital for controlling head and eye movement and postural stability, which may lead to dizziness. This role has been confirmed in healthy asymptomatic individuals by the effects produced when artificial disturbances are applied to cervical afferents in the laboratory. CV is one of the most common clinical complaints, and misdiagnoses are uncommon. Therefore, correctly identifying vertigo and excluding other possibilities are essential.

The precise cause of CV remains controversial, and its underlying mechanism has not been fully clarified. Proposed hypotheses include rotational misalignment of the vertebral artery and CDDD, cervical stenosis, and spondylosis, the which may cause a decrease in vertebral artery flow velocity or the compression of the spinal cord and nerve roots, causing vertigo. It has been reported that changes in vertebral artery diameter are not associated with vertigo[23]. The diagnosis of CV is mostly based on the subjective symptoms of the patients and positive findings. Due to the lack of specific laboratory tests and clinical studies, diagnosis often relies on the limited clinical experience of healthcare professionals. In addition to relying on cranial CT, MRI, other imaging techniques, detailed inquiries about the cause of the disease, the time of onset, and the characteristics of the vertigo are necessary to exclude and correctly identify vertigo. The manifestation of vertigo varies and may be due to a combination of multiple causes. Therefore, each cause must be thoroughly investigated and correctly diagnosed, and the relevant treatment must be selected. Identifying vertigo is difficult. In addition to exclusion by MRI, CT, and other ancillary tests, simple exclusion methods can be used during consultations and physical examinations. Thus, clinicians can quickly and accurately assess the condition and exclude life-threatening causes.

The causes of CV can be grouped into four main categories: sympathetic dysfunction, proprioceptive vertigo, vertebral artery rotational CV, and migraine-associated CV. In rotational vertebral artery vertigo, a rare condition, decompressive surgery should be the treatment of choice when the exact site of arterial compression is determined by appropriate testing magnetic resonance angiography, CT angiography or digital subtraction angiography. It has been reported that Ruffini bodies are more abundant in diseased cervical discs than in other discs in vertigo patients, indicating that Ruffini bodies may play a significant role in the pathogenesis of vertigo of cervical origin[24]. Proprioceptive CV is the most prevalent type, highlighting the critical role of the cervical spine, along with visual and vestibular inputs, in maintaining sensorimotor control. Dysfunctional cervical proprioception can result in symptoms such as dizziness, imbalance, visual disturbances, and disrupted sensorimotor control.

Treatment strategies targeting cervical musculoskeletal and sensorimotor control have proven effective in alleviating symptoms in individuals with cervical musculoskeletal disorders[25]. We found that the severity of vertigo significantly decreased in patients who underwent microdiscectomy ($p<0.02$). However, when comparing cervical vertebral levels, a significantly greater reduction in vertigo severity was observed in patients who underwent surgery on the upper cervical vertebrae compared to those treated in the lower segments. Apart from studies of percutaneous procedures, few studies have approached surgical intervention of the degenerative disc for the treatment of CV. Anterior fusion surgery was conducted on patients diagnosed with cervical spondylosis, resulting in an improvement of vertigo symptoms in approximately 80% of the cases[10]. In patients with multilevel cervical disc degeneration, upper level disc surgery has been shown to treat vertigo better than LCS[4].

Clinicians should acknowledge the distinctive and critical role of the cervical spine in vertigo and assess its impact when patients present with neck pain, dizziness, and other symptoms indicative of altered sensorimotor control. The limitations of this study are that it was retrospective, had a small sample size, and was single-centered, comprehensive prospective and multicenter studies are necessary to confirm the results obtained.

CONCLUSION

CDA is an effective treatment for vertigo symptoms, especially in the upper cervical segment. However, the mechanisms and treatment approaches of CV are still controversial.

Ethics

Ethics Committee Approval: This study protocol was approved by the Ethics Review Board (approval number: KAEK/2021/10/267, date: 14/10/2021) of the University of Health Sciences Türkiye, Kanuni Sultan Süleyman Training and Research Hospital.
Informed Consent: This study was retrospective.

Footnote

Authorship Contributions

Surgical and Medical Practices: B.O.G., S.D., Concept: B.O.G., S.D., Design: B.O.G., S.D., Data Collection or Processing: B.O.G., S.D., Analysis or Interpretation: B.O.G., S.D., Literature Search: B.O.G., S.D., Writing: B.O.G., S.D.
Conflict of Interest: The authors have no conflicts of interest to declare.
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EVALUATING INCIDENTAL FINDINGS IN CERVICAL MRI SCANS: THE PREVALENCE AND CLINICAL RELEVANCE OF INCIDENTAL FINDINGS

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ABSTRACT

Objective: This study aims to examine the frequency, types, and clinical significance of incidental findings in cervical magnetic resonance imaging (MRI) scans and their implications for patient care.

Materials and Methods: A total of 331 cervical MRI scans were reviewed retrospectively at Karabük University Research and Teaching Hospital between April 2022 and April 2023. Patients presenting with arm and neck pain or symptoms suggesting abnormalities of the cervical spine were included; those whose images were affected by artifacts were excluded. Incidental findings were recorded and categorized according to their type, location, and potential clinical significance.

Results: Our cohort consisted of 221 female patients (69%) and 101 male patients (31%), amounting to a total of 322 patient records. Loss of cervical lordosis (71%) and cervical disc herniation (92%) were the most prevalent findings in the cervical spine. Additional findings included syringomyelia, cerebellar tonsillar herniation, and empty sella. After being diagnosed with thyroid cancer, one patient received appropriate care. The distribution of incidental findings by gender was not statistically significant. This study highlights the frequency and variety of incidental findings in cervical MRI scans, along with their possible clinical significance. The findings are consistent with earlier studies, highlighting the necessity of carefully analyzing these results to detect potentially fatal disorders.

Conclusion: It is crucial not to overlook incidental abnormalities in cervical MRI scans for the early identification of clinically relevant disorders. Future research should concentrate on creating uniform protocols for handling incidental results to successfully balance clinical benefits and resource consumption.

Keywords: Cervical MRI, incidental findings, cervical spine, extraspinal findings, thyroid nodules

INTRODUCTION

Cervical magnetic resonance imaging (MRI) is a sophisticated imaging method commonly employed for identifying neck and spine disorders. This treatment offers a thorough assessment of the cervical area because of its exceptional soft tissue contrast and ability to capture images from several angles[1]. The request for a cervical MRI is usually prompted by specific indicators such as neck pain, radiculopathy, myelopathy, or trauma[2]. Cervical MRI enables doctors to obtain precise and comprehensive images of the anatomical structures and potential abnormalities in the cervical area of the spine. This information is crucial for clinicians to accurately diagnose and plan appropriate treatments. MRI is often regarded as the most reliable method for identifying diseases such as disc herniations, spinal stenosis, degenerative changes, malignancies, and infectious processes[3]. Nevertheless, a cervical MRI often reveals other findings that are unrelated to the main purpose of the examination. The term "incidental findings" is used in the literature to describe

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these unanticipated discoveries[4]. Incidental results are highly influential in clinical practice. Although some of these findings may not show any symptoms and may not be clinically important, in specific situations, they can help in the early detection of life-threatening diseases[5].

Incidental findings have gained growing attention due to their rising occurrence and clinical importance in recent years. Research has indicated that chance discoveries on cervical MRI scans are extremely prevalent. Typical findings that are not the main focus but are often discovered in cervical MRI scans include degenerative disc disease, spinal stenosis, osteophytes (bone spurs), and facet joint arthrosis (joint degeneration). In addition, the identification of incidental findings can potentially uncover less common but medically important disorders such as Chiari malformation, syringomyelia, spinal cord malignancies, or anomalies in the vertebral artery[6-10].

The objective of this study is to examine the occurrence, categories, and medical importance of diseases that are unintentionally discovered in individuals undergoing cervical MRI scans. In addition, the study will investigate the impact of these findings on patient care and the degree to which they change the necessity for further testing or treatments. Based on the provided information, the project seeks to implement a more thorough strategy for evaluating cervical MRI scans and provide guidance to clinicians on how to handle incidental discoveries. This study aims to conduct a retrospective analysis of cervical MRI images from individuals who were examined during a certain period. The primary objective is to document any unexpected or incidental results. We shall categorize these discoveries according to their classifications, positions, and medical importance. In addition, we will assess the influence of these discoveries on patient care and determine if any further examinations or therapies are required. Ultimately, this study aims to perform a thorough exam of diseases incidentally discovered on cervical MRI scans and provide insights into the appropriate management of these findings in a clinical setting. The acquired data will guide professionals in diagnosing and treating patients, potentially leading to early diagnoses that could save lives. Moreover, this work will establish a basis for subsequent extensive research.

MATERIALS AND METHODS

Patient records were evaluated between April 2022 and April 2023 after approval from Karabük University non-interventional clinical research ethics committee (approval number: 2024/1873, date: 17/09/2024). Three hundred and thirty-one patient records were assessed, and nine patients were excluded due to artifacts disabled by investigating the cervical images. Patients with neck and arm pain, claudication, or any symptom that might indicate cervical disc herniation, radiculopathy, and canal stenosis with a cervical MRI were included in this study. Patients were excluded if they had distorted MRI images due to surgical or movement artifacts that may have enabled the clinician or radiologist to thoroughly investigate the natural anatomy of the cervical region.

Image Acquisition

All images were acquired with a 1.5 Tesla MRI scanner using a 20-channel neck coil (Magnetom Aera, Siemens Healthcare, Erlangen, Germany). The images included in the investigation were T1-weighted sagittal spin-echo, T2-weighted sagittal turbo spin-echo, and T2-weighted axial turbo spin echo. Although axial images were not continuous, four axial slices were obtained for each cervical intervertebral disc, primarily focusing on the intervertebral disc pathologies. Following the evaluation of regional pathologies and classification, each lesion and incidental findings were recorded for each patient. Patients were referred to appropriate departments according to incidental findings.

Diagnosis

Two independent radiologists and one neurosurgeon have reviewed the MRI images. Nasopharyngeal mucosal thickening was measured on sagittal, T2 sequences, and >3 mm mucosal thickness was accepted as mucosal thickening[11]. Cysts with distinct margins along the nasopharyngeal posterior wall are termed Tornwaldt cysts if they are in the midline, otherwise termed retention cysts[11]. >3 mm was also accepted as mucosal thickening for paranasal sinus mucosal thickness[12]. For the Thyroid Gland, enlargement of each lobe is accepted as >20 mm in the anteroposterior dimension or the Isthmus being thicker than 10 mm[13]. Sellar and parasellar regions were meticulously investigated. For empty sella diagnosis, more than half of the sella needed to be filled with cerebrospinal fluid, and the pituitary thickness needed to be <2 mm, while partial empty sella diagnosis made if less than half of the sella was empty and the pituitary had ≥3 mm thickness[14]. Cerebellar tonsillar herniation diagnosis was made if the tonsils were below ≥3 mm of the foramen magnum[15].

Statistical Analysis

Jamovi (version 2.4.7) was used for all statistical analyses. Categorical variables were dichotomized and presented as frequencies and percentages, while continuous data were summarized as means ± standard deviations, with normality assessed using the Shapiro-Wilk test. Comparisons of categorical variables were conducted using the chi-square test or Fisher's exact test, as appropriate. Differences in continuous variables between groups were analyzed using independent samples t-tests or Mann-Whitney U tests, depending on the data distribution.

A p-value of <0.05 was considered statistically significant, and all analyses were conducted using a two-tailed approach.

RESULTS

The cohort was mainly made up of females (n=221, 69%), while males comprised 31% of the cohort (n=101). The demographics

are summarized in Table 1. Cervical disc herniation and loss of cervical lordosis lead to the cervical spinal column findings, 92% and 71%, respectively, outlined in Table 1. In total, 105 (33%) patients presented with extraspinal cervical findings, summarized in Table 2. Nasopharynx posterior wall thickening was the most common incidental finding (7%), followed by thyroid nodules and multinodular guatr, both 6%.

Furthermore, 15 patients have been found to have empty sella, while nine patients had cerebellar tonsillar herniation, although only three patients had syringomyelia (Table 2). One patient had laboratory and advanced imaging results suspicious of thyroid malignancy and, after further investigation, underwent thyroidectomy and appropriate medical therapy. Lastly, there were no statistical differences in rates between gender groups in the most commonly encountered eight pathologies, summarized in Table 3.

DISCUSSION

MRI of the cervical spine is a routine examination in several different departments and may be employed to investigate certain malignancies, including thyroid, parotid nasopharynx, and larynx. Furthermore, it may be utilized to investigate musculoskeletal disorders. Due to the complex and close anatomy of the several systems within the cervical region, it is easy to miss other findings besides the most apparent one. Our study aims to investigate incidental findings within a patient group where cervical MRI is utilized to investigate underlying arm and neck pain. Naturally, the most common findings were cervical disc herniation and loss of lordosis, resulting in signs of radiculopathy and neurologic deficits. Furthermore, careful evaluation of the scans revealed several additional incidental findings, most commonly nasopharynx posterior wall thickening and thyroid nodules.

Previous studies have made a point in this matter. Kızılgöz et al.[16], in their study including 1000 patients, revealed nasopharyngeal mucosal thickening was the most common cause of incidental findings, followed by thyroid gland enlargement, paranasal mucosal thickening, and thyroid nodules, which reflects our results in the bigger scale although the incidences vary. Nasopharyngeal and paranasal mucosal thickening can be linked to seasonal allergies or chronic rhinosinusitis, which is very common in the general population. Thyroid nodules were another incidental finding within their study in 16.4% of patients. Whether this is a subclinical situation or patients do experience symptoms of hyper-or hypothyroidism is a matter of meticulous clinical and laboratory investigation. Our results indicate a 6% thyroid nodule incidence rate. While most thyroid nodules are benign and can present in a significant portion of patients, it is imperative to do a thorough work-up to exclude any underlying malignancy.

Özdemir and Kavak.[17] have found a 49.6% rate of thyroid nodule incidence within their cohort, further revealing papillary thyroid carcinoma in three patients. Also, one other important finding was vertebral hemangiomas within our cohort. Kaya et al.[18] and Kızılgöz et al.[16] have commented on this previously.

Managing incidental findings involves addressing ethical and legal problems. It is the ethical duty of clinicians to notify patients about incidental findings that have been found and to provide suitable ways for managing them. Nevertheless, this might occasionally result in superfluous distress and supplementary examinations. Hence, it is crucial to embrace a

Table 1. Cohort demographics and cervical spine MRI findings

N. of patiens (mean age ± SD)	322 (51.4±14.1)
	N. of patients (%)
Female (mean age ± SD)	221 (52.2±13.6)
Male (mean age ± SD)	101 (49.6±14.9)
Cervical disc herniation	297 (92%)
Increase in lordosis	5 (2%)
Loss of cervical lordosis	230 (71%)
Canal stenosis	13 (4%)
Thickening of the posterior longitudinal ligament	1 (0.3%)
Anthelisthesis	1 (0.3%)
Spinal hemangioma	58 (18%)
Cervical degeneration	11 (3%)
Schmorl's nodes	7 (2%)
Sclerotic bone lesion	3 (1%)
Syringomyelia	3 (1.2%)
Spinal instrumentation	1 (0.3%)
Myelomalasia	2 (0.6%)
Block vertebra	1 (0.3%)
Thickening of the ligamentum flavum	1 (0.3%)
Vertebral fusion anamoly	2 (0.6%)
Perineural cyst	4 (1.2%)

MRI: Magnetic resonance imaging, SD: Standard deviation

Table 2. Incidental extraspinal cervical findings

	N. of patients (%)
Thyroid nodules	18 (6%)
Nasopharynx posterior wall thickening	22 (7%)
Multinodular guatr	18 (6%)
Paranasal sinus mucosal thickening	12 (4%)
Cerebellar tonsillar herniation	9 (3%)
Empty sella	15 (5%)
Tornwaldt cyst	7 (2%)
Maxillary sinus retantion cyst	7 (2%)
Parotid lesion	1 (0.3%)
Pituitary lesion	1 (0.3%)
Tonsil hypertrophy	1 (0.3%)
Increase in thyroid size	1 (0.3%)
Thyroidectomy	1 (0.3%)

Table 3. Cross table for dependent gender

	N	Male (N=101)	Female (N=221)	Test statistic
Thyroid nodules	322	9/101	9/221	P=0.08
Nasopharynx posterior wall thickening	322	10/101	12/221	P=0.14
Multinodular guatr	322	4/101	14/221	P=0.39
Paranasal sinus thickening	322	6/101	6/221	P=0.16
Cerebellar tonsillar herniation (Chiari type 1)	322	1/101	8/221	P=0.18
Empty sella	322	2/101	13/221	P=0.12
Tornwaldt cyst	322	4/101	3/221	P=0.14
Maxillary sinus thickening	322	4/101	3/221	P=0.14

N is the number of non-missing values

well-rounded strategy while disclosing fortuitous discoveries and interacting with patients.

An interdisciplinary strategy is essential for effectively handling unexpected cervical MRI findings. Effective collaboration among experts from several fields, including radiology, neurology, neurosurgery, and physical therapy, is essential for effectively interpreting these data and deciding on suitable treatment approaches. Another crucial consideration regarding incidental results is the cost-effectiveness and the impact it has on the healthcare system. Superfluous supplementary examinations and therapies can result in elevated healthcare costs. Therefore, it is crucial to create and apply evidence-based standards for managing incidental results.

Our study is not without its limitations. Being a single-institution study and having a small cohort impacted the generalizability of our findings. Furthermore, the examination of the MRI scans is individual and highly dependent on the examiner's level of experience and the quality of the workstation. The close and intricate anatomy of the cervical region also makes it harder for radiologists to identify individual structures within proximity.

There is a specific need for additional studies to be conducted on the long-term clinical results and how they affect the way patients are treated when it comes to accidental findings. Recommendations for further research are typically presented in the discussion to emphasize knowledge gaps identified during the study.

Conclusion

Incidental findings in cervical MRI scans can lead to life-changing discoveries in patients and should not be disregarded. Our findings underscore the careful evaluation to determine the clinical significance and guide patients to appropriate care. Future research can focus on streamlining and standardizing the guidelines to discover incidental findings as a secondary aim besides the primary goal of evaluation of the spinal column and spinal cord.

Ethics

Ethics Committee Approval: Ethical approval for the study was obtained from the Karabük University Non-interventional Clinical Research Ethics Committee (approval number: 2024/1873, date: 17/09/2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: N.K.K., M.D.Y., O.B., P.A., A.S.A., Concept: N.K.K., O.B., A.E.T., P.A., A.S.A., Design: N.K.K., M.B., A.E.T., P.A., A.S.A., Data Collection or Processing: N.K.K., M.D.Y., O.B., A.S.A., Analysis or Interpretation: N.K.K., M.B., A.E.T., P.A., A.S.A., Literature Search: N.K.K., M.D.Y., M.B., A.E.T., P.A., A.S.A., Writing: N.K.K., M.B., O.B., A.S.A.

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ORIGINAL ARTICLE
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THE IMPACT OF BLOOD TRANSFUSION ON OUTCOMES IN POSTERIOR LUMBAR FUSION SURGERY

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ABSTRACT

Objective: Posterior lumbar fusion (PLF) is becoming increasingly common. One of the most critical aspects of these operations is the management of bleeding and blood products, which is of great importance for anesthetists and surgeons. The objective of this study was to examine the relationship between blood transfusion and complications after PLF surgery. The secondary objective was to identify risk factors associated with transfusion.

Materials and Methods: The data from the PLF surgeries that were performed over a four-year period at a training and research hospital were subjected to a comprehensive retrospective analysis. A comprehensive examination of the following variables was conducted: age, comorbidities, laboratory values, anti-coagulant use, surgical and anesthetic notes, blood and blood product use, post-operative complications, and length of stay.

Results: The study included 497 patients. The mean age of the patients was 60.78 years, the mean body mass index was 28.89, and the mean operation time was 3.63 hours. A total of 30.6% of patients received blood transfusions. Complications occurred in 10.1% of patients, and a higher prevalence was noted among those who received blood transfusions. The most common complication was sepsis. The likelihood of receiving blood transfusions was higher in patients who were older and female, had lower pre-operative hemoglobin (Hb) levels, underwent more fusions, experienced longer operative times, and had surgeries involving the sacral region. Logistic regression analysis identified pre-operative low Hb levels, a greater number of fusions, and an extended operation duration as significant risk factors for blood transfusion.

Conclusion: A higher incidence of complications was observed among patients undergoing PLF surgery who received blood transfusions. The implementation of improved pre-operative management of haemoglobin levels, along with more effective intraoperative transfusion practices, and reducing post-operative complications will lead to more favorable outcomes.

Keywords: Blood transfusion, complication, spine, neurosurgery

INTRODUCTION

With the aging population, the frequency of spinal deformities is increasing, and this has made spinal surgery one of the most commonly performed surgical procedures**.** Posterior lumbar fusion (PLF) surgery is widely used for the treatment of various conditions such as stenosis, spondylolisthesis, deformity, tumor, trauma and infection[1]. This type of surgery provides spinal stability by relieving nerve compression, which can significantly alleviate nerve root symptoms and pain[2]. As more PLF surgeries are performed each year, it becomes increasingly important to identify features that predispose surgical candidates to a higher complication risks[3,4]. Studies have shown that blood transfusions increase post-operative mortality and morbidity in many surgical procedures[5].

As evidence grows that blood transfusions increase the risk of post-operative infections, lead to cancer recurrence, shorten survival in cancer patients, and carry other direct risks such as infections transmitted through transfusion, blood transfusion policies have become stricter in recent years[6,7]. However, PLF surgery may be associated with significant intraoperative blood loss, which can lead to cardiac, pulmonary, and renal dysfunction, hemodynamic instability, and coagulopathy[8]. In some patients, blood transfusion may be necessary to avoid perioperative morbidity and mortality of this blood loss[9].

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When considering the impact on perioperative outcomes, a balance should be struck between the risks of anemia and the benefits of blood transfusion[10]. With the recent development of the concept of enhanced recovery after surgery, better blood management to prevent perioperative anemia has become increasingly important.

The primary aim of this study was to examine the effects of blood transfusion during the intraoperative period on post-operative complications in the 30-day period following PLF surgery. Our secondary aim was to identify risk factors for blood transfusion.

MATERIALS AND METHODS

After the study protocol was determined, Ethical Approval was obtained from the University of Health Sciences Türkiye, Gülhane Scientific Research Ethics Committee (approval number: 2024/508, date: 05.11.2024). The files of the patients who underwent PLF surgery in neurosurgery clinic of a tertiary education and research hospital between January 2021 and August 2024 were retrospectively reviewed. The patients' perioperative data were accessed through the hospital data system, neurosurgery and anesthesia clinic archive records. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The demographic data and medical history, pre-operative and post-operative laboratory values, surgery and anesthesia notes, blood and blood product transfusion data, length of hospital stay, consultations received, and their reasons are recorded using the information management system employed by our hospital.

Patients over the age of 18 and under the age of 85 who underwent PLF surgery were included in the study. All patients underwent interpedicular screw placement for stabilisation, followed by osteotomy of the posterior elements for decompression. It should be noted that no patients underwent only interpedicular screw placement or only osteotomy for decompression. Patients with coagulation disorders, thrombocytopenia, liver disease, as well as those undergoing revision surgery, those undergoing surgery due to spinal tumors or infections, emergency surgeries, and patients for whom the necessary medical information could not be obtained due to deficiencies in their medical records were excluded from the study.

Data

Patients' age, accompanying chronic diseases (diabetes mellitus, hypertension, coronary artery disease, chronic obstructive pulmonary disease, asthma, renal diseases and other diseases), pre-operative and post-operative hemoglobin (Hb) levels, number of spine levels treated in the surgical procedure, duration of the surgical procedure, whether they used blood thinners, whether they were given intraoperative allogeneic blood and blood product, presence of any complications in the post-operative 30-day period, what kind of complication [infection, pneumonia, deep vein thrombosis (DVT), sepsis, urinary complications, pulmonary complications, etc.] and whether complications developed due to transfusion (acute hemolytic reactions, late hemolytic reaction, graft-versus-host disease, febrile non-hemolytic transfusion reaction, transfusion-related acute lung injury, allergic transfusion reaction, post-transfusion purpuria length of hospital stay were examined.

In our clinic, blood transfusion in the perioperative period is performed in case of blood loss, anaemia or haemodynamic instability. The decision for blood transfusion is usually made by the anaesthesiologist, taking into account the clinical condition, Hb levels, type of surgery and general health status of our patient. In our clinic, the perioperative blood transfusion protocol is determined as follows: In case of mild anaemia (Hb≥10 g/dL), transfusion is usually not performed, but it is assessed whether our patient is symptomatic. In case of moderate to severe anaemia (Hb<10 g/dL or symptomatic) transfusion may be recommended. When there is large blood loss during the surgical procedure, transfusion can be performed without the need for a low Hb level. In case of significant blood loss after major surgical procedures and traumatic injuries, early blood transfusion may be administered to ensure haemodynamic stability of the patient.

Table 1. Demographic data, medical history and operation information of the patients

n=497	
Age (year) median (IQR)	63 (53-70)
BMI (kg/m²) median (IQR)	28.73 (27.53-30.04)
Number of fusion levels	3 (2-4)
Operation time (hour)	3.5 (3-4)
Gender, n (%)	
Female	289 (58.1)
Male	208 (41.9)
ASA	
1	140 (28.2)
2	207 (61.8)
3	50 (10.0)
Anti-coagulant use, n (%)	103 (20.7)
Additional disease, n (%)	357 (71.8)
Vertebral region, n (%)	
Thoracic and lumbar	38 (7.6)
Sacral and lumbar	52 (10.5)
Only lumbar	407 (81.9)
Number of fusion levels, n (%)	
1-2 segments	133 (26.8)
3 segments	230 (46.3)
≥4 segments	134 (27.0)
Patient receiving blood transfusion, n (%)	152 (30.6)

BMI: Body mass index, ASA: American Society of Anestesiologists, n: Number, IQR: Inter quantile range

Statistical Analysis

Mean standard deviation, median, minimum, maximum values were given in descriptive statistics for continuous data, and percentages were given for discrete data. Shapiro-Wilk test was used to examine the conformity of continuous data to normal distribution. In the comparison of continuous data between patients who received blood transfusions and patients who did not, t-test (independent samples t-test) was used for data with normal distribution and Mann-Whitney U test was used for data without normal distribution.

Chi-square and Fisher's exact tests were used for group comparisons of nominal variables (cross tables). Paired samples t-test was used to examine the difference between pre-operative and post-operative Hb levels in dependent groups. Risk factors affecting blood transfusion were examined by multivariate logistic regression analysis (MLRA).

IBM SPSS version 20 (Chicago, IL, USA) program was used in the evaluations, and $p<0.05$ was accepted as statistical significance limit.

RESULTS

A total of 497 patients, 289 (58.1%) female and 208 (41.9%) male, were included in the study. Dermographic data of the patients and the data related to the operation information are given in Table 1.

Blood transfusion was performed in 152 (30.6%) of the patients. A comparison of the demographic characteristics of patients who received a blood transfusion and those who did not revealed some significant differences. The proportion of females was higher ($p<0.01$) and the mean age was higher ($p<0.05$) in patients who received a transfusion. The rate of comorbidities was similar between patients who received and those who did not receive blood transfusions ($p>0.05$). Additionally, there was no significant difference in the body mass index values ($p>0.05$), American Society of Anesthesiologists (ASA) scores ($p>0.05$), and anti-coagulant use ($p>0.05$) between the two groups (Table 2).

It was determined that 10.1% of the patients developed complications and wound infection (4.2%) was the most common. Complications were more common in the post-operative period in patients who underwent blood transfusion ($p<0.005$) and sepsis was the most common ($p=0.002$) (Table 3). However, it was determined that blood transfusion did not cause any difference in terms of complications such as pneumonia, pulmonary embolism, wound infection, DVT, and urinary infection in the post-operative period. The mean length of hospital stay was 8.52±5.82 days and the median was 7 days. The length of hospital stay of the patients who underwent blood transfusion was also significantly longer ($p=0.002$) (Table 4).

57.2% of patients who underwent blood transfusion were given erythrocyte suspension (ES), 37.5% fresh frozen plasma (FFP), and 36.8% of patients were given only ES, and 63.2% were given ES+FFP. There was no difference between the post-operative complications of patients who received only ES and those who received ES+FFP ($p>0.05$).

The fusion level of 46.3% of the patients was "3 segments". It was founded that the duration of surgery was longer and the

Table 2. Comparison of the characteristics of patients with and without blood transfusion

	BT+ (n=152)	BT- (n=345)	p-value
Age median (IQR)	65 (57-71)	63 (52-70)	**0.042**[b]
BMI median (IQR)	28.89 (27.77-30.38)	28.73 (27.44-29.99)	0.106[b]
Gender, n (%)			
Female	104 (68.4)	185 (53.6)	**<0.001**[c]
Male	48 (31.6)	160 (46.4)	
ASA			
1	35 (23.0)	105 (30.4)	
2	98 (64.5)	209 (60.6)	0.164[c]
3	19 (12.5)	31 (9.0)	
Anti-coagulant use	31 (20.4)	72 (20.9)	0.904[c]
DM, n (%)	46 (30.3	102 (29.6)	0.875[c]
HT, n (%)	81 (53.3)	154 (44.6)	0.075[c]
CAD, n (%)	23 (15.1)	48 (13.9)	0.721[c]
COPD, n (%)	1 (0.7)	8 (2.3)	0.287[c]
Asthma, n (%)	12 (7.9)	21 (6.1)	0.456[c]
Renal, n (%)	1 (0.7)	1 (0.3)	0.519[c]

[b]: Mann-Whitney U test, [c]: Chi-square test/Fisher's exact test.
BT+: Patients receiving blood transfusion, BT- : Patients not receiving blood transfusion, IQR: Inter quantile range, BMI: Body mass index, n: number, ASA: American Society of Anestesiologists, DM: Diabetes mellitus, HT: Hipertension, CAD: Coronary artery disease, COPD: Chronic obstructive pulmonary disease

rate of having a fusion level of 4 or more was higher in patients who received blood transfusion (Table 5).

While the operated vertebral region was only in the "lumbar" region in 81.9% of the patients, a difference was found between the operated vertebral regions of the patients who underwent blood transfusion and the patients who did not ($p<0.05$). In patients who received blood transfusion, the rate of occurrence in the sacral vertebrae in addition to the lumbar region was found to be higher (Table 5).

In the study, post-operative Hb levels of all patients were significantly lower than pre-operative Hb levels ($p<0.001$). A difference was also found between the pre-operative Hb levels of the patients who underwent blood transfusion and those who did not ($p<0.001$). Pre-operative Hb values of the patients who underwent blood transfusion were found to be lower (Table 5).

In the examination of the risk factors affecting blood transfusion, independent variables (age, gender, pre-operative Hb levels, number of fusion levels, vertebral region, operation time) considered to be related to blood transfusion and found to be significant in the univariate analysis were included in the MLRA. As a result of the analysis, pre-operative Hb level, fusion level number, and operation time were determined as risk factors for blood transfusion.

According to the analysis results, a 1 g/dL decrease in pre-operative Hb levels increased the likelihood of blood transfusion by 2,150 times ($p<0.001$). Having 3 fusion levels increased the likelihood of blood transfusion by 2,769 times compared to 1-2 levels ($p<0.01$), and having 4 or more fusion levels increased it by 5,584 times compared to 1-2 levels. Additionally, a 1-hour increase in operation time increased the likelihood of blood transfusion by 1,337 times ($p<0.001$). Logistic regression analysis showed that age, gender, and the vertebral region operated on were not found to be significant for blood transfusion (Table 6).

Table 3. The distribution of length of hospitalization, intraoperative transfusion, and post-operative complications

Length of hospital stay (day) median (IQR)	7 (5-10)
RBC, n (%)	87 (57.2)
FP, n (%)	57 (37.5)
RBC/FP, n (%)	
RBC	32 (36.8)
RBC+FP	55 (63.2)
Post-operative complication, n (%)	50 (10.1)
Pneumonia, n (%)	8 (1.6)
Pulmonary embolism, n (%)	5 (1.0)
Wound site infection, n (%)	21 (4.2)
DVT, n (%)	5 (1.0)
Sepsis, n (%)	14 (2.8)
Urinary infection, n (%)	10 (2.0)

IQR: Inter quantile range, RBC: Red blood cell, FP: Frozen plasma, n: Number, DVT: Deep vein thrombosis

DISCUSSION

This study reveals that pre-operative Hb levels, the number of fusion levels, and the duration of the operation are significantly associated with intraoperative blood transfusion during PLF surgery. Additionally, the most common complication associated with PLF surgery was wound infection, and intraoperative blood product transfusion was found to be significantly associated with an increased rate of post-operative sepsis.

Many studies have demonstrated that intraoperative blood transfusion leads to various post-operative complications after surgery[11,12]. These complications not only increase mortality and morbidity but also lead to higher costs[11-13]. Studies on

Table 4. Comparison of post-operative complications in patients with and without blood transfusion

	BT+ (n=152)		BT- (n=345)		p-value
	Mean±SD median (min.-max.) (IQR)		Mean±SD median (min.-max.) (IQR)		
Hospitalization duration (day)	10.09±8.52 8 (3-66);(6-11)		7.73±3.92 7 (2-35);(5-9)		**0.002[b]**
	n	%	n	%	
Post-operative complication	24	15.8	26	7.5	**<0.005[c]**
Pneumonia	4	2.6	4	1.2	0.256[c]
Pulmonary embolism	1	0.7	4	1.2	1,000[c]
Wound site infection	10	6.6	11	3.2	0.083[c]
DVT	3	2.0	2	0.6	0.170[c]
Sepsis	10	6.6	4	1.2	0.002[c]
Urinary infection	1	2.6	6	1.7	0.503[c]

[b]: Mann-Whitney U test, [c]: Chi-square test/Fisher's exact test. BT+: Patients receiving blood transfusion, BT-: Patients not receiving blood transfusion, n: Number, DVT: Deep vein thrombosis, IQR: Inter quantile range, SD: Standard deviation, min.-max.: Minimum-maximum

spinal surgeries have reported that the most common post-operative complication in patients receiving blood transfusions is wound infection[14]. Wound infections are most observed after combined anterior/posterior spinal fusion surgeries, whereas cervical spinal surgeries have been shown to be associated with a lower risk[15]. For this reason, we limited our study to spinal fusion surgeries performed with a posterior approach involving the lumbar spine. In our study, as in the literature, the most common complication after PLF surgery was wound infection, while the most common complication associated with blood transfusion was sepsis.

Although the exact mechanism is unclear, studies have shown that blood transfusions increase infection risk by suppressing the immune system through immunomodulatory effects[16-18]. In a study by Park et al.[19], which examined 188.581 patients who underwent lumbar spinal fusion surgery, blood transfusion was found to be associated with post-operative infections, although the types of infections were not compared. Kato et al.[20] compared 80,000 patients who underwent elective lumbar surgery for post-operative infections and found that the most common infections in those receiving blood transfusions were wound infections, followed by urinary tract infections. Basques et al.[14], in their study involving more than 400 patients, demonstrated that blood transfusion was associated with an increase in wound infections and thromboembolic events. Unlike these studies, we did not find any differences in thromboembolic complications, urinary tract infections, or wound infections between those who received and those who did not receive blood transfusions. We observed that sepsis occurred more frequently in patients who received allogeneic blood transfusion during the intraoperative period. No allergic reactions related to allogeneic blood transfusion were observed in any of the patients in our study. A review of the literature indicates that there is no dose-response relationship between the number of blood units transfused and post-operative infections[21]. In our study, although the number of blood units administered was not specifically assessed, the effect of FFP transfusion on post-operative complications was examined,

Table 5. Comparison of pre-operative Hb values and operative characteristics of patients with and without blood transfusion

	BT+ (n=152)	BT- (n=345)	p-value
Pre-operative Hb, mean±SD	12.35±1.52	13.84±1.42	**<0.001**[a]
Number of fusion levels median (IQR)	3 (3-4)	2.93±0.89 3 (1-6); (2-3)	**<0.001**[b]
Operation time (hour) median (IQR)	4 (3-4.5)	3.5 (3-4)	**0.002**[b]
Number of fusion levels, n (%)			
1-2 segments[a]	24 (15.8)	109 (31.6)	**a-b 0.029** **a-c<0.001** **b-c<0.001**
3 segments[b]	65 (42.8)	165 (47.8)	
⩾4 segments[c]	63 (41.4)	71 (20.6)	
Vertebral region, n (%)			
Thoracic and lumbar[a]	16 (10.5)	22 (6.4)	a-b 0.985 a-c 0.068 **b-c 0.033**
Sacral and lumbar[b]	22 (14.5)	30 (8.7)	
Only lumbar[c]	114 (75.0)	293 (84.9)	

[a]: Independent samples t-test, [b]: Mann-Whitney U test, [c]: Chi-square test/Fisher's exact test. BT+: Patients receiving blood transfusion, BT-: Patients not receiving blood transfusion, n: Number, IQR: Inter quantile range, SD: Standard deviation, Hb: Hemoglobin

Table 6. Results of multivariate logistic regression analysis of factors affecting blood transfusion

Variable	Regression coefficient (SE)	Adjusted OR	95% CI		p-value
Age	-0.008 (0.010)	1,008	0.988	1,028	0.992
Gender (female)	0.106 (0.247)	1,112	0.685	1,804	0.668
Pre-operative Hb	-0.767 (0.091)	2,150	1,801	2,570	**<0.001**
Number of fusion levels					
3 segments	1.08 (0.321)	2,769	1,477	5,191	**0.001**
⩾4 segments	1,720 (0.362)	5,584	2,746	11,357	**<0.001**
Vertebral region					
Sacral and lumbar	0.536 (0.520)	1,709	0.617	4,736	0.302
Only lumbar	-0.193 (0.427)	1,207	0.525	2,801	0.625
Operation duration	0.290 (0.107)	1,337	1,084	1,647	**0.007**

SE: Standart error, OR: Odds ratio, CI: Confidence interval, Hb: Hemoglobin

and no significant difference was found when compared to ES transfusion. We found that this topic had not been previously studied in the literature.

In patients undergoing spinal surgery, various factors such as female gender, pre-operative low Hb levels, pre-operative ASA score, comorbidities, longer surgery time, fusion surgery, and a greater number of decompression or fusion levels have been associated with blood transfusion[19,22,23]. In our study, the identified risk factors for blood transfusion were pre-operative low Hb levels, an increased number of fusion levels, and longer operation times. Studies have shown that the posterior approach in spinal fusion surgery is a risk factor for blood transfusion by itself[18]. Therefore, we only included patients who underwent surgery with a posterior approach in our study. Furthermore, when comparing spinal surgeries that involve the lumbar region with additional thoracic or sacral vertebrae, we found, similar to the study by Morcos et al.[24], that the surgical levels involving the sacral region increased the risk of blood transfusion.

With a better understanding of the risks associated with blood transfusion, including the risk of infection transmission and immunomodulation, a more cautious and limited approach to blood transfusion has been adopted[25]. Various studies have shown that aprotinin, tranexamic acid, and aminocaproic acid reduce perioperative blood loss in spinal surgeries, although discussions continue regarding their safety profile, potential side effects, and appropriate dosing regimens. A review of the literature indicates that there is no dose-response relationship between the number of blood units transfused and post-operative infections[26-28]. In appropriate patients, the use of intraoperatively salvaged blood and the use of pre-operative hemodilution are also methods to reduce the risk of blood transfusion[25]. It has also been stated that pre-operative epoetin alfa administration in eligible patients may reduce the need for perioperative transfusion[29]. New blood products used may also reduce the risk of complications. Studies have demonstrated that minimizing blood use older than 15 days can reduce the risk of post-operative complications, including infection[30].

Study Limitations

Our study has some limitations. Since our study was retrospective, some data such as the amount of intraoperative bleeding are missing. Our study is single-centered, and the sample size is not large enough. It would be possible to confirm the results with a prospective, multicenter study with a larger sample size. We think that studies examining the role of blood transfusion in immunomodulation in more detail may also be useful in preventing possible complications.

CONCLUSION

We think that reducing intraoperative blood transfusion would be beneficial in reducing post-operative complications in PLF patients. For this purpose, patients at risk of blood transfusion should be identified in advance and necessary precautions should be taken. Thus, better surgical results can be achieved, and treatment costs can be reduced.

Ethics

Ethics Committee Approval: Ethical approval for this study was obtained from Gülhane Scientific Research Ethics Committee, University of Health Sciences Türkiye (approval number: 2024/508, date: 05.11.2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Design: E.E., F.Ş., Data Collection or Processing: M.T.P., Z.B., Analysis or Interpretation: F.N.K., Literature Search: E.E., F.Ş., Writing: E.E., F.Ş., B.E.

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

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SUDDEN SEVERE NEUROLOGICAL DEFICIT IN SCHEUERMANN'S DISEASE: A CASE REPORT AND LITERATURE REVIEW

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ABSTRACT

Scheuermann's disease is a spinal deformity that typically presents with back pain and cosmetic concerns. Neurological deficits are rare, particularly in adult patients without trauma or associated spinal pathology. We report the case of a 29-year-old female with a longstanding history of kyphosis, who presented with the onset of severe neurological deficits, including paraparesis and incontinence. Imaging revealed thoracic kyphosis with spinal cord compression at the apex without evidence of disc herniation or other spinal abnormalities. Surgical intervention using a posterior-only approach, including decompression and stabilization, was performed. Post-operative recovery was significant, with complete resolution of neurological symptoms at the one-year follow-up. This case underscores the importance of considering Scheuermann's disease as a rare cause of severe neurological impairment. Advanced imaging modalities, such as diffusion tensor imaging, are valuable in detecting spinal cord involvement. Surgical decompression and kyphosis correction are critical for successful outcomes.

Keywords: Neurological deficit, Scheuermann's disease, spinal cord compression, spinal surgery, thoracic kyphosis

INTRODUCTION

Scheuermann's disease, first described in 1921, is a form of dorsal kyphosis characterized by painful, rigid, and wedged vertebrae. It is commonly associated with vertebral endplate irregularities, Schmorl's nodes, and narrowing of the intervertebral disc spaces[1,2]. This condition represents the most prevalent spinal deformity in adolescents after idiopathic scoliosis[3]. While its exact etiology remains unclear, it is hypothesized to develop prior to puberty, following the ossification of the vertebral ring apophysis. The deformity typically becomes more pronounced during the adolescent growth spurt, most frequently between the ages of 12 and 15 years[4].

Scheuermann's kyphosis rarely presents with significant clinical symptoms. The most common complaints include back pain and cosmetic concerns. The majority of cases are effectively managed through conservative measures or bracing. However, it is exceedingly uncommon for the condition to result in severe neurological deficits[5,6]. In this report, we present the case of an adult with Scheuermann's kyphosis who experienced a sudden and severe neurological deficit. Notably, this case occurred in the absence of trauma, associated disc herniation, or other identifiable intraspinal pathology.

CASE PRESENTATION

A 29-year-old female presented with complaints of progressive back pain and gait disturbance, which had worsened over the past two years. She reported noticing a more pronounced kyphosis since her puberty, though she had not sought evaluation or treatment for it due to the absence of significant symptoms. Over the preceding three days, her symptoms had rapidly exacerbated, with marked numbness and paraparesis developing. She was unable to walk and denied any history of trauma.

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On neurological examination, the patient exhibited 2/5 muscle strength in the lower extremities below the T7 level according to the Medical Research Council (MRC) scale. Spasticity in the bilateral lower extremities was graded as 2 using the Modified Ashworth Scale. Sensory testing revealed hypoesthesia below the T7 dermatome, with diminished light touch and pinprick sensation. Plantar reflexes were extensor bilaterally, while both knee and ankle reflexes were exaggerated. Bilateral clonus was noted. Superficial skin reflexes were absent. Additionally, the patient had urinary and fecal incontinence, accompanied by reduced tone of the external anal sphincter.

Investigations

Laboratory investigations, including markers for systemic inflammatory or autoimmune diseases, were unremarkable. Electromyography did not indicate any neuromuscular disease but revealed findings suggestive of active spinal cord compression.

Plain radiographs of the thoracic spine demonstrated anterior wedging of the vertebral bodies and kyphosis spanning the T6 to T8 levels (Figure 1). Thoracic kyphosis measured 55 degrees from T4 to T10. Flexion and extension lateral radiographs showed no change in the degree of hyperkyphosis, indicating a rigid deformity. Additional findings included endplate irregularities and narrowed disc spaces, consistent with the diagnosis of Scheuermann's disease. Although features such as Schmorl's nodes and endplate irregularities were not readily apparent on plain radiographs or magnetic resonance imaging (MRI), they were clearly visualized on computed tomography (CT) scans. CT provided detailed evidence of Scheuermann's disease, showing anterior wedging, Schmorl's nodes, degenerative disc changes, and narrowed disc spaces at the T6 to T8 levels. MRI, supplemented with diffusion tensor imaging (DTI), confirmed spinal cord compression at the apex of the kyphosis without evidence of disc herniation, tumor, or other spinal abnormalities (Figure 2). These findings, supported by the CT scans, align with the established diagnostic criteria for Scheuermann's disease.

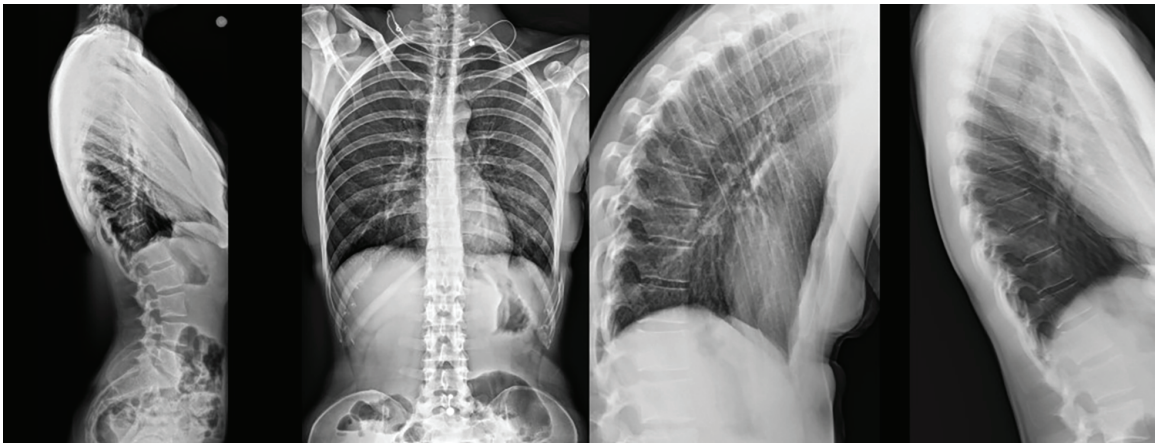

Figure 1. Pre-operative plain coronal and lateral radiographs of the thoracic spine demonstrating a 55-degree kyphotic angle from T4 to T10. Flexion and extension lateral views show that the hyperkyphosis does not change, indicating a rigid deformity. Additional findings include endplate irregularities and narrowed disc spaces, consistent with the diagnosis of Scheuermann's disease

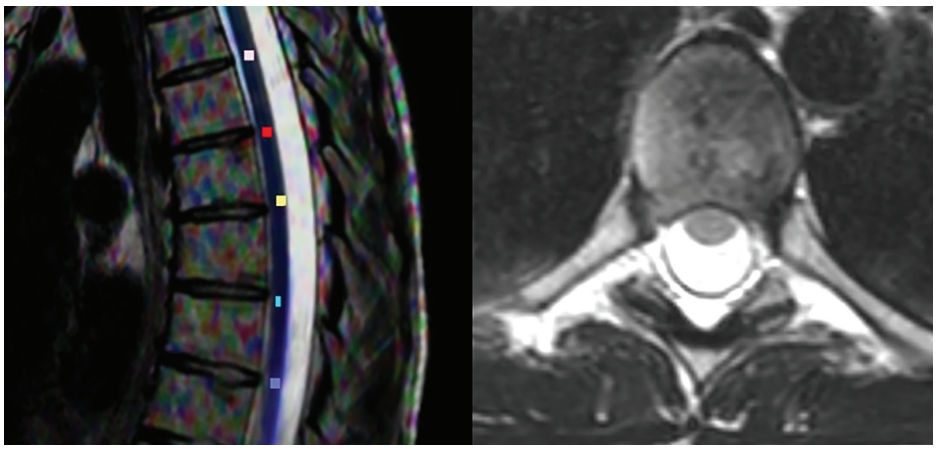

Figure 2. Pre-operative thoracic MRI with diffusion tensor imaging illustrating spinal cord compression at the apex of the kyphotic deformity
MRI: Magnetic resonance imaging

Management

Given the severity of the neurological deficit and radiological evidence of spinal cord compression, surgical intervention was planned. A posterior-only (PO) decompression and stabilization procedure was performed. Total laminectomies were conducted at the T6, T7, and T8 levels. Bilateral transpedicular screws were inserted from T5 to T10 for stabilization, and a rod system was used to correct the kyphosis. Intraoperative neuromonitoring confirmed spinal cord decompression without complications.

Post-operative imaging included a CT scan, which confirmed proper placement of the hardware and satisfactory correction of the kyphosis. Follow-up MRI with DTI demonstrated decompression of the spinal cord, with restored integrity of the compressed tracts (Figure 3).

Outcome and Follow-up

The patient experienced slight improvement in her motor deficit immediately post-operatively, with lower limb strength improving from 2/5 to 3/5 per the MRC scale. She was managed post-operatively with thoracolumbar rigid bracing and an intensive rehabilitation program. Initial therapy focused on passive range of motion exercises, progressing to postural training and assisted walking exercises.

One month post-operatively, the patient regained the ability to walk independently. At her one-year follow-up, she demonstrated complete neurological recovery, including restored motor strength, resolution of spasticity, and regained sphincter control. Radiographic follow-up confirmed stable instrumentation and maintained correction of the kyphosis. Written informed consent was obtained from the patient for the publication of this case report and any accompanying images.

DISCUSSION

The dura mater is fixed at the skull and sacrum, allowing limited elasticity along the spinal column. As the spine flexes and extends, the spinal cord experiences stretching and relaxation. Notably, the thoracic spine-especially the upper thoracic region-exhibits the least elasticity, rendering it more vulnerable to deformities, particularly acquired ones. Thoracic kyphosis stretches the posterior dura excessively, potentially leading to spinal cord compression[7,8].

Most deformities progress gradually, allowing the dura and spinal cord to adapt without causing neurological symptoms. However, severe neurological deficits, as seen in our case, have been reported in the literature. In this case, CT scans were crucial in identifying the diagnostic features of Scheuermann's disease, including anterior wedging, Schmorl's nodes, and endplate irregularities, which were less evident on plain radiographs and MRI. These findings, combined with the kyphosis angle of 55 degrees, fulfilled the diagnostic criteria for Scheuermann's disease. The thoracic kyphosis and spinal cord compression occurring at the apex of the deformity further underscore the significance of this rare presentation. These cases typically involve younger patients in their second decade of life during growth spurts, often associated with trauma or concomitant disc herniation[9-12]. While the prevalence of Scheuermann's disease is similar among males and females, males are more prone to developing spinal cord compression due to more pronounced spinal growth and a greater contribution of trunk growth during adolescence[13,14]. Our case is unique because it involves a 29-year-old female without a history of trauma or associated spinal pathology, highlighting the atypical presentation in adulthood.

Factors Influencing Neurological Complications

Several parameters influence the progression of deformities leading to neurological deficits. These include the kyphosis angle, the number of segments involved, the rate of deformity progression, local anatomical variations, concomitant disc herniation, hypertrophy of the facet joints or ligamentum

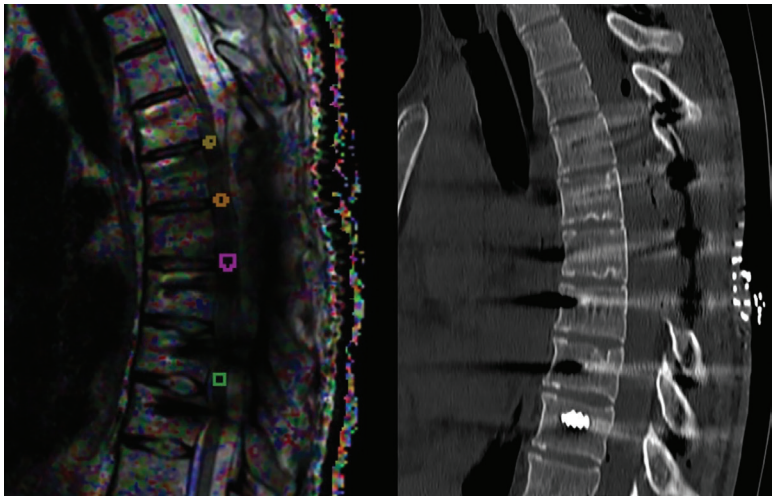

Figure 3. Post-operative CT scan and MRI with diffusion tensor imaging showing successful spinal cord decompression, accurate placement of instrumentation, and adequate correction of the kyphotic deformity
CT: Computed tomography, MRI: Magnetic resonance imaging

flavum, and vascular compromise of the spinal cord[13,15]. A study reported the average kyphosis angle in Scheuermann's disease as 56.3 degrees and found no significant correlation between kyphosis angle and neurological complications. Contrarily, another study indicated that higher kyphosis angles correlated with an increased risk of neurological impairment, regardless of the deformity's underlying cause. Interestingly, this study also suggested that neurological impairment is less likely when larger segments of the spine are involved[14].

Disc herniation is a frequent finding at the deformity's apex, often at T7-T8 or T8-T9 levels. Due to the stretched spinal cord, even a minor disc protrusion can result in significant neurological impairment. In younger patients, the harder nature of non-degenerated disc material exacerbates the compression. However, the presence of Schmorl's nodes may act as a protective mechanism by redirecting disc material toward the vertebral body instead of the spinal canal[10,12,16].

Surgical Management

Early surgical intervention is crucial in cases presenting with neurological deficits. The primary objectives of surgery are spinal cord decompression and deformity correction [4,17]. A combined anterior-posterior (AP) approach is traditionally recommended due to the frequent presence of disc herniation at the deformity's apex, which often contributes to compression. However, recent meta-analyses comparing AP and PO approaches found no significant differences in kyphosis correction, proximal junctional kyphosis, or distal junctional kyphosis. Furthermore, the PO approach was associated with reduced blood loss and shorter surgical duration[18,19].

In our case, the absence of disc protrusion allowed successful decompression and kyphosis correction through a PO approach. Post-operative recovery was favorable, with the patient achieving full neurological recovery within a year. These findings suggest that PO surgery can be an effective option for Scheuermann's disease cases without significant disc pathology.

CONCLUSION

Scheuermann's disease is an uncommon cause of neurological impairment, with spinal cord compression occurring only in rare cases. Advanced imaging modalities, such as spinal MRI with DTI, play a pivotal role in identifying the underlying pathology and determining the extent of spinal cord involvement. Early detection and prompt surgical intervention are critical for achieving optimal outcomes. Surgical treatment focusing on spinal cord decompression and kyphosis correction offers an effective solution, particularly in cases presenting with severe neurological deficits.

Ethics

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

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.Z.Y., Concept: M.Z.Y., Y.B., C.İ.G., Z.O.T., Design: M.Z.Y., Y.B., C.İ.G., Z.O.T., Data Collection or Processing: M.Z.Y., Y.B., Analysis or Interpretation: M.Z.Y., Y.B., C.İ.G., Z.O.T., Literature Search: C.İ.G., Z.O.T., Writing: C.İ.G.

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

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