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A clinical study of unilateral biportal endoscopy after radiotherapy for the treatment of short-segment lumbar brucella spondylitis

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► ***Original article***

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ABSTRACT

Background: To evaluate the efficacy of unilateral biportal endoscopy (UBE) following radiotherapy in patients with short-segment lumbar Brucella spondylitis (LBS). ***Materials and Methods:*** A retrospective analysis was performed on 45 patients with LBS treated between January 2020 and January 2022. All patients underwent radiotherapy as an adjunct to standardized anti-Brucella pharmacological therapy before surgical intervention. Radiotherapy was delivered to the affected lumbar region with a fractionated dose of 30–40 Gy (2 Gy per fraction, 5 fractions per week), aimed at controlling local infection and reducing inflammatory granulomas. Patients were subsequently assigned to two groups: UBE (n=21) or posterior lumbar interbody fusion (PLIF, n=24). Clinical outcomes were compared using operative time, intraoperative blood loss, hospitalization duration, visual analog scale (VAS), Oswestry Disability Index (ODI), Japanese Orthopaedic Association (JOA) score, inflammatory markers (CRP, ESR), neurological recovery, and complication rates. ***Results:*** Compared with PLIF, the UBE group demonstrated significantly shorter operative times (136.1±31.6 vs. 178.5±33.5 min, P<0.01), less blood loss (223.7±160.2 vs. 434.4±230.8 mL, P<0.01), and reduced hospitalization (12.2±7.6 vs. 15.6±4.1 days, P=0.028). Both groups showed marked postoperative improvements in VAS, ODI, JOA, CRP, and ESR, with normalization of inflammatory markers at 6 months. Neurological improvement exceeded 79% in both groups. Although not statistically significant, complication rates were lower with UBE (4.8% vs. 12.5%). ***Conclusion:*** Radiotherapy combined with UBE provides effective infection control and functional recovery in LBS, with advantages in reduced surgical trauma, faster recovery, and comparable long-term outcomes to PLIF.

INTRODUCTION

Brucellosis is a zoonotic infection caused by *Brucella* species, with spinal involvement being one of its most debilitating complications. Short-segment lumbar Brucella spondylitis (LBS) often results in disc destruction, paravertebral abscesses, and neurological compromise, which can lead to significant disability if inadequately treated [1, 2]. While standardized anti-Brucella antibiotic therapy remains the cornerstone of management, a subset of patients develops persistent inflammatory granulomas or abscesses despite prolonged treatment, necessitating surgical or adjunctive interventions [3, 4].

Radiotherapy has historically been applied for selected infectious and granulomatous diseases, exploiting its immunomodulatory and anti-inflammatory properties [5, 6]. Low- to moderate-dose fractionated radiotherapy has been shown to reduce local inflammatory activity, promote granuloma resolution, and improve host immune balance [7, 8]. These mechanisms suggest a potential role in controlling residual or refractory lesions in spinal infections when combined with antimicrobial therapy. Clinical experiences in granulomatous spinal conditions, including tuberculous spondylitis, also support the hypothesis that local adjuvant therapies may facilitate lesion regression and improve surgical outcomes [9, 10].

However, despite these promising findings, evidence for radiotherapy as an adjunct in Brucella spondylitis remains scarce. To date, no standardized radiotherapy regimens or comparative evaluations of surgical techniques following radiotherapy have been systematically reported. This gap is critical, as modern minimally invasive techniques such as unilateral biportal endoscopy (UBE) minimize tissue trauma and may be particularly advantageous in previously irradiated fields [11, 12].

To our knowledge, this is among the first studies to evaluate clinical outcomes of standardized radiotherapy combined with either UBE or posterior lumbar interbody fusion (PLIF) in short-segment LBS. This work provides new evidence on (i) radiotherapy as an adjunctive infection-control strategy, (ii) perioperative outcomes of UBE compared with conventional fusion in radiated spines, and (iii) the

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feasibility of combining minimally invasive surgery with fractionated radiotherapy for complex infectious spinal disease.

MATERIALS AND METHODS

Study design and ethical approval

This retrospective study was conducted at the Department of Orthopaedics, The First Affiliated Hospital of Hebei North University, Zhangjiakou, China. The protocol was reviewed and approved by the Institutional Ethics Committee of Hebei North University (Approval No: HNU2020-015, Date: January 15, 2020). All participants provided written informed consent prior to inclusion. The study was registered with the Chinese Clinical Trial Registry (Registration No: CTR051 [registration date: 2024.1.23]).

Patient population

Between January 2020 and January 2022, forty-five patients diagnosed with short-segment lumbar Brucella spondylitis were included. Diagnosis was established based on clinical presentation, epidemiological history, radiographic findings, and serological confirmation using the Tiger Red Plate Agglutination Test and Standard Tube Agglutination Test (Zhuhai Livzon Diagnostics Inc., China). Patients were eligible if they demonstrated intervertebral disc involvement as the primary lesion after a complete course of standardized anti-Brucella therapy, along with radiological evidence of intravertebral abscesses or non-resolving granulomas causing spinal cord or cauda equina compression, and radiographic signs of posterior column instability. Patients with more than two contiguous lumbar segments involved, isolated vertebral body disease without disc involvement, systemic brucellosis with minimal spinal symptoms, or incomplete follow-up data were excluded.

Radiotherapy

All patients received local radiotherapy to the affected lumbar segment prior to surgical intervention. Radiotherapy was delivered using a linear accelerator unit with three-dimensional conformal planning performed in Eclipse software (Varian Medical Systems, USA). Patients were immobilized in the supine position using a vacuum mold, and CT simulation was performed with 3 mm slice thickness. Gross tumor volume (GTV) was defined as the infected vertebral body and adjacent disc, and the clinical target volume (CTV) included a 0.5 cm margin around the lesion. Planning target volume (PTV) was generated with an additional 0.5–1.0 cm margin. Treatment was delivered with opposed posterior-anterior fields using 6 MV photon beams. A total dose of 30-40 Gy was prescribed in daily fractions of 2 Gy, five days per week. The average dose rate was [2 Gy/min], with individualized constraints applied to the spinal cord to limit the maximum dose to <40 Gy. Representative planning images with target delineation and arrows marking regions of interest are shown in figure 1.

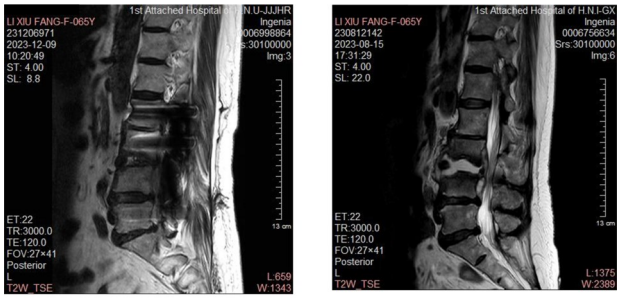

Figure 1. Left temporal glioma, before and after radiotherapy. **(A)** Before radiotherapy. **(B)** Several months after radiotherapy, showing reduced tumor size and mass effect.

Imaging

Baseline imaging consisted of lumbar X-rays, computed tomography (CT; SOMATOM Definition AS, Siemens, Germany), and magnetic resonance imaging (MRI; Magnetom Skyra 3T, Siemens, Germany). MRI was particularly valuable for identifying epidural abscesses, paraspinal collections, and spinal cord compression. Imaging was repeated postoperatively and during follow-up to evaluate fusion status, resolution of infection, and spinal stability. Representative MRI images for before and after radiotherapy treatment is are in figure 1

Preoperative management

All patients were admitted to hospital for bed rest and nutritional optimization. Preoperative antimicrobial therapy consisted of doxycycline (Vibramycin®, Pfizer, USA), rifampicin (Rifadin®, Sanofi, France), and sulfamethoxazole-streptomycin (Septrin®, Roche, Switzerland; Streptomycin®, Meda Pharma, Sweden). Treatment was continued until stabilization of systemic parameters was achieved, including hemoglobin ≥100 g/L, albumin ≥45 g/L, and ESR ≤40 mm/h. Liver and renal function tests were monitored regularly.

Surgical techniques

Surgical procedures were performed by the same senior surgical team. Twenty-one patients underwent unilateral biportal endoscopy (UBE), whereas twenty-four underwent posterior lumbar interbody fusion (PLIF).

In the UBE group, the affected vertebra was localized using intraoperative C-arm fluoroscopy (Ziehm Vision FD, Ziehm Imaging, Germany). Two portals of approximately 0.5–1.0 cm was created lateral to the midline, and the multifidus muscle was gently separated to establish a working channel. Debridement included removal of epidural abscesses, infected disc material, and granulomas. The posterior

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lamina was partially removed, and the ligamentum flavum was excised for decompression of neural elements. The surgical site was irrigated with gentamicin saline (Gentamicin®, Schering-Plough, USA), and streptomycin powder was locally applied. Interbody fusion was achieved with pedicle screw fixation (CD Horizon® Spinal System, Medtronic, USA).

In the PLIF group, patients were positioned prone under general anesthesia. A midline incision was used to expose the lamina and intervertebral space. Infected disc and granulation tissue were excised, and decompression of neural elements was performed. Similar to the UBE technique, irrigation with gentamicin and local streptomycin application were carried out. Fusion was accomplished with pedicle screws and cages (PEEK Cage®, Johnson & Johnson, USA).

Postoperative management

After surgery, all patients continued anti-Brucella therapy for a minimum of three months. Wound drains were removed when the output was <50 mL/day. Early mobilization with lumbar bracing was initiated within 3-5 days, followed by a supervised rehabilitation program.

Outcome assessment

Patients were followed for at least 12 months. Clinical outcomes included pain measured by the Visual Analog Scale (VAS), functional disability by the Oswestry Disability Index (ODI), and neurological recovery by the Japanese Orthopaedic Association (JOA) score. Laboratory indices included ESR and C-reactive protein (CRP; measured by ELISA, Roche Diagnostics, Germany). Neurological function was graded using the Frankel scale.

Statistical analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality and expressed as mean ± standard deviation. Between-group comparisons were performed using independent sample *t*-tests for normally distributed variables and Mann–Whitney *U* tests otherwise. Within-group pre- and postoperative changes were evaluated using paired *t*-tests or Wilcoxon signed-rank tests as appropriate. Repeated measures ANOVA was used for serial ESR and CRP measurements with Bonferroni correction for multiple comparisons. Categorical variables were analyzed using the chi-square test or Fisher's exact test. A two-tailed p value <0.05 was considered statistically significant.

RESULTS

Patient demographics and baseline features

A total of forty-five patients with short-segment lumbar Brucella spondylitis were analyzed in this study. Of these, twenty-one patients underwent unilateral biportal endoscopy (UBE) after radiotherapy, and twenty-four underwent posterior lumbar interbody fusion (PLIF) after radiotherapy. The demographic profile was comparable between the two groups. The mean age of patients in the UBE group was 46.2 ± 10.3 years (15 males and 6 females), while that in the PLIF group was 52.2 ± 7.6 years (17 males and 7 females). The distribution of single- versus double-segment involvement did not differ significantly between the two cohorts. This ensured that both groups were clinically and radiologically comparable at baseline, and any observed differences in outcome could be reliably attributed to the treatment modalities rather than underlying patient variation (table 1).

Table 1. Baseline demographic and clinical characteristics of patients with short-segment lumbar Brucella spondylitis treated after radiotherapy.

Group	Case	Gender (male/female)	Age ($\bar{x}\pm s$, year)	Involved segments	Single-segment double-segment
UBE	21	15/6	46.21±10.28	11	10
PLIF	24	17/7	52.174±7.62	12	12
-	-	$\chi2$=0.003	t=1.837	$\chi2$ =0.025	
P	-	>0.05	>0.05	>0.05	

UBE = unilateral biportal endoscopy; PLIF = posterior lumbar interbody fusion; SD = standard deviation.

Laboratory response to radiotherapy

Before radiotherapy, patients presented with significantly elevated inflammatory markers consistent with active infection. The average ESR exceeded 45 mm/h in both treatment groups, while mean CRP concentrations were greater than 35 mg/L, reflecting ongoing systemic inflammation and inadequate resolution of infection after pharmacological therapy alone.

Following the administration of fractionated radiotherapy (30-40 Gy delivered in daily fractions of 2 Gy, five sessions per week), a clear downward trend in inflammatory markers was observed. At the three-month post-radiotherapy assessment, ESR had fallen to approximately 9 mm/h in both groups, approaching the upper limit of normal, while CRP levels decreased to around 5 mg/L. By six months post-treatment, these markers had further normalized, with ESR stabilizing at 6-7 mm/h and CRP at 2-2.5 mg/L. These improvements were statistically significant compared with baseline values ($p<0.01$). Importantly, no significant differences in ESR or CRP were found between the UBE and PLIF cohorts at any follow-up time point, indicating that radiotherapy achieved similar biochemical control of infection regardless of the subsequent surgical approach (table 2).

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Clinical outcomes after radiotherapy and surgery

Beyond laboratory normalization, radiotherapy also facilitated clinical improvement. Pain, disability, and neurological symptoms were systematically assessed at baseline (before radiotherapy) and at six months after treatment completion.

Table 2. Inflammatory response to radiotherapy in patients with short-segment lumbar Brucella spondylitis.

Group	Case	Operative time (min)	Intraoperative bleeding (mL)	Postoperative length of hospitalization (day)
UBE	21	136.1±31.6	223.7±160.2	12.2±7.6
PLIF	24	178.5±33.5	434.4±230.8	15.6±4.1
-	-	t=8.275 P<0.01	t=2.853 P<0.01	t=2.135 P=0.028

UBE = unilateral biportal endoscopy; PLIF = posterior lumbar interbody fusion.

Patients reported substantial pain relief, as measured by the Visual Analog Scale (VAS). In the UBE cohort, mean VAS scores decreased from 5.9 before radiotherapy to 0.4 at six months, while in the PLIF cohort, VAS dropped from 5.1 to 0.3 during the same interval. Functional disability, quantified by the Oswestry Disability Index (ODI), showed corresponding improvements, with average scores reducing from nearly 60% pre-radiotherapy to around 10-11% by six months. Neurological recovery was also consistent, as Japanese Orthopaedic Association (JOA) scores more than doubled from baseline values (~13) to 26 points, indicating significant restoration of neurological function.

When stratified by surgical method, the magnitude of improvement was broadly similar between UBE and PLIF, suggesting that the beneficial effect was largely attributable to radiotherapy-mediated infection control. Neurological improvement was documented in more than 79% of patients overall, without significant differences between the treatment groups (table 3).

Table 3. Clinical outcomes before radiotherapy and at six-month follow-up.

Group	Case	VAS score			
		Pre-operative	6 months after surgery	Z	P
UBE	21	5.87±1.28	0.41±0.82	4.251	<0.01
PLIF	24	5.13±1.96	0.35±0.13	4.083	<0.01
t	-	0.263	1.135	-	-
P	-	>0.05	>0.05	-	-
Group	Case	ODI (%)			
		Pre-operative	6 months after surgery	t	P
UBE	21	59.87±11.38	10.28±3.35	24.32	<0.01
PLIF	24	57.79±12.58	11.24±4.37	25.42	<0.01
t	-	2.312	2.441	-	-
P	-	>0.05	>0.05	-	-
Group	Case	JOA score			
		Pre-operative	6 months after surgery	Z	P
UBE	21	12.87±2.23	26.37±3.72	4.325	<0.01
PLIF	24	13.08±3.43	25.81±4.12	4.167	<0.01
t	-	4.167	3.493	-	-
P	-	>0.05	>0.05	-	-

VAS = Visual Analog Scale for pain; ODI = Oswestry Disability Index; JOA = Japanese Orthopaedic Association score; UBE = unilateral biportal endoscopy; PLIF = posterior lumbar interbody fusion; SD = standard deviation.

DISCUSSION

Brucella spondylitis is a zoonotic infection of the spine characterized by inflammatory disc involvement, vertebral body destruction, and paravertebral abscess formation [13, 14]. The disease primarily affects the lumbosacral spine, with the L4-L5 region being the most commonly involved segment—accounting for nearly 78% of cases [17]. In recent years, the clinical management of short-segment lumbar Brucella spondylitis (LBS) has drawn increasing attention due to its rising incidence and the complexity of treatment.

Pharmacological anti-brucella therapy remains the first-line treatment. In early-stage cases, where imaging shows only mild vertebral inflammation without structural compromise or neurologic symptoms, medication alone often leads to full recovery [9, 18]. However, surgery becomes necessary when conservative treatment fails or when complications such as severe back pain, persistent abscesses, spinal instability, or neurological deficits develop [18, 19].

Traditionally, posterior lumbar interbody fusion (PLIF) - adopted from spinal tuberculosis surgery - has been the preferred surgical approach. Although effective, PLIF involves a large incision, wide exposure, and extensive lesion removal, leading to drawbacks such as prolonged operative time, higher blood loss, delayed recovery, and increased hospital costs [20].

Recently, unilateral biportal endoscopy (UBE) has emerged as a minimally invasive alternative in spinal surgery. In the context of short-segment LBS following radiotherapy and anti-brucella therapy, our study found that UBE provided equally effective outcomes as PLIF in terms of pain relief, functional recovery, and infection control, while offering significant advantages in reducing operative time, intraoperative bleeding, and hospital stay - consistent with previous reports [21].

Compared with PLIF, UBE minimizes surgical trauma by avoiding large incisions and extensive muscle dissection. PLIF requires stripping of the paravertebral muscles from the spinous process, which compromises posterior stabilizing structures and increases the risk of postoperative complications such as muscle atrophy and chronic low back pain [11, 12]. In contrast, UBE employs standard arthroscopic and spinal instruments through two small portals, enabling adequate visualization and flexible manipulation under endoscopic guidance [22].

This approach facilitates thorough lesion debridement while preserving spinal stability and minimizing damage to surrounding soft tissues. As a result, patients undergoing UBE are less likely to experience incisional infection or deep paraspinal muscle damage [23]. Our findings support this advantage: although both groups demonstrated

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significant postoperative improvements in VAS, ODI, JOA, ESR, and CRP, only the UBE group benefited from significantly reduced operative trauma and recovery time. The absence of significant differences in functional outcomes at follow-up further confirms that UBE achieves comparable efficacy to PLIF, while offering improved perioperative safety.

Therefore, UBE-when combined with standardized anti-brucella therapy and radiotherapy-can be considered a safe, effective, and less invasive surgical option for managing short-segment LBS.

Despite its benefits, UBE has certain limitations. In this study, the duration of patients' diseases was not analyzed in detail since it was a retrospective study, and the control was not strict enough. As a basis for judging postoperative efficacy, some indicators are easily influenced by subjective factors. The sample size of this study is insufficient and the follow-up period is short, lacking long-term efficacy observation.

Establishing the working channel requires manipulation near the multifidus muscle, posing a risk of iatrogenic injury. ANH *et al.* [24] reported a correlation between longer operative times and increased T2-weighted signal changes in the multifidus muscle on MRI, indicating muscle strain. Furthermore, UBE requires high surgical proficiency; insufficient hemostasis or technical experience can prolong surgery and increase the risk of complications.

Another limitation is the endoscopic view during interbody fusion. The constrained and sometimes "blinded" field during cage placement presents challenges, particularly for surgeons unfamiliar with UBE techniques [25-27]. Thus, while effective, UBE demands a steeper learning curve and careful intraoperative handling to achieve optimal results.

CONCLUSION

Radiotherapy followed by surgery effectively controlled infection and improved clinical outcomes in patients with short-segment lumbar Brucella spondylitis. Both UBE and PLIF achieved comparable results, but UBE provided the advantages of a minimally invasive approach with reduced perioperative morbidity.

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***Conflict of interest*:** The authors declare that they have no conflict of interest related to this study.

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***Ethical consideration*:** This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Ethics Committee of Hebei North University. Written informed consent was obtained from all participants.

***Authors' contributions*:** Y.J.: Conceptualization, study design, manuscript drafting. X.Z.: Data collection, patient follow-up, critical revision. X.Y.: Statistical analysis, results interpretation. Y.Z.: Radiotherapy planning and supervision. Y.Y.: Imaging review and data validation. Y.Y.: Literature review, manuscript editing. All authors read and approved the final manuscript.

***AI usage declaration*:** Artificial intelligence (AI) tools were not used.

REFERENCES

1. Franco MP, Mulder M, Gilman RH, Smits HL (2007) Human brucellosis. *Lancet Infect Dis,* ***7****(12): 775-86*.
2. Kaygusuz TO, Kaygusuz I, Kilic SS, Yalcin S, Felek S (2005) Investigation of hearing loss in patients with acute brucellosis by standard and high frequency audiometry. *Clin Microbiol Infect,* ***11*** *(7): 559-63*.
3. Jiang H and Kan B (2020) The current situation of brucellosis prevention and control in China, progress and suggestions. *Zhonghua Liu Xing Bing Xue Za Zhi,* ***41****(9): 1424-7*.
4. Chen Y, Yang JS, Li T, Liu P, Liu TJ, He LM, *et al.* (2017) One-stage surgical management for lumbar brucella spondylitis by posterior debridement, autogenous bone graft and instrumentation: a case series of 24 patients. *Spine (Phila Pa 1976),* ***42****(19): E1112-8*.
5. Franc KA, Krecek RC, Häsler BN, Arenas-Gamboa AM (2018) Brucellosis remains a neglected disease in the developing world: a call for interdisciplinary action. *BMC Public Health,* ***18****(1): 125*.
6. Zhang P, Yang XM, Meng XY (2013) Brucella spondylitis diagnosis and treatment. *Zhongguo Ji Zhu Ji Sui Za Zhi,* ***23****(11): 1029-32*.
7. Yang XM, Meng XY, Shi W, Du Y, Wang Y (2014) The comparison of the manifestation of the clinical imageology and pathology between the brucellar spondylitis and the spine tuberculosis. *Surg Sci,* ***5****(2): 60-9*.
8. Bagheri AB, Ahmadi K, Chokan NMJ, Abbasi B, Akhavan R, Bolvardi E, *et al.* (2016) The diagnostic value of MRI in brucella spondylitis with comparison to clinical and laboratory findings. *Acta Inform Med,* ***24****(2): 107-10*.
9. Yang XM, Shi W, Meng XY, Zhang Y, Du YK, Zhang L, *et al.* (2013) The assessment of the clinical effect of the drug compatibility and course of treatment to the brucellar spondylitis. *Surg Sci,* ***4****(1): 92-9*.
10. Yang XM, Zuo XH, Jia YL (2014) Comparison of effectiveness between two surgical methods in treatment of thoracolumbar brucella spondylitis. *Zhonghua Xiu Fu Chong Jian Wai Ke Za Zhi,* ***28*** *(10): 1241-7*.
11. Wu J, Guan T, Tian F, Liu XQ (2020) Comparison of biportal endoscopic and microscopic decompression in treatment of lumbar spinal stenosis: a comparative study protocol. *Medicine (Baltimore),* ***99****(30): e21309*.
12. Kim N and Jung SB (2019) Percutaneous unilateral biportal endoscopic spine surgery using a 30-degree arthroscope in patients with severe lumbar spinal stenosis: a technical note. *Clin Spine Surg,* ***32****(8): 324-9*.
13. Hua W, Wang B, Ke W, Wu X, Zhang Y, Li S, *et al.* (2020) Comparison of lumbar endoscopic unilateral laminotomy bilateral decompression and minimally invasive surgery transforaminal lumbar interbody fusion for one-level lumbar spinal stenosis. *BMC Musculoskelet Disord,* ***21****(1): 785*.
14. Peng H, Tang G, Zhuang X, Lu S, Bai Y, Xu L (2019) Minimally invasive spine surgery decreases postoperative pain and inflammation for patients with lumbar spinal stenosis. *Exp Ther Med,* ***18****(4): 3032-6*.
15. Wen B, Zhang X, Zhang L, Huang P, Zheng G (2016) Percutaneous endoscopic transforaminal lumbar spinal canal decompression for lumbar spinal stenosis. *Medicine (Baltimore),* ***95****(50): e5186*.

[DOI: 10.61186/ijrr.24.2.9]

16. Yong A, Youn MS, Dong HH (2019) Endoscopic transforaminal lumbar interbody fusion: a comprehensive review. *Expert Rev Med Devices,* ***16****(2): 1-8*.
17. Cai XY, Maimaiti M, Abulizi Y (2017) Progress in diagnosis and treatment of brucellosis spondylitis. *Zhonghua Jie He He Hu Xi Za Zhi,* ***39****(12): 1348-52*.
18. Yang X, Meng X, Hu C, Zhang Z, Kang C, Cheng Y, *et al.* (2016) Diagnostic and surgical treatment of Brucella spondylitis. *Zhongguo Gu Jie Wai Ke Za Zhi,* ***9****(4): 308-16*.
19. Yang XM, Meng XY, Zhang Y, Yin YL, Zhang JW, Zhang PN, *et al.* (2012) Treatment of the brucellar spondylitis in the thoracic and lumbar vertebrae by surgery. *Zhongguo Ji Zhu Ji Sui Za Zhi,* ***22*** *(7):600-6*.
20. Yang XM, Zhang L, Jia YL, Hu CB, Ren YX, Zhang ZL, *et al.* (2015) Retrospective analysis of posterior or anterior debridement with internal fixation for lumbar brucellosis spondylitis. *Zhongguo Jiepou Linchuang,* ***20****(5): 428-34*.
21. Park MK, Son SK, Park WW, Choi SH, Jung DY, Kim DH (2021) Unilateral biportal endoscopy for decompression of extraforaminal stenosis at the lumbosacral junction: surgical techniques and clinical outcomes. *Neurospine,* ***18****(4): 871-9*.
22. Kim JE, Choi DJ, Park E, Lee HJ, Hwang JH, Kim MC, *et al.* (2019) Biportal endoscopic spinal surgery for lumbar spinal stenosis. *Asian Spine J,* ***13****(2): 334-42*.
23. Mobbs RJ, Li J, Sivabalan P, Raley D, Rao PJ (2014) Outcomes after decompressive laminectomy for lumbar spinal stenosis: comparison between minimally invasive unilateral laminectomy for bilateral decompression and open laminectomy. *J Neurosurg Spine,* ***21****(2): 179-86*.
24. Ahn JS, Lee HJ, Park EJ, Kim SB, Choi DJ, Kwon YS, *et al.* (2019) Multifidus muscle changes after biportal endoscopic spinal surgery: magnetic resonance imaging evaluation. *World Neurosurg,* ***130****: e525-34*.
25. Park MK, Park SA, Son SK, Park WW, Choi SH (2019) Clinical and radiological outcomes of unilateral biportal endoscopic lumbar interbody fusion (ULIF) compared with conventional posterior lumbar interbody fusion (PLIF): 1-year follow-up. *Neurosurg Rev,* ***42****(3): 753-61*.
26. Liu X, Pang H, Zhou H, Li J, Lu X, Wang Y, *et al.* (2025) The value of imaging techniques based on enhanced magnetic resonance imaging in the diagnosis and prediction response of radiotherapy for nasopharyngeal carcinoma. *Int J Radiat Res,* ***23****(2): 311-6*.
27. Koca T, Sengun Y, Atak E, Aksu M, Tuncel N, Korcum A (2025) The impact of anthropometric measurements on radiotherapy planning for patients with breast cancer. *Int J Radiat Res,* ***23****(2): 365-70*.

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