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Surgical outcomes of minimally invasive microscopic debridement in thoracolumbar pyogenic spondylodiscitis

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Thoracolumbar infectious spondylodiscitis is a serious condition that often requires surgical intervention if conservative treatment fails. Debridement and drainage are crucial in removing infected tissues and achieving adequate control of the source of infection. In this study, we aimed to evaluate the surgical outcomes of microscopic debridement in patients with thoracolumbar spondylodiscitis. We retrospectively reviewed the data of 128 patients treated for thoracolumbar spinal infections between March 2017 and December 2021. Overall, 40 patients with spondylodiscitis who underwent only microscopic debridement were included in the study. Patient demographics, clinical characteristics, laboratory results, surgical details, and clinical outcomes were analyzed. Of 40 patients, 28 had bone destruction. Patients with bone destruction showed poorer initial clinical outcomes, higher low back pain, worse disability, and lower quality of life scores than those without it. However, the long-term outcomes were favorable, with 63% achieving spontaneous bone union and all patients showing resolution of instability. However, 14% of the patients with bone destruction required further fusion surgery. Microscopic debridement results in favorable clinical outcomes in patients with thoracolumbar spondylodiscitis, including those with bone destruction. This approach is a potential alternative to fusion surgery, particularly in patients with a poor general condition.

Keywords Bone destruction, Discectomy, Laminectomy, Spondylodiscitis, Stabilization surgery, Thoracolumbar

Thoracolumbar infectious spondylodiscitis is a serious condition characterized by infection of the intervertebral disc space and vertebral body.[1–3] Prompt diagnosis and treatment are critical to avoid the associated mortality and poor outcomes. Spondylodiscitis is treated with a combination of medication and surgical procedures, with the primary objective of infection management, spine stabilization, and function recovery.[4,5] It is typically treated conservatively, with bed rest, antimicrobial therapy, and optimum spinal stability[6]. Surgery is recommended to eradicate the infection source and restore spinal stability when conservative treatment fails or when instabilities or complications arise[3,7,8]. Despite the clear indications for surgery in these cases, the optimal surgical approach remains a topic of debate.

The surgical options for spondylodiscitis include debridement and drainage, such as decompressive laminectomy with or without discectomy, as well as more extensive procedures like spinal instrumentation with or without fusion[9]. Debridement and drainage are crucial in removing infected tissue and achieving adequate control of the infection source[9,10]. Early surgical intervention combined with antibiotic treatment has demonstrated better clinical outcomes, shorter hospital stays, and improved quality of life in patients with pyogenic spondylodiscitis[6]. Debridement with stabilization surgery is commonly performed in cases of severe bone destruction with or without instability to provide immediate structural stabilization[11]. However, stabilization surgery has its own challenges, such as increased complication risks in patients with a poor overall health condition, the probability of instrumentation failure in infected bone, and the possibility of treating

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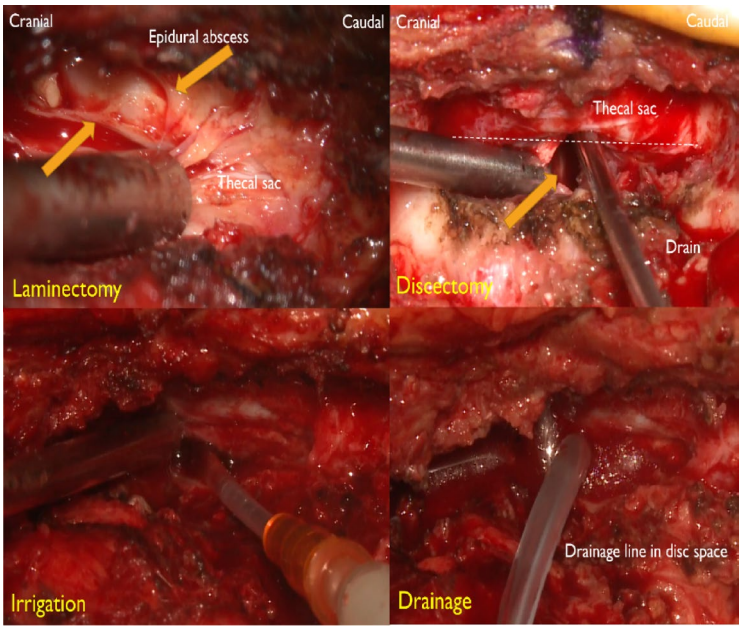


Fig. 1. Initially, a unilateral partial laminectomy was conducted. Following the laminectomy, a total discectomy was performed at the segments affected by discitis. The infected disc material was meticulously removed using a pituitary rongeur and curettes. After the infected tissues were removed, the disc space was thoroughly irrigated with saline. After irrigation, hemovac drain lines were inserted at infected segments.

infection due to the presence of hardware[12]. Minimally invasive debridement and drainage offer a less-invasive approach for treating infectious spondylodiscitis, especially in immunocompromised patients, while achieving effective debridement and restoration of spinal stability[13]. However, in patients with bone destruction and instability, stabilization surgery along with debridement is recommended[14].

We hypothesized that minimally invasive surgical debridement, even in the presence of bone destruction, may provide favorable outcomes and serve as a viable alternative to fusion surgery in patients with spondylodiscitis. Thus, in this study, we aimed to evaluate the clinical and radiographic outcomes of minimally invasive surgical debridement in patients with thoracolumbar pyogenic spondylodiscitis and bone destruction.

Methods

Study design and patient selection

In this retrospective study, we evaluated the clinical and radiographic outcomes of minimally invasive surgical debridement in patients with thoracolumbar pyogenic spondylodiscitis. The study was approved by the Institutional Review Board of Seoul National University Bundang Hospital (B-2203-742-104) and conducted in accordance with the Declaration of Helsinki. The ethics committees of Seoul National University Bundang Hospital have waived the requirement to obtain informed consent due to the retrospective study design.

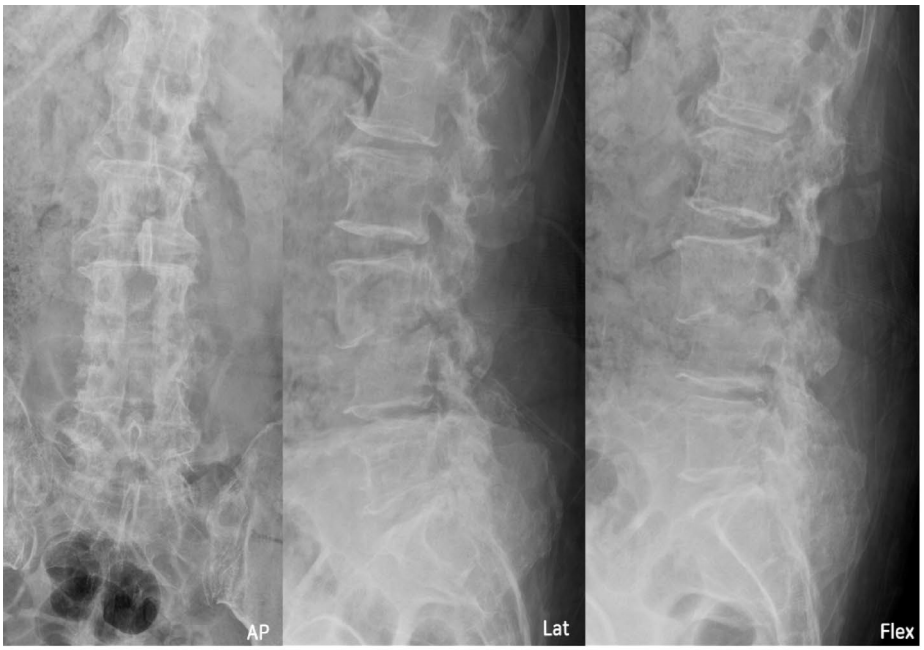
Between March 2017 and December 2021, we identified 128 patients who underwent surgery for thoracolumbar spinal infections. The inclusion criteria for this study were as follows: patients diagnosed with thoracolumbar spondylodiscitis, patients who underwent microscopic debridement and disc drainage procedures, patients aged 20 years or older, and patients who underwent follow-up for at least 24 months postoperatively. The exclusion criteria were as follows: (1) surgical site infections, (2) tuberculosis spondylitis, (3) intradural abscess, (4) infections that directly spread from internal organs, (5) undergoing initial stabilization surgery using a pedicle screw because of severe instability and bone destruction with significant neurological deficit, and (6) not undergoing discectomy for an epidural abscess.

We reviewed the medical records of 128 patients, of whom 88 were excluded because of surgical site infections (n = 48), tuberculosis spondylitis (n = 11), intradural abscess (n = 1), aortic graft-related infection (n = 1), initial fusion surgery (n = 7), and epidural abscess (n = 20). Therefore, only patients with spondylodiscitis who underwent microscopic debridement and disc drainage were included, resulting in a final cohort of 40 patients.

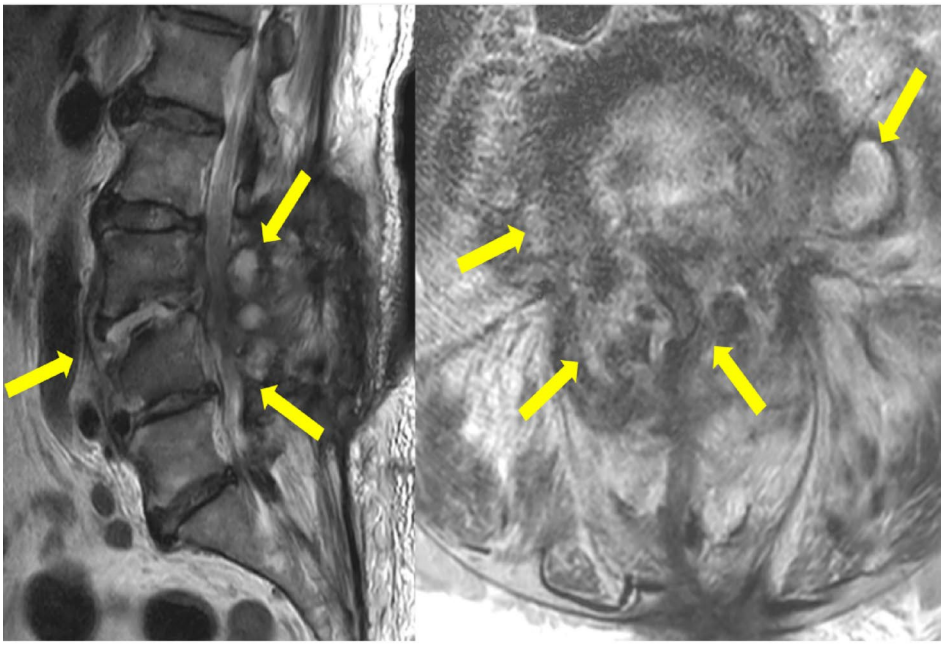
Data collection and outcome measures

Patient characteristics included age, sex, body mass index, Charlson Comorbidity Index, smoking status, alcohol intake, American Society of Anesthesiologists score, infected spinal segments, extent of infection, and cause of infection. The initial laboratory findings showed the white blood cell count ($10^3/\mu L$) and high-sensitivity C-reactive protein levels in mg/dL.

Surgical outcomes included operative time (min), intraoperative blood loss (mL), transfusion requirements (packs), postoperative drainage volume (mL), and length of hospital stay (days). Radiographic outcomes were evaluated using plain radiography, computed tomography (CT), or magnetic resonance imaging. All preoperative



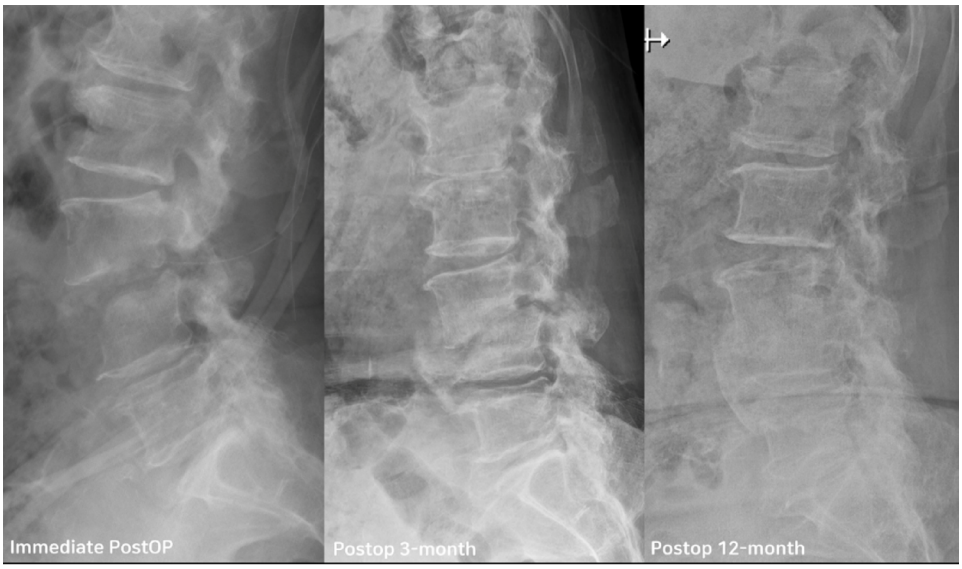
(A)



(B)

Fig. 2. A 78-year-old woman with severe spondylodiscitis at L3-4 level. (**A**) Initial plain radiographs showed L3 inferior and L4 superior endplate destruction with spondylolisthesis and instability. (**B**) Initial MRI showed L3-4 intradiscal, perineural, psoas muscle abscess and severely compressed neural tissue, which induced cauda equina syndrome. (**C**) After L3-4 microscopic debridement surgery and continuous intravenous antibiotics, she completely cured of spondylodiscitis. During follow-up, the disc space was collapsed, and completely fused at the postoperative 12-month after surgery.

and final follow-up radiographs of all patients were analyzed to confirm the spread of infection, vertebral body destruction, instability, disc space height changes, and radiographic union at the final follow-up. Disc space height was measured at the midpoint of the disc space. Radiographic bone union was assessed using CT. Union was defined as the presence of a bone bridge on CT at the final follow-up[15].



(C)

Fig. 2. (continued)

Clinical outcomes were assessed using patient-reported outcome measures at several time points: preoperative (baseline) and at 3, 6, 12, and 24 months after surgery. Clinical assessments included the visual analog scale (VAS) for low back pain (VAS-LBP) and radiating pain in the lower extremities, the Oswestry Disability Index (ODI)[16] for disabilities, the European Quality of Life-5 Dimensions (EQ-5D) value for quality of life (QOL)[17], and painDETECT for neuropathic pain[18]. The VAS ranges from 0 (no pain) to 100 (severe pain). The ODI score indicates the level of disability in the daily activities of patients with low back pain. The EQ-5D values ranged from -0.066 to 1.000, with 1 indicating the highest QOL. The painDETECT questionnaire assesses neuropathic pain in the lower extremities, with scores ranging from -1 to 38; scores below 12 suggest that neuropathic pain is unlikely, while scores above 19 indicate a high likelihood of neuropathic pain.

Surgical technique and treatment protocol

The procedure was performed under general anesthesia, with the patient in a prone position on a radiolucent operating table. This technique is similar to classic unilateral partial laminectomy followed by discectomy. Initially, unilateral partial laminectomy was performed. In cases with multiple segments of epidural abscess, laminectomies were performed at the most distal and proximal segments to facilitate drainage of the epidural abscess. Following laminectomy, total discectomy was performed on the segments affected by discitis. During discectomy, care was taken to avoid injury to the facet joints. The infected disc material was meticulously removed using a pituitary rongeur and curette. To achieve thorough removal of disc material on both the ipsilateral and contralateral sides, we used angled curettes and an angled pituitary rongeur. After removing the infected tissues, the disc space was thoroughly irrigated with at least 5000 cc of saline. After irrigation, Hemovac drain lines (Zimmer Biomet, Warsaw, Indiana, USA) were inserted into all infected segments to facilitate postoperative abscess drainage. Abscesses in the paraspinal muscles were removed during the procedure. The surgical procedure was completed after confirming adequate drainage and clearance of the infected material (Fig. 1).

Postoperatively, antibiotic therapy was continued for at least 6 weeks. Antibiotics were administered until the CRP levels were normalized. If CRP levels did not normalize within 12 weeks, the therapy was switched to oral antibiotics. The initial treatment involved empirical antibiotics, which were later changed based on the culture results. The drainage line was removed when the drainage volume was less than 10 mL/day (Fig. 2).

Statistical analysis

All variables were summarized using descriptive statistics. Continuous variables are expressed as means and standard deviations, while categorical variables are summarized as frequencies and percentages. To analyze the results according to bone destruction, we divided patients into group 1 (without bone destruction) and group 2 (with bone destruction) according to the presence of bone destruction. To compare continuous variables between groups, the Shapiro–Wilk test was used to assess normality. An independent t-test was used to analyze normally distributed data. If the data were not normally distributed, the Mann–Whitney U test was used. For categorical variables, the chi-squared test or Fisher's exact test was used. This determined the significance of the differences in proportions between the two groups.

We performed statistical analysis using generalized estimating equations (GEE) to analyze changes in clinical outcomes and laboratory results during the follow-up period. The GEE model was used to analyze repeated outcomes during follow-up between the two groups. The GEE model was specified with an exchangeable correlation structure and Gaussian family. The interaction term between bone destruction and time was

Characteristics	Data
Age	70.3 ± 10.9
Sex (M:F)	25:15
BMI	22.7 ± 3.8
CCI	2.0 ± 2.1
Smoking	
Non	30 (75%)
Ex	6 (15%)
Current	4 (10%)
Alcohol	
No	29 (73%)
Yes	11 (28%)
ASA score	2.6 ± 0.9
Infected level	
T	1 (3%)
TL	1 (3%)
L	38 (94%)
Extent of levels	
1	18 (45%)
2	12 (30%)
3	3 (8%)
> 3	7 (17%)
Cause	
Spontaneous	26 (65%)
Steroid injection	10 (25%)
Acupuncture	4 (10%)
Initial vertebral body destruction	28 (70%)
Initial vertebral body instability	25 (63%)
Initial laboratory result	
WBC, /ul	11,921 ± 6,314
hsCRP, mg/dl	16.2 ± 7.7

Table 1. Patient characteristics and clinical manifestations. M, male; F, female; BMI, body mass index; CCI, Charlson comorbidity index; ASA, American Society of Anesthesiology; T, thoracic; TL, thoracolumbar junction; L, lumbar; WBC, white blood cell; hsCRP, high-sensitivity C-reactive protein.

included to evaluate the differential effects of bone destruction on clinical outcomes over time. Stata/MP 17.1 (StataCorp LLC, College Station, Texas, USA) was used for all analyses. All statistical tests were two-tailed, statistical significance was set at $p < 0.05$.

Results

Demographic data

Between March 2017 and December 2021, we retrospectively evaluated 40 patients diagnosed with pyogenic spondylodiscitis who underwent microscopic debridement and disc drainage. This study included 25 men and 15 women with an average age of 70.3 years (Table 1). Most infections were spontaneous (65%), while others resulted from steroid injections (25%) or acupuncture (10%). Among the patients, 28 had vertebral body bone destruction. Detailed patient information is presented in Table 1.

Characteristics of infection according to bone destruction

A significant difference was observed in the cause of infection ($p = 0.021$). Spontaneous infections were more common in group 2 (79%), whereas epidural steroid injections were more frequent in group 1 (50%). Patients with bone destruction received a shorter duration of antibiotic treatment (7.1 weeks) than those without bone destruction (8.7 weeks); however, the difference was not significant ($p = 0.095$). The number of I&D procedures performed was similar between the groups, with no significant difference ($p = 0.33$). No significant differences were observed in the types of bacteria cultured between the two groups. However, *Escherichia coli* was more common in group 2 and *Staphylococcus aureus* was more common in group 1. The bone destruction group had a significantly higher rate of initial radiographic instability (89% vs. 0%, $p < 0.001$) and higher rates of radiographic union at the final follow-up (63% vs. 11%, $p = 0.009$). Most patients in both groups achieved a complete clinical cure (89% in group 2 vs. 75% in group 1), with similar rates of follow-up loss and mortality (Table 2).

Characteristics	Bone destruction (–) (n = 12)	Bone destruction (+) (n = 28)	*p*-value
Age	66.5 (15.5)	71.9 (8.0)	0.16
Sex (M:F), No. (%)	9 (75%) : 3 (25%)	16 (57%) : 12 (43%)	0.29
BMI	22.3 (3.6)	22.8 (3.9)	0.71
CCI	2.2 (1.6)	2.0 (2.2)	0.78
Extent of levels, No. (%)			0.60
1	5 (42%)	13 (46%)	
2	5 (42%)	7 (25%)	
3	0 (0%)	3 (11%)	
> 3	2 (16%)	5 (18%)	
Cause, No. (%)			0.021
Spontaneous	4 (33%)	22 (79%)	
Epidural steroid injection	6 (50%)	4 (14%)	
Acupuncture	2 (17%)	2 (7%)	
Duration of antibiotics (wks)	8.7 (2.6)	7.1 (2.6)	0.095
Number of I&D, No. (%)			0.33
1	10 (83%)	17 (61%)	
2	2 (17%)	9 (32%)	
> 2	0 (0%)	2 (7%)	
Culture, No. (%)			
Burkholderia cepacia	1 (8%)	0 (0%)	0.24
Campylobacter fetus	0 (0%)	1 (4%)	
Coagulase negative Staphylococcus	0 (0%)	1 (4%)	
E. cloacae	0 (0%)	1 (4%)	
Escherichia coli	1 (8%)	7 (25%)	
Enterobacter cloacae	0 (0%)	2 (7%)	
Enterococcus faecalis	0 (0%)	1 (4%)	
Klebsiella pneumoniae	0 (0%)	1 (4%)	
MRSA	2 (17%)	4 (14%)	
MSSA	4 (33%)	3 (11%)	
Pseudomonas aeruginosa	1 (8%)	0 (0%)	
Streptococcus agalactiae	0 (0%)	1 (4%)	
Streptococcus dysgalactiae	1 (8%)	0 (0%)	
Viridans streptococcus	1 (8%)	0 (0%)	
No growth	1 (8%)	6 (21%)	
Spread of infection, No. (%)			
Vertebral body	10 (83%)	28 (100%)	0.36
Epidural abscess	11 (92%)	26 (93%)	0.90
Psoas muscle	3 (25%)	11 (39%)	0.39
Paraspinal muscle	4 (33%)	6 (21%)	0.43
Surgical outcomes			
Operation time	100.8 (34.8)	104.5 (40.7)	0.78
Intraoperative blood loss	196.7 (176.7)	220.7 (274.7)	0.78
Transfusion	0.2 (0.6)	0.2 (0.6)	0.82
Drainage	167.5 (119.8)	221.0 (163.5)	0.31
Hospital stay	40.5 (24.4)	34.4 (23.4)	0.46
Radioagrphic vertebral body instability at initial, No. (%)	0 (0%)	25 (89%)	< 0.001
Instrumentation during FU, No. (%)	0 (0%)	4 (14%)	0.17
End result, No. (%)			0.51
Completely cure	9 (75%)	25 (89%)	
Follow-up loss	1 (8%)	1 (4%)	
Death	2 (17%)	2 (7%)	

Table 2. Clinical manifestations according to bone destruction. M, male; F, female; BMI, body mass index; CCI, Charlson comorbidity index; I&D, incision and drainage; MRSA, Methicillin Resistant *Staphylococcus Aureus*; MSSA Methicillin Sensitive *Staphylococcus Aureus;* FU, follow-up. Data are presented as given as mean (standard deviation), unless otherwise indicated.

Variables	Bone destruction (−) (n = 9)	Bone destruction (+) (n = 25)	*p*-value
VAS back			
Preoperative	69.2 (19.3)	82.5 (16.5)	
3 month	28.8 (16.4)	34.0 (23.6)	
6 month	42.5 (29.6)	36.5 (22.8)	
12 month	18.8 (21.7)	28.1 (22.6)	
24 month	18.8 (12.5)	22.7 (18.9)	< 0.001†
Overall group effect*	NA	NA	0.163
VAS lower extremities			
Preoperative	67.5 (25.6)	64.3 (25.6)	
3 month	32.5 (21.9)	33.2 (29.1)	
6 month	38.8 (28.5)	30.4 (27.5)	
12 month	17.5 (17.5)	23.5 (25.9)	
24 month	21.3 (14.6)	19.6 (19.3)	< 0.001†
Overall group effect*	NA	NA	0.567
ODI			
Preoperative	76.0 (10.4)	77.3 (18.2)	
3 month	25.4 (12.9)	35.5 (25.5)	
6 month	25.5 (17.8)	30.7 (16.9)	
12 month	13.4 (17.4)	26.6 (17.3)	
24 month	13.0 (13.5)	21.8 (15.6)	< 0.001†
Overall group effect*	NA	NA	0.987
EQ-5D			
Preoperative	0.322 (0.206)	0.215 (0.170)	
3 month	0.760 (0.072)	0.662 (0.255)	
6 month	0.680 (0.230)	0.741 (0.184)	
12 month	0.830 (0.147)	0.759 (0.179)	
24 month	0.825 (0.146)	0.799 (0.164)	< 0.001†
Overall group effect*	NA	NA	0.535
painDETECT			
Preoperative	8.7 (5.9)	9.6 (7.9)	
3 month	2.4 (2.3)	5.0 (6.1)	
6 month	2.9 (3.5)	5.6 (6.1)	
12 month	3.3 (3.6)	4.6 (4.5)	
24 month	2.3 (2.7)	3.3 (2.9)	0.005†
Overall group effect*	NA	NA	0.553

Table 3. Clinical outcomes for both groups after surgery during 24-month follow-up. VAS, visual analog scale; NA, not available; ODI, Oswestry disability index; EQ-5D, European Quality of Life-5 Dimensions. Data are presented as given as mean (standard deviation). **P*-value is from generalized estimating equations for repeated measures comparing between interventions during 24-month follow-up period. †Overall time effect.

Clinical outcomes and laboratory results according to bone destruction

Patients with bone destruction had higher initial lower back VAS scores than those without lower back pain (82.5 vs. 69.2%, respectively). Both groups showed significant postoperative improvement, but group 2 consistently reported higher pain levels at all follow-up points ($p < 0.001$ for the overall time effect). The initial VAS scores for the lower extremities were similar between groups. Both groups experienced significant pain reduction, with no significant difference in overall pain improvement ($p = 0.567$ for the overall group effect). Group 2 had higher initial ODI scores and slower improvement than group 1 ($p < 0.001$ for the overall time effect). Quality of life improved significantly in both groups, with no significant differences between the groups over the follow-up period ($p = 0.535$ for the overall group effect). Neuropathic pain decreased significantly in both groups, with the bone destruction group having higher initial scores and showing substantial improvement over time ($p = 0.005$ for the overall time effect) (Table 3, Fig. 3).

Both groups had elevated preoperative WBC counts and CRP levels, which normalized over the follow-up period ($p < 0.001$ for the overall time effect). The normalization period was slightly longer in group 2, but there was no significant difference between the groups ($p = 0.72$) (Table 4, Fig. 4).

Discussion

In this study, we evaluated the surgical outcomes of minimally invasive microscopic debridement for thoracolumbar pyogenic spondylodiscitis, focusing on patients with and without bone destruction. Our results

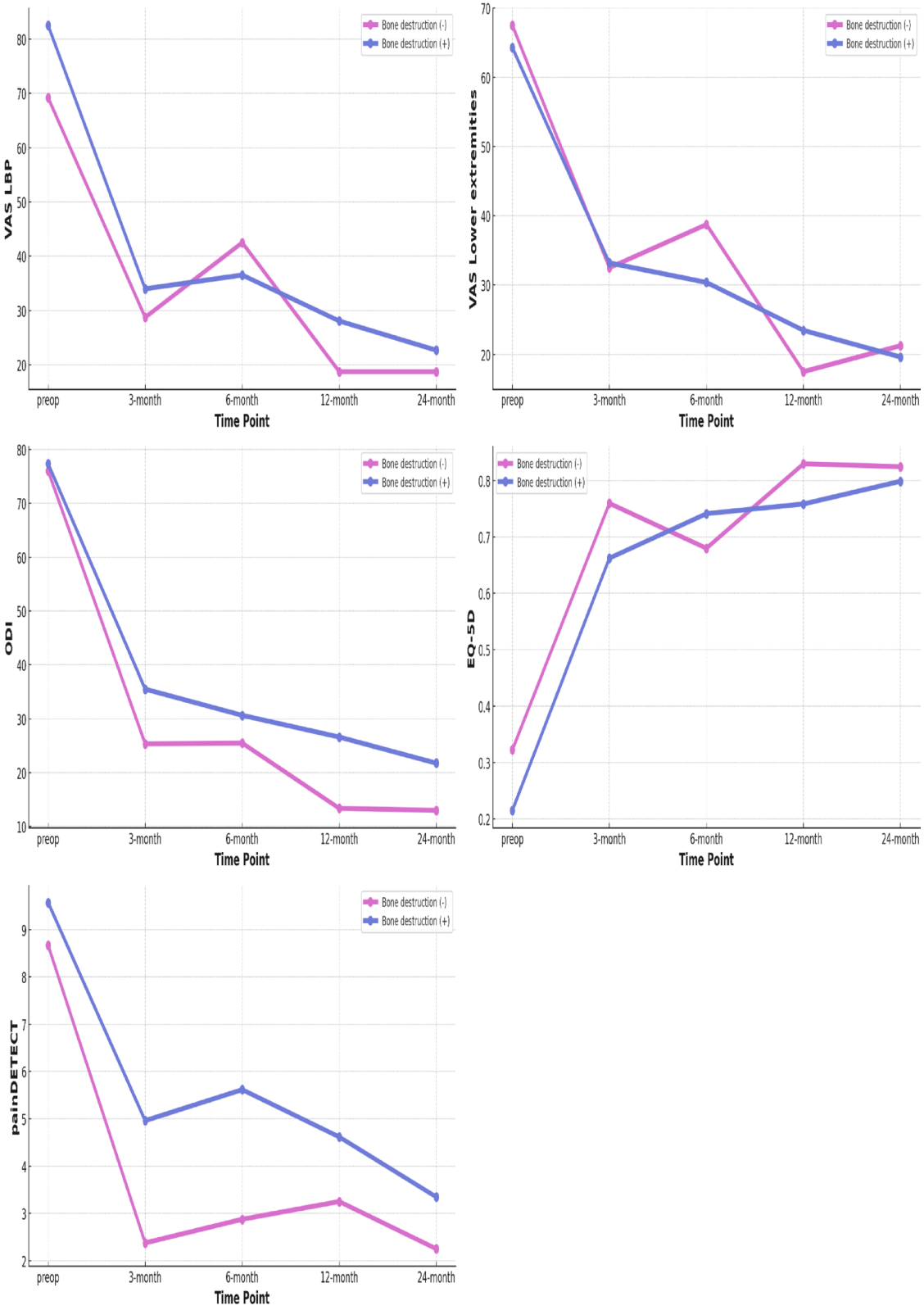


Fig. 3. Illustrate the mean values for each clinical outcome over time during the 24-month follow-up period, stratified by the presence or absence of bone destruction. The purple line represents the group without bone destruction (Bone destruction –), and the blue line represents the group with bone destruction (Bone destruction +).

Variables	Bone destruction (−) (n = 9)	Bone destruction (+) (n = 25)	*p*-value
WBC (10^3/μL)			
Preoperative	14.231 (7.372)	10.872 (5.687)	
2 weeks	6.253 (2.498)	7.327 (2.457)	
4 weeks	7.087 (2.444)	6.990 (2.667)	
6 weeks	7.040 (3.820)	6.438 (2.260)	
12 weeks	6.577 (1.831)	6.262 (2.473)	< 0.001†
Overall group effect*	NA	NA	0.251
hsCRP (mg/dL)			
Preoperative	15.128 (8.236)	16.669 (7.574)	
2 weeks	6.325 (6.034)	5.182 (6.168)	
4 weeks	4.044 (3.284)	4.618 (6.004)	
6 weeks	1.949 (1.886)	2.652 (4.209)	
12 weeks	1.196 (2.443)	1.932 (4.830)	< 0.001†
Overall group effect*	NA	NA	0.837
hsCRP normalization (days)	63.9 (33.2)	59.4 (29.9)	0.72
Radiographic outcomes			
Disc height decrease (mm)$	4.7 (1.6)	5.3 (3.0)	0.62
Disc height decrease (%)	62.1% (16.4)	73.3% (27.3)	0.26
Union at final FU, No. (%)	1 (11%)	15 (63%)	0.009

Table 4. Laboratory outcomes for both groups after surgery during 12-week follow-up. WBC, white blood cell; hsCRP, high sensitivity c-reactive protein. Data are presented as given as mean (standard deviation). **P*-value is from generalized estimating equations for repeated measures comparing between interventions during 24-month follow-up period. †Overall time effect. $Disc space height changes from initial to final follow-up.

showed that microscopic debridement provided favorable outcomes in patients with bone destruction compared to those without, despite requiring subsequent fusion surgery.

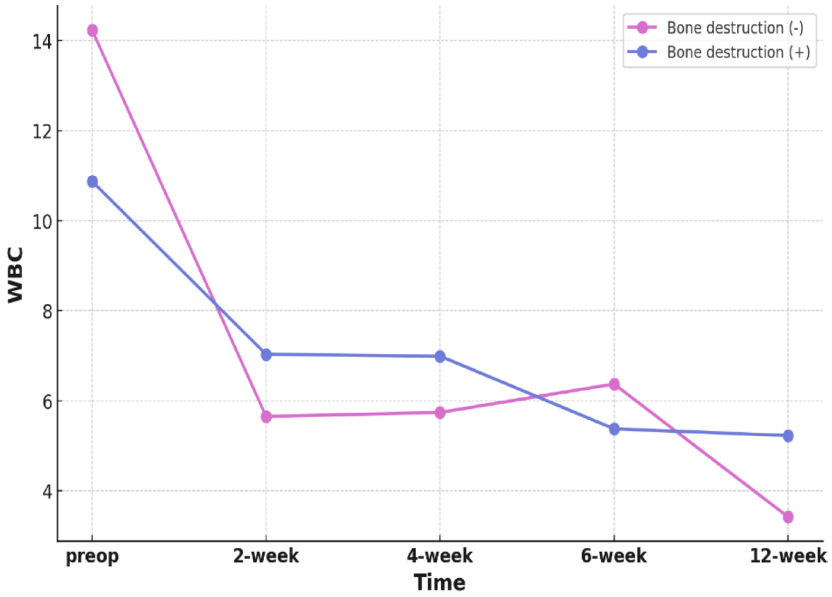
For the management of spondylodiscitis, most patients have demonstrated improvement with antimicrobial treatment[1–3]. Surgical treatment combined with antibiotics has been shown to improve clinical outcomes for patients with pyogenic spondylodiscitis[7]. Rutges et al. recommend a 6-week course of antibiotic treatment, based on evidence from a recent randomized controlled trial[7]. Early surgical treatment with antibiotics resulted in better clinical outcomes compared to antibiotic treatment alone[6,19]. While various surgical techniques exist for spondylodiscitis, including anterior, posterior, or combined approaches with or without instrumentation, there is no definitive consensus on the optimal surgical strategy[20].

Stabilization surgery is often performed in patients with spondylodiscitis and bone destruction. However, there are difficulties with this procedure because some patients may not be suitable candidates, especially those who need extensive surgery or are in poor general condition[21]. Moreover, the infected vertebrae often have poor bone quality and bone destruction, which increases the risk of instrumentation failure and decreases the overall outcome success[22]. Instrumentation itself may interfere with the treatment of infection[23]. Especially when instability or neurologic impairments accompany significant fractures, such cases require fusion surgery. Owing to clinical diversity, choosing a surgical procedure is difficult.

Recently, minimally invasive spine surgery, such as microscopic or endoscopic surgery, has also demonstrated effectiveness and safety in the treatment of pyogenic spondylodiscitis[13,24,25]. Previous studies emphasize the benefits of minimally invasive techniques in addressing pyogenic spondylodiscitis, reducing surgical damage, lowering the risk of complications compared to conventional open surgery, and maintaining spinal stability by preserving normal tissues. Minimally invasive spinal surgery for pyogenic spondylodiscitis has thus shown favorable outcomes and represents a valuable surgical technique for this challenging condition.

In our study, we primarily performed microscopic debridement under partial laminectomy with discectomy and drainage in patients with spondylodiscitis, regardless of bone destruction. Patients without bone destruction showed favorable outcomes with no need for additional fusion surgery. However, 14% of patients with bone destruction eventually required stabilization surgery and bone grafting. Spontaneous spondylodiscitis was more common in patients with bone destruction, likely because of hematogenous spread leading to bone destruction[26]. Despite significant radiographic instability due to bone destruction, 63% of these patients achieved spontaneous bone union, and instability was resolved in all cases. Clinically, patients with bone destruction had higher initial VAS-LBP scores and worse ODI, EQ-5D, and painDETECT scores, and their clinical outcomes remained poor throughout the follow-up period. Nonetheless, there were no significant differences in surgical outcomes, suggesting that even in severe infections with poor general condition and bone destruction, microscopic debridement can yield relatively good clinical results, similar to those in patients without bone destruction.

This study had several limitations. First, this was a retrospective analysis with a relatively small sample size, particularly in the subgroup of patients with bone destruction. Spondylodiscitis is a relatively rare disease, and surgical treatment is less commonly performed, making it challenging to recruit a substantial number of patients who have undergone surgical intervention. However, we believe that our study had a relatively large number



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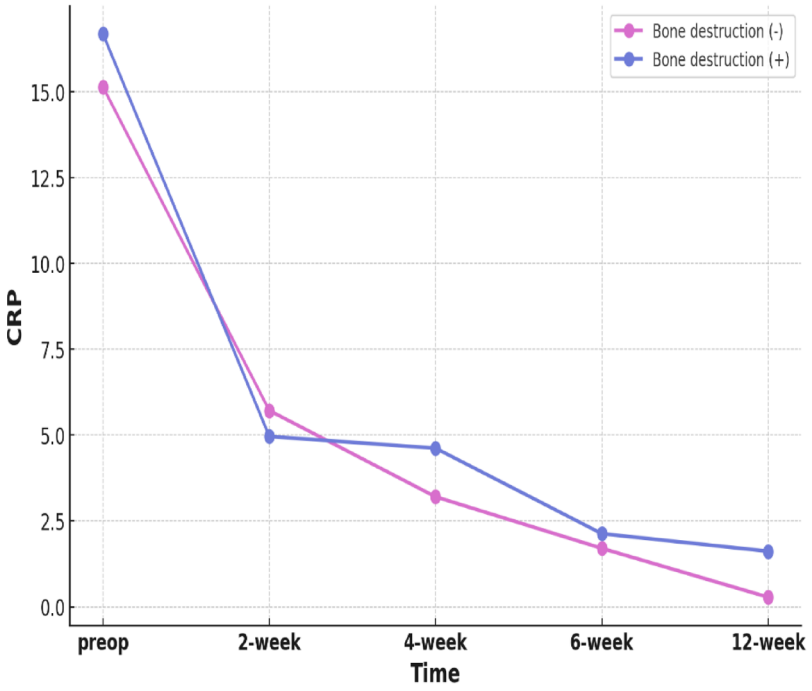

(B)

Fig. 4. Changes in laboratory results between the two groups during the 12-week follow-up period. (**A**) Changes in mean white blood cell counts ($10^3/\mu L$). (**B**) Changes in mean high-sensitivity c-reactive protein (normal value range, under 0.05 mg/dL). The purple line represents the group without bone destruction (Bone destruction −), and the blue line represents the group with bone destruction (Bone destruction +). WBC, white blood cell; CRP, high sensitivity c-reactive protein.

of patients compared to previous studies. Nevertheless, we aim to recruit more patients in future multicenter studies. Second, the lack of a control group undergoing different surgical techniques (stabilization surgery) limited the direct comparison of the outcomes. An ideal methodology would be to conduct a randomized controlled trial. However, the complexity of the disease makes it difficult to conduct such studies. Additionally, the follow-up period, while adequate, could be extended to further observe the long-term outcomes. Future studies with larger sample sizes and prospective cohort designs are needed to validate these findings and provide more definitive recommendations.

In conclusion, minimally invasive microscopic debridement is an effective surgical option for patients with thoracolumbar infectious spondylodiscitis, including those with bone destruction. Patients with bone destruction have poorer initial clinical outcomes; however, their clinical outcomes are ultimately favorable and similar to those of patients without bone destruction. However, some patients may require further stabilization surgery. This approach may be particularly beneficial for patients with significant infections and a poor general condition, offering a viable alternative to fusion surgery.

Data availability

All data generated or analyzed during this study are included in this published article. The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request. Data are located in controlled access data storage at Seoul National University Bundang Hospital.

Received: 3 July 2024; Accepted: 20 August 2025
Published online: 01 September 2025

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Acknowledgements
We would like to thank Editage (www.editage.co.kr) for English language editing.

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Funding
This study was partially supported by research grants from CGBio corporation in Seoul, Republic of Korea. The funder had no role in the study desig n, data collection and analysis, decision to publish, or preparation of the manuscript.

Declarations

Competing interests
The authors declare that they have no conflict of interest.

Ethical approval
The study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval no. BHospital (approval no. B–22032203–742742–104). The ethics committees of Seoul National University Bundang Hospital 104). The ethics committees of Seoul National University Bundang Hospital have have waived the requirement to obtain informed consent due to the retrospective study design. This study was waived the requirement to obtain informed consent due to the retrospective study design. This study was performed in accordance with the tenets of the Declaration of Helsinki, and all research methods were carried performed in accordance with the tenets of the Declaration of Helsinki, and all research methods were carried out in accordance with appropriate regulatout in accordance with appropriate regulations and guidelines.ions and guidelines.

Additional information
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