Dual-Channel Endoscopic Decompression, Debridement, and Interbody Fusion Combined with Percutaneous Screw Fixation for Lumbar Brucella Spondylitis: A Postprint

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Abstract

Background: Dual-channel endoscopic technique is an emerging minimally invasive spinal surgery technique that has been used in recent years to treat various degenerative spinal diseases. However, there have been no relevant literature reports on the use of this technique for the treatment of lumbar brucellosis spondylitis (LBS). Objective: To investigate the efficacy and feasibility of decompression, debridement, and interbody fusion under dual-channel endoscopy combined with percutaneous screw fixation in the treatment of LBS. Methods: A total of 13 patients with LBS who underwent decompression, debridement, and interbody fusion under dual-channel endoscopy combined with percutaneous screw fixation at the Department of Orthopedics, First Affiliated Hospital of Xinjiang Medical University from January 2020 to June 2021 were enrolled. Operative time, estimated blood loss, and incidence of complications were recorded. Clinical outcomes including erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), Visual Analog Scale (VAS) scores for low back and leg pain, Japanese Orthopaedic Association (JOA) score, Oswestry Disability Index (ODI), American Spinal Injury Association (ASIA) neurological classification, and lordotic angle were analyzed. All patients were evaluated using the modified Macnab criteria at the final follow-up. Interbody bone graft fusion was assessed using the Bridwell grading system. Results: Operative time ranged from 145-210 min, with an average of (177.31 ± 19.54) min; estimated blood loss ranged from 120–290 ml, with an average of (176.15 ± 43.79) ml. At 3 months postoperatively, ESR and CRP levels returned to normal. VAS scores for low back and leg pain, JOA score, and ODI all showed significant improvement compared with preoperative values, with statistically significant differences ($F = 100.013$, $F = 27.093$, $F = 187.472$, $F = 209.695$, all $P < 0.001$).

Evaluation using the modified Macnab criteria at final follow-up showed excellent results in 10 cases, good in 2 cases, fair in 1 case, and poor in 0 cases, with an excellent-good rate of 12/13. One patient received percutaneous screw fixation only on the decompression side due to severe osteoporosis; one patient developed superficial incision infection postoperatively, which healed after dressing changes and effective antibiotic treatment. All patients achieved bony fusion at final follow-up, including 12 cases with grade I fusion and 1 case with grade II fusion, yielding a fusion rate of 12/13. Conclusion: Decompression, debridement, and interbody fusion under dual-channel endoscopy combined with percutaneous screw fixation is an effective, safe, and feasible surgical approach for the treatment of LBS.

Full Text

Preamble

Biportal Endoscopic Decompression, Debridement, Interbody Fusion Combined with Percutaneous Screw Fixation for Lumbar Brucellosis Spondylitis

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Abstract

Background: Biportal endoscopic technique is an emerging minimally invasive spinal surgical approach that has been increasingly applied to treat various degenerative spinal diseases. However, its use for lumbar brucellosis spondylitis (LBS) has not yet been reported in the literature.

Objective: To investigate the effectiveness and feasibility of biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation for LBS.

Methods: Thirteen patients with LBS who underwent biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation at the Department of Orthopaedics, The First Affiliated Hospital of Xinjiang Medical University between January 2020 and June 2021 were included. Operative duration, estimated blood loss, and complications were recorded. Clinical outcomes including erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), visual analog scale (VAS) scores for low back and leg pain, Japanese Orthopaedic Association (JOA) score, Oswestry Disability Index (ODI), American Spinal Injury Association (ASIA) neurological classification, and lordotic angle were analyzed. All patients were assessed using modified Macnab criteria at final follow-up. Intervertebral bone graft fusion was evaluated using Bridwell grading criteria.

Results: Operative duration ranged from 145–210 minutes (mean 177.31 ± 19.54 minutes). Estimated blood loss was 120–290 ml (mean 176.15 ± 43.79 ml). ESR and CRP levels normalized by the 3-month follow-up. VAS scores for low back and leg pain, JOA score, and ODI showed significant improvement compared with preoperative values ($F = 100.013$, $F = 27.093$, $F = 187.472$, $F = 209.695$, respectively; all $P < 0.001$). Modified Macnab criteria at final follow-up showed excellent outcomes in 10 patients, good in 2, fair in 1, and poor in 0, with an excellent-to-good rate of 12/13. One patient received percutaneous screw fixation only on the decompression side due to severe osteoporosis. One case developed superficial incision infection that healed after dressing changes and effective antibiotic treatment. All patients achieved bony fusion at final follow-up, including 12 cases with grade I fusion and 1 case with grade II fusion, yielding a fusion rate of 12/13.

Conclusion: Biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation is an effective, safe, and feasible surgical procedure for LBS.

Keywords: Lumbar brucellosis spondylitis; Biportal endoscopic; Debridement; Interbody fusion; Minimally invasive surgery

Introduction

Brucellosis is a zoonotic infectious disease caused by *Brucella* bacteria that can involve multiple organ systems, with the musculoskeletal system being most commonly affected [1]. Osteoarticular infections most frequently occur in the spine, with reported incidence rates of 6%–58% [2, 3]. The lumbar spine is the most common site, followed by thoracic and cervical regions [4, 5]. The treatment of lumbar brucellosis spondylitis (LBS) remains controversial. Antibiotic chemotherapy is currently considered the primary treatment modality, typically yielding favorable outcomes [6]. However, surgical intervention may be necessary for patients with progressive kyphotic deformity, neurological deficits, spinal instability, abscess formation, intractable low back pain, or failed conservative treatment [7, 8].

Biportal endoscopic technique is an emerging minimally invasive spinal technology that utilizes two independent channels—an observation channel for the endoscope to monitor the surgical field and a working channel for various surgical instruments. Several studies have demonstrated favorable clinical outcomes using biportal endoscopic technique for lumbar degenerative diseases [9-11]. In recent years, as this technology has gained widespread clinical application, its surgical indications have expanded beyond lumbar degenerative diseases. Some scholars have attempted to apply this technique to spinal infectious lesions, such as epidural abscess [12], pyogenic spondylitis [13], and spinal tuberculosis [14]. However, we have not found any literature reports on the application of biportal endoscopic technique for LBS. Therefore, this retrospective study analyzed patients with LBS treated using biportal endoscopic technique to evaluate the feasibility and effectiveness of biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation for LBS, and to summarize key surgical points and precautions.

1.1 Inclusion and Exclusion Criteria

Inclusion criteria: (1) Definitive diagnosis of LBS based on epidemiological history, clinical manifestations, laboratory tests, and imaging findings; (2) Intractable low back pain, severe or progressive neurological dysfunction, or imaging evidence of significant epidural abscess; (3) Failed conservative treatment (persistently worsening clinical symptoms and/or uncontrolled infection); (4) Underwent biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation.

Exclusion criteria: (1) Uncertain diagnosis of brucellosis spondylitis (BS) or coexisting other spinal infectious or neoplastic diseases; (2) Lesions involving two or more segments; (3) Inability to tolerate surgery; (4) Treatment with other surgical approaches.

1.2 Patient Data

Thirteen patients with LBS who underwent biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation at the Department of Orthopaedics, The First Affiliated Hospital of Xinjiang Medical University between January 2020 and June 2021 were enrolled. The cohort included 10 males and 3 females, aged 34-71 years (mean 52 ± 9.77 years). Infected segments included L1/2 (1 case), L2/3 (1 case), L3/4 (2 cases), L4/5 (4 cases), and L5/S1 (5 cases). All patients had varying degrees of cattle or sheep exposure history. According to the diagnostic criteria for brucellosis issued by the National Health Commission of the People' s Republic of China [15], all 13 patients were definitively diagnosed based on epidemiological history, clinical manifestations, laboratory tests [6], and imaging findings. The disease onset was insidious in all patients, with symptom duration ranging from 1-13 months (mean 5.46 ± 3.89 months). Clinical manifestations included intermittent fever, night sweats, fatigue, decreased appetite, weight loss, and intractable low back pain, with 11 cases accompanied by nerve root compression symptoms. Mean preoperative erythrocyte sedimentation rate (ESR) was 38.69 ± 18.98 mm/h, and mean C-reactive protein (CRP) was 26.82 ± 19.87 mg/L. Rose bengal plate test (RBPT) was positive in 9 cases and negative in 4 cases. Serum agglutination test (SAT) titers were $ $1/160 in all patients. Blood cultures were positive in 3 cases (23.08%). Imaging examinations (X-ray, CT, MRI) showed characteristic features of brucellosis spondylitis [16]. MRI demonstrated that lesion tissues appeared as low or isointense signals on T1WI and hyperintense signals on T2WI and fat-suppressed images [Figure 1: see original paper]A, with epidural inflammatory granulation tissue or abscess compressing the spinal cord, cauda equina, or nerve roots [Figure 1: see original paper]B. Three cases were accompanied by vertebral instability. This study was approved by the Ethics Committee of The First Affiliated Hospital of Xinjiang Medical University (210723-15), and all patients and their families provided informed consent.

1.3 Preoperative Preparation

All patients received regular oral doxycycline (200 mg/day) and rifampin (600 mg/day) combination chemotherapy for at least 2 weeks preoperatively [17]. Surgery was performed after fever and other systemic symptoms resolved and body temperature returned to normal.

1.4 Surgical Technique

1.4.1 Anesthesia and Positioning All surgeries were performed by the same surgical team. General anesthesia with endotracheal intubation was used. Patients were placed in prone position on an iliac crest support pad with the abdomen naturally suspended, both upper limbs abducted and fixed, and axillary pads placed. Both hip and knee joints were maintained in semi-flexion.

1.4.2 Localization and Sterilization C-arm fluoroscopy was used to obtain standard anteroposterior lumbar radiographs to identify the target segment and mark the surface projection of the pedicle and the junction between the base of the upper spinous process and the lower edge of the lamina. The surgical field was routinely disinfected and draped with sterile waterproof sheets to form a U-shaped waterproof groove for drainage of irrigation fluid. A skin protective film was applied to the surgical area. The arthroscopic irrigation system was connected and tested.

1.4.3 Channel Establishment and Working Space Creation The surgeon stood on the symptomatic side. For patients with bilateral radicular symptoms, the side with more severe symptoms or larger abscess was selected as the primary approach. Using a scalpel, longitudinal incisions were made at the marked junction between the base of the upper spinous process and lower lamina edge (approximately 1 cm superiorly and inferiorly) and at the lateral border of the ipsilateral pedicle. Skin, subcutaneous tissue, and fascia were incised sequentially, with a transverse incision made in the fascial layer to create a cross-shaped opening. Using a left-sided approach as an example, the cranial observation channel incision was approximately 1 cm, and the caudal working channel incision was approximately 1.2 cm. Primary dilators and lamina anatomical dissectors were inserted through each channel, passed through the paraspinal muscles, and converged at the bony surface of the junction between the base of the upper spinous process and lower lamina edge. C-arm fluoroscopy confirmed the convergence point [Figure 2: see original paper]A, 2B. Sequential dilation was performed along the base of the spinous process outward to separate soft tissues from the bony surface and create initial working space. The endoscope was held in the left hand and inserted into the observation channel with the irrigation system opened to ensure continuous, steady inflow of irrigation fluid for a clear surgical field. A plasma radiofrequency probe held in the right hand was inserted through the working channel to clear bony structures and soft tissues under endoscopic visualization with careful hemostasis. The inferior articular process apex and facet joint were exposed outward and inferiorly. A bone osteotome or Kirschner wire was inserted into the facet joint space or positioned on the bony surface, and C-arm fluoroscopy confirmed the target level. The junction between the spinous process and lower edge of the upper lamina was exposed superiorly, and the upper edge of the lower lamina was exposed inferiorly to establish the working space.

1.4.4 Spinal Canal Decompression Osteotomes, rongeurs, and burrs were used alternately to remove the inferior articular process and part of the lower edge of the upper lamina until the origin of the ligamentum flavum was exposed. Part of the upper edge of the lower lamina was removed to expose the insertion of the ligamentum flavum. An endoscopic reciprocating saw was used to remove the apex of the superior articular process of the lower vertebra, with residual bone and the medial aspect of the superior articular process removed using rongeurs until the lateral ligamentum flavum and medial pedicle margin were exposed, creating space between the traversing and exiting nerve roots.

For patients with bilateral radicular symptoms or extensive intraspinal abscess, contralateral decompression was performed simultaneously. The endoscope was appropriately tilted, and a protected burr or osteotome was used to carefully remove bone at the base of the spinous process to expose the midline of the ligamentum flavum. The endoscope direction was adjusted to allow the lens to cross the midline gap of the ligamentum flavum ("over-the-top" technique). Contralateral bone of the upper lamina was removed again to create a space between the lamina and ligamentum flavum until the contralateral pedicle medial margin and superior articular process of the lower vertebra were exposed. Local autologous bone harvested during the procedure was preserved for interbody grafting.

After bony decompression was completed, Kerrison rongeurs and pituitary forceps were used to completely remove the ligamentum flavum covering the dura mater and nerve roots, fully exposing the inflammatory lesions, dura mater, and nerve roots.

1.4.5 Tissue Biopsy and Resection After careful dissection of the dural margins and nerve roots, the assistant gently retracted the dura mater and nerve roots medially using a nerve root retractor. Endoscopic visualization revealed light red, non-caseating inflammatory granulation tissue compressing the dura mater and nerve roots [Figure 2: see original paper]C. Careful dissection was performed using a hook probe to expose the inflammatory granulation tissue [Figure 2: see original paper]D. Radiofrequency coagulation was used for meticulous hemostasis of dilated vessels. Inflammatory granulation tissue was alternately grasped and removed using pituitary forceps and rongeurs, with appropriate specimens sent for pathological examination.

1.4.6 Intervertebral Space Management and Endoscopic Fusion After careful pre-emptive hemostasis with an intraspinal radiofrequency probe, the assistant protected the dura mater and nerve roots with retractors. A long-handled scalpel was used to perform an annulotomy. Discectomy was performed alternately using reamers, curettes, and pituitary forceps. The endoscope was advanced into the intervertebral space to monitor lesion clearance and endplate preparation. Residual pathological tissue and nucleus pulposus were completely removed, along with intraspinal and perivertebral pus. Destroyed and sclerotic bone was curetted, and cartilaginous endplates were removed until the bony endplates showed slight bleeding. If endplate destruction was significant with severe vertebral collapse, the harvested bone was cut into small pieces, mixed with rifampin, and implanted into the intervertebral space. If bone graft quantity was insufficient, artificial bone or allograft was used. For patients with intact upper and lower endplates and mild destruction, a Cage could be implanted. A Cage trial was first inserted to determine appropriate size while avoiding damage to subchondral bone, restoring intervertebral height and determining the required Cage dimensions.

Rifampin mixed with autologous bone and artificial bone was loaded into a graft delivery catheter to fill and compact the anterior intervertebral space. After protecting the dura mater and nerve roots with a nerve root retractor, a Cage filled with rifampin-mixed autologous bone was placed under endoscopic visualization [Figure 2: see original paper]E. A mallet was used to tap the Cage deeper into the intervertebral space, with fluoroscopy confirming its position and size. The endoscope and surgical instruments were then withdrawn.

1.4.7 Percutaneous Screw Fixation Two ipsilateral percutaneous pedicle screws were placed through the previously described skin incisions. Two additional percutaneous pedicle screws were placed through two new skin incisions on the contralateral side. Two pre-bent connecting rods were inserted, and caps were tightened and locked. Final fluoroscopy confirmed appropriate position and size of the internal fixation device. Residual irrigation fluid in the channels was manually expressed. Drainage tubes were placed through the working channels and secured to drain small bone fragments and prevent epidural hematoma. Incisions were sutured, covered with sterile gauze, and secured [Figure 2: see original paper]F.

1.5 Postoperative Management

Intravenous antibiotics (ceftriaxone [18] 2.0 g q12h) were administered for 24 hours postoperatively to prevent infection. Non-steroidal anti-inflammatory drugs were prescribed to reduce postoperative pain. Drainage tubes were removed when output was <30 ml/24h. Patients could ambulate with lumbar brace support 1-2 days postoperatively. Oral doxycycline (200 mg/day) and rifampin (600 mg/day) combination therapy was continued for at least 3 months postoperatively, discontinued only after three consecutive normal ESR and CRP results. Liver and kidney function were monitored regularly during medication. Lumbar anteroposterior and lateral radiographs and CT were obtained before discharge to evaluate graft status and position of the Cage and screw-rod system [Figure 3: see original paper]A–3C. Lumbar MRI was performed to assess decompression and lesion clearance [Figure 3: see original paper]D, 3E. Lumbar brace protection was maintained for 3 months.

1.6 Observation Indicators

Operative duration, estimated blood loss, and complications were recorded. Preoperative and postoperative ESR, CRP, visual analog scale (VAS) scores, Japanese Orthopaedic Association (JOA) score, Oswestry Disability Index (ODI), ASIA neurological classification, and lordotic angle were analyzed. Modified Macnab criteria were assessed at final follow-up. Lumbar anteroposterior and lateral radiographs were obtained at 1, 3, 6 months and final follow-up. Intervertebral bone graft fusion was evaluated using Bridwell grading criteria [19], with CT performed when X-ray findings were inconclusive.

1.7 Statistical Methods

SPSS 26.0 software was used for statistical analysis. Normally distributed continuous data were expressed as mean ± standard deviation ($\bar{x} \pm s$). One-way repeated measures ANOVA was used to compare VAS, JOA scores, and ODI between preoperative and postoperative time points. Paired-sample t-tests were used to evaluate changes in ESR, CRP, and lordotic angle between preoperative and postoperative time points. $P < 0.05$ was considered statistically significant.

Results

2.1 General Conditions and Complications

All patients successfully completed surgery. Operative duration ranged from 145–210 minutes (mean 177.31 ± 19.54 minutes). Estimated blood loss was 120–290 ml (mean 176.15 ± 43.79 ml). Patients could ambulate with lumbar brace support 1-2 days postoperatively. Postoperative hospital stay ranged from 3–12 days (mean 5 ± 2.31 days). Follow-up duration ranged from 12–30 months (mean 18.23 ± 4.71 months). One patient received percutaneous screw fixation only on the decompression side due to severe osteoporosis, requiring extended bed rest, brace wear, and regular anti-osteoporosis medication. One case developed superficial incision infection on postoperative day 3, which healed after dressing changes and effective antibiotic therapy.

Typical Case: A 57-year-old male presented with intractable low back pain for 1 year, worsening with left lower extremity radiating pain for 1 month. He had a history of sheep farming and long-term sheep contact. Physical examination revealed tenderness and percussion pain at L4-5 spinous processes. Straight leg raise test was positive on the left at approximately 40°, with positive augmentation test at approximately 30°. Decreased sensation was noted in the anterolateral left calf and dorsal foot. Clinical diagnosis of lumbar brucellosis spondylitis was made. Conservative treatment with anti-brucellosis medication, analgesics, and neurotrophic agents provided no significant improvement, with progressive left lower extremity numbness developing. The patient underwent biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation. Preoperative, intraoperative, and postoperative imaging are shown in Figures 1, 2, and 3.

2.2 Functional Outcomes

All patients experienced relief of low back and lower extremity radiating pain on the first postoperative day. Systemic symptoms and low back pain improved significantly at 1-month follow-up, with complete resolution of clinical symptoms and absence of local tenderness or percussion pain at final follow-up. VAS scores for low back and leg pain, JOA score, and ODI showed significant improvement compared with preoperative values .

At final follow-up, modified Macnab criteria showed excellent outcomes in 10 patients, good in 2, fair in 1, and poor in 0, with an excellent-to-good rate of 12/13. Preoperative ASIA neurological classification included 8 type D and 5 type E cases. Two patients recovered to type E before discharge, and all patients were type E at final follow-up.

Table 1 Comparison of VAS scores for low back and leg pain, JOA score, and ODI between preoperative and postoperative time points (n=13, $\bar{x} \pm s$)

Time Point	Low Back VAS	Leg VAS	JOA Score	ODI (%)
Preoperative	5.85 ± 1.28	3.69 ± 2.02	13.46 ± 3.18	55.57 ± 10.99
1 month postoperative	3.15 ± 0.8	1.92 ± 1.19	20.85 ± 2.91	37.09 ± 9.99
3 months postoperative	1.92 ± 0.64	1.31 ± 0.75	24.77 ± 1.92	26.54 ± 6.96
6 months postoperative	1.38 ± 0.51	1.08 ± 0.64	25.92 ± 1.04	10.63 ± 2.91
Final follow-up	0.85 ± 0.8	0.69 ± 0.48	27.08 ± 0.95	6.14 ± 3.38
P-value	<0.001	<0.001	<0.001	<0.001

P < 0.001 compared with preoperative values. VAS = visual analog scale, JOA = Japanese Orthopaedic Association, ODI = Oswestry Disability Index.

Table 2 Comparison of ESR between preoperative and postoperative time points (n=13, $\bar{x} \pm s$)

Time Point	ESR (mm/h)	t-value	P-value
Preoperative	38.69 ± 18.98	-	-
1 month postoperative	36.23 ± 11.39	3.705	<0.001
3 months postoperative	24.85 ± 9.17	7.630	<0.001
6 months postoperative	8.77 ± 3.72	7.787	<0.001
Final follow-up	8.46 ± 2.73	6.158	<0.001

P < 0.001 compared with preoperative values. ESR = erythrocyte sedimentation rate.

Table 3 Comparison of CRP between preoperative and postoperative time points (n=13, $\bar{x} \pm s$)

Time Point	CRP (mg/L)	t-value	P-value
Preoperative	26.82 ± 19.87	-	-
1 month postoperative	29.56 ± 14.32	2.275	<0.001
3 months postoperative	13.72 ± 6.03	7.630	<0.001
6 months postoperative	5.45 ± 1.84	7.787	<0.001
Final follow-up	5.13 ± 1.75	6.158	<0.001

P < 0.001 compared with preoperative values. CRP = C-reactive protein.

2.3 Laboratory Findings

Postoperative pathology results showed non-caseating necrotizing granulomatous inflammation with numerous lymphocytes and mononuclear cells [Figure 3: see original paper]F, consistent with brucellosis spondylitis diagnosis. Comparisons of ESR and CRP between preoperative and postoperative time points are shown in Tables 2 and 3, with $P < 0.001$ considered statistically significant.

2.4 Imaging Results

Preoperative lordotic angle was 47.18° ± 6.88°, decreasing to 40.83° ± 6.71° before discharge ($t = 2.384$, $P = 0.025$). At final follow-up, lordotic angle was 42.26° ± 6.92°, which was not significantly different from preoperative values ($t = 1.819$, $P = 0.081$). Although lordotic angle decreased after surgery, no significant angle loss was observed at final follow-up. Intervertebral fusion was assessed at final follow-up [Figure 3: see original paper]G, 3H. According to Bridwell grading criteria, 12 cases achieved grade I fusion and 1 case achieved grade II fusion, with a fusion rate of 12/13. Flexion-extension radiographs and CT in the grade II case showed no pseudarthrosis formation. No screw loosening or rod breakage was observed in any patient.

Discussion

Brucellosis has a high incidence, with over 500,000 new human cases annually worldwide, representing a major public health problem and imposing substantial socioeconomic burdens, particularly in underdeveloped regions [20]. Osteoarticular infection is a common manifestation of brucellosis, with lumbar brucellosis spondylitis being the most frequent spinal involvement, accounting for 6%-12% of all infected sites and representing a major cause of disability-related complications [21]. Antimicrobial chemotherapy remains the primary treatment for LBS, with most cases achieving cure through conservative medical management [22]. However, some patients develop residual kyphotic deformity and spinal instability after treatment completion. The diagnosis and management of this disease pose significant challenges to clinicians. Delayed diagnosis and treatment may lead to neurological dysfunction due to compression by intraspinal inflammatory granulation tissue or abscess, intractable or progressive low back pain from spinal instability, and extensive paraspinal abscess formation. Additionally, antibiotic therapy may be ineffective in some cases, making surgical intervention necessary [7, 8]. However, consensus regarding the optimal surgical approach and the role of surgical intervention has not been established. In this study, the primary surgical goals were thorough clearance of infected lesions, pain relief or elimination, decompression of spinal cord/cauda equina and nerve roots, neurological function improvement, spinal stability reconstruction, and restoration of normal spinal alignment.

3.1 Feasibility of Biportal Endoscopic Decompression, Debridement, Interbody Fusion Combined with Percutaneous Screw Fixation for LBS

Current literature on surgical treatment of LBS is limited. Main surgical approaches include anterior debridement, traditional posterior fenestration, and combined anterior-posterior approaches. In 1988, Redfern et al. [23] successfully treated non-tuberculous spinal infection through anterior debridement, fusion, and fixation. In 2018, Yin et al. [24] reported good clinical outcomes using anterior debridement, interbody fusion, and instrumentation for LBS. Anatomically, brucellosis spondylitis typically originates at the anterior superior endplate due to rich blood supply in this region [16]. Therefore, anterior surgery can achieve thorough debridement and neural decompression without affecting posterior column stability. However, anterior approaches have several drawbacks, including longer operative times and potential complications such as vascular injury, graft failure, and postoperative ileus compared with posterior open surgery [25-27]. Traditional posterior open surgery allows direct lesion clearance and decompression for cases with intraspinal inflammatory granulation tissue or abscess, relieving compression of spinal cord/cauda equina and nerve roots. For cases with spinal instability or kyphotic deformity, pedicle screw fixation can maintain or reconstruct spinal stability, correct deformity, and promote graft fusion, effectively treating LBS. Although traditional posterior open surgery addresses the limitations of anterior approaches, destruction of posterior muscular-ligamentous structures may lead to postoperative chronic low back pain and muscle atrophy [28].

Brucellosis spondylitis abscesses are relatively localized, primarily involving the superior and inferior endplates and intervertebral space of the affected segment. Unlike tuberculous spondylitis, bone destruction is predominantly sclerotic. During debridement, excessive emphasis on complete lesion removal should be avoided as it may cause loss of residual bone and lead to spinal instability [29]. Kang et al. [12] successfully treated spinal epidural abscess using biportal endoscopic technique in 2019. Hsu et al. [13] reported successful treatment of Salmonella spondylodiscitis with epidural abscess using unilateral biportal endoscopic discectomy and debridement with good outcomes. In 2021, Kim et al. [14] successfully treated spinal tuberculosis patients using biportal endoscopic debridement and percutaneous screw fixation. Based on these experiences, we applied biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous internal fixation in 13 LBS patients. This approach minimizes damage to posterior muscular-ligamentous and bony structures. Endoscopic visualization enables safer and more efficient decompression and debridement, ensuring adequate decompression and effective lesion clearance while preserving more normal muscular-ligamentous and bony structures, thereby reducing postoperative low back pain, muscle atrophy, and spinal instability. Simultaneous percutaneous screw fixation effectively maintains or reconstructs spinal stability and promotes bony union. Our results demonstrate good clinical efficacy and achievement of clinical cure criteria, indicating that biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation is a feasible treatment for LBS.

3.2 Advantages, Key Technical Points, Indications, and Limitations

In recent years, as biportal endoscopic technology has gained widespread clinical application, its surgical indications have expanded from simple lumbar disc herniation [30] and lumbar spinal stenosis [31, 32] to lumbar interbody fusion [33], spinal infectious diseases [12-14], and even epidural tumor resection [34], with outcomes comparable to traditional open surgery. Biportal endoscopic technology enables decompression and debridement under visualization, allowing more thorough decompression and lesion clearance. Endoscopic monitoring of intervertebral space management and graft fusion facilitates complete endplate preparation and safe Cage implantation. This technique offers advantages of clear visualization, large working space, and free instrument manipulation, allowing use of traditional spinal surgical instruments for decompression. It combines features of endoscopic and traditional open surgery, truly embodying the minimally invasive concept of "endoscopic open surgery."

Key Technical Points: 1. **Identify the pathological segment:** After prone positioning, the lumbar spine is placed in slight flexion with knees bent to maximize disc space distraction. C-arm fluoroscopy confirms the pathological segment is nearly perpendicular to the floor. During working space establishment, particularly for right-sided approaches, a bone osteotome or Kirschner wire can be inserted into the facet joint space or positioned on bony surfaces after facet joint exposure, with C-arm fluoroscopy confirming the correct level. 2. **Decompression sequence:** Bony structures first, then ligamentum flavum. Remove inferior articular process and lower edge of upper lamina first, then upper edge of lower lamina, followed by medial border and apex of superior articular process. For bilateral radicular symptoms or extensive intraspinal abscess, unilateral laminectomy with bilateral decompression can be performed. 3. **Contralateral decompression:** First remove part of the spinous process base using an osteotome or protected high-speed burr to facilitate "over-the-top" crossing of the ligamentum flavum midline gap. During the learning curve, using a protected high-speed burr reduces risk of dural sac and nerve root injury. For spinal infectious diseases, preserving ipsilateral ligamentum flavum initially reduces injury risk to dura mater and ipsilateral nerve roots from surgical instruments during contralateral decompression. In LBS patients, significant vascular proliferation and rich blood supply increase bleeding risk; early ligamentum flavum removal may cause oozing that obscures visualization and increases nerve injury risk. Particularly for severe epidural abscess or lesion compression, early ligamentum flavum removal may cause significant dural expansion, making over-the-top technique difficult and increasing injury risk. 4. **In LBS patients, inflammatory exudates often cause dense adhesion of ligamentum flavum to dura mater and nerve roots.** Careful separation of ligamentum flavum covering the dura mater and nerve roots reduces iatrogenic dural tears. Gentle traction with rongeurs or pituitary forceps facilitates spontaneous separation, or careful dissection with a hook probe can be used. Continuous saline irrigation allows fluid to enter the epidural space between inflammatory tissue, dura mater, and ligamentum flavum, helping dissolve adhesions. 5. **Disc management:** Before disc incision, the corresponding nerve root at the pathological segment must be fully exposed. Under direct vision, the nerve root is gently retracted with a nerve root retractor to expose the posterolateral annulus. A long-handled scalpel is used to incise the annulus along its margins, removing as much nucleus pulposus and pathological tissue as possible. 6. **Intervertebral space management:** Straight and curved ring curettes are used to remove cartilaginous endplates, with residual endplates stripped using endplate scrapers to ensure complete removal of cartilaginous endplates on the symptomatic side and as much as possible on the contralateral side. 7. **Grafting and Cage implantation:** Preoperative MRI sagittal measurements can predict Cage length and height by measuring anteroposterior disc space dimensions. Intraoperative trial sizing after disc space preparation confirms Cage dimensions. Appropriate Cage size is selected. Placing an adequate amount of rifampin-mixed bone chips anteriorly in the disc space and compacting them provides effective local anti-infection. After protecting dura mater and nerve roots with a retractor, the Cage filled with rifampin-mixed bone chips is placed horizontally in the disc space, ensuring its posterior edge is at least 3 mm from the posterior vertebral margin. Fluoroscopy confirms satisfactory Cage position after placement. 8. **Maintain clear visualization through meticulous hemostasis rather than increasing irrigation pressure** to prevent irrigation fluid pressure-related complications resembling spinal hypertension syndrome. 9. **Preoperative CT axial imaging can be used to plan pedicle screw trajectory, diameter, and length.** 10. **After percutaneous pedicle screw placement, drainage tubes are inserted to prevent epidural hematoma or drain small bone fragments.**

Indications: Similar to traditional open surgery: (1) Severe disc or vertebral body destruction causing intractable low back pain unresponsive to medical therapy; (2) Intraspinal inflammatory granulation tissue or epidural abscess compressing spinal cord/cauda equina and nerve roots causing severe or progressive neurological deficits; (3) Spinal instability from vertebral destruction; (4) Failed medical anti-brucellosis therapy.

Limitations: (1) Severe anterior column destruction or large anterior abscess requiring anterior debridement, or extensive paraspinal abscess formation; (2) Incomplete debridement and decompression due to poor visualization; (3) Potential retroperitoneal rupture with irrigation fluid entering the abdominal cavity, causing ascites and infection [35].

3.3 Safety and Clinical Efficacy

Some surgeons may have concerns about intraspinal or central nervous system infection when performing posterior debridement and decompression using biportal endoscopy. In 2016, Chen et al. [36] reported 24 cases of brucellosis spondylitis treated with posterior debridement, grafting, and instrumentation, showing significant postoperative improvement in VAS scores and neurological function with no recurrent cases during follow-up. Another study reported 62 LBS patients treated with posterior debridement, grafting, and internal fixation, with all patients achieving clinical cure at final follow-up [37]. In 2021, a study reported 48 cases of lumbosacral brucellosis spondylitis treated with unilateral and bilateral posterior fenestration, lesion clearance, and interbody fusion, with good outcomes and no recurrence in both groups [38].

Some concerns have been raised regarding infection risk from implants, as internal fixation may reduce antibiotic effectiveness and increase bacterial adhesion and glycocalyx formation. Oga et al. [39] studied *Staphylococcus epidermidis* adhesion to stainless steel, finding extensive bacterial colonization on screws and rods. However, Chang and Merritt [40] suggested titanium is less prone to bacterial colonization compared with polymethylmethacrylate and stainless steel. Studies have confirmed the safety and efficacy of titanium alloy screw-rod systems for spinal infectious diseases, provided effective lesion debridement and postoperative regular, full-course antimicrobial therapy are implemented [40-42]. Our results are consistent with these reports, with no cases of intraspinal or central nervous system infection and no implant-related complications during follow-up, likely attributable to preoperative and postoperative regular anti-brucellosis therapy. Additionally, local antibiotics and percutaneous screw fixation play important roles in treating spinal infection by suppressing infection and providing a relatively stable internal environment to prevent recurrence [43].

In our 13 LBS patients, low back and lower extremity radiating pain were significantly relieved after surgery. VAS scores for low back and leg pain, JOA score, and ODI showed significant improvement compared with preoperative values. The excellent-to-good rate according to modified Macnab criteria was 92.3%. Patients with neurological dysfunction showed improvement postoperatively, with complete recovery at final follow-up. This improvement can be attributed to: (1) decompression and debridement relieving compression of spinal cord/cauda equina and nerve roots by inflammatory granulation tissue or abscess, with continuous saline irrigation eliminating inflammatory pain mediators; and (2) interbody fusion and percutaneous screw fixation reconstructing or maintaining spinal stability, alleviating severe low back pain caused by spinal instability from vertebral destruction.

Although ESR showed no significant improvement and CRP increased compared with preoperative values before discharge, both normalized in an increasing number of patients over time, likely due to normal postoperative inflammatory response and disease course. Most patients in our study had vertebral destruction causing spinal instability but without significant kyphotic deformity, explaining the minimal postoperative change in lordotic angle. All patients showed radiographic evidence of bony fusion at final follow-up, with no screw loosening, rod breakage, or pseudarthrosis. One patient with severe osteoporosis received unilateral percutaneous screw fixation only, with postoperative anti-osteoporosis therapy. One case of superficial incision infection, likely related to obesity and diabetes mellitus, healed after dressing changes and effective antibiotic therapy.

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4. Study Limitations

This study has several limitations: it is a retrospective study with a small sample size and lacks a control group, potentially introducing bias in analysis of historical case data. To our knowledge, this is the first application of biportal endoscopic technique for LBS, and its safety and efficacy require confirmation through additional clinical studies. However, the included patients showed significant improvement in clinical symptoms, laboratory findings, and imaging results, suggesting that biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation is a feasible and effective treatment for LBS.

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5. Conclusion

For LBS, antimicrobial chemotherapy remains the foundation of treatment. Surgical intervention becomes necessary when intractable low back pain, severe or progressive neurological dysfunction, spinal instability, or failed conservative treatment occurs. Biportal endoscopic decompression, debridement, interbody fusion combined with percutaneous screw fixation is an effective and safe surgical option that should be considered for LBS treatment.

Author Contributions

Wang Xiangbin conceived the research direction, collected and organized case data, and drafted the manuscript. Long Yubin revised the manuscript. Li Yong and Maiwulan Mansuerjiang collected and organized case data. Tian Zheng and Aikebaier Younusi were responsible for patient management and provided case data. Wang Chong was responsible for quality control and final review of the article and takes overall responsibility. All authors approved the final manuscript.

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