# Full Endoscopic Discectomy, Debridement, and Drainage for High-Risk Patients with Spondylodiscitis

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■ OBJECTIVE: **To evaluate the efficacy and clinical results of full endoscopic debridement and drainage (FEDD) for high-risk patients with spondylodiscitis.**

■ METHODS: **Fourteen patients who underwent FEDD at our institution between November 2015 and September 2017 were retrospectively reviewed. All patients had single-level infectious spondylodiscitis and were high-risk candidates for surgery. Their general condition was evaluated according to the American Society of Anesthesiologists grading system. The Charlson Comorbidity Index was used for comprehensive assessment of comorbidity status. Outcomes were evaluated by numeric rating scale (NRS) pain score, Oswestry Disability Index, modified Macnab criteria, and radiographic images at follow-up.**

■ RESULTS: **All 14 patients experienced immediate relief of back pain after FEDD, with no procedure-related complications. The causative bacteria were identified in 10 of the 14 patients (71.5%). Half of the 14 patients had an American Society of Anesthesiologists score of ≥3. The average Charlson Comorbidity Index was 5.1 ± 1.6 points. Compared with the preoperative NRS score of 8.2 ± 0.9, the NRS scores at 1 week and 12 months after surgery were 3.4 ± 1.1 and 1.4 ± 1.2, respectively. A significant improvement in Oswestry Disability Index was observed after surgery (preoperative, 30.1 ± 3.9; 12 months postoperatively, 17.6 ± 6.2; $P < 0.05$). Satisfaction rate was 85.7% based on the Macnab criteria (excellent or good outcome). None of the patients developed any significant kyphotic deformity after FEDD.**

■ CONCLUSIONS: **FEDD may be an effective alternative to extensive open surgery in patients with infectious spondylodiscitis, especially those who are high-risk candidates for surgery (elderly patients with multiple comorbidities and patients in poor general condition).**

## INTRODUCTION

The diagnosis and treatment of spinal infections are a considerable challenge because of the high risk of complications in the early postoperative period.[1,2] Spondylodiscitis can occur secondary to blood-borne spread or as a primary infection of the intervertebral disk.[3] Accurate identification of the causative organism and timely antibiotic therapy can help prevent further morbidity and are the main goals of treatment of infectious spondylodiscitis. Surgical intervention is usually reserved for patients who do not respond to antibiotic therapy, or those with spinal deformity, instability, epidural abscess, or neurologic deficit.[4,5] Computed tomography (CT)-guided spine biopsy for bacteriologic diagnosis is not particularly valuable.[6,7] Inadequate extraction of biopsy specimens and a high degree of radiation exposure are the main shortcomings.[8] Furthermore, traditional open surgery and debridement are associated with morbidity and mortality,[7,9] especially in immunocompromised elderly patients or in those with a poor general condition.[10,11]

Full endoscopic discectomy and debridement (FEDD) with drainage is a minimally invasive surgical treatment for infectious spondylodiscitis. It allows for aggressive local debridement, affords rapid pain relief, and facilitates isolation of the causative

**Key words**
- Endoscopic debridement
- Infectious spondylodiscitis
- Minimally invasive surgery
- Percutaneous endoscopic drainage

**Abbreviations and Acronyms**
CCI: Charlson Comorbidity Index
CRP: C-reactive protein
CT: Computed tomography
ESR: Erythrocyte sedimentation rate
FEDD: Full endoscopic debridement and drainage
ODI: Oswestry Disability Index

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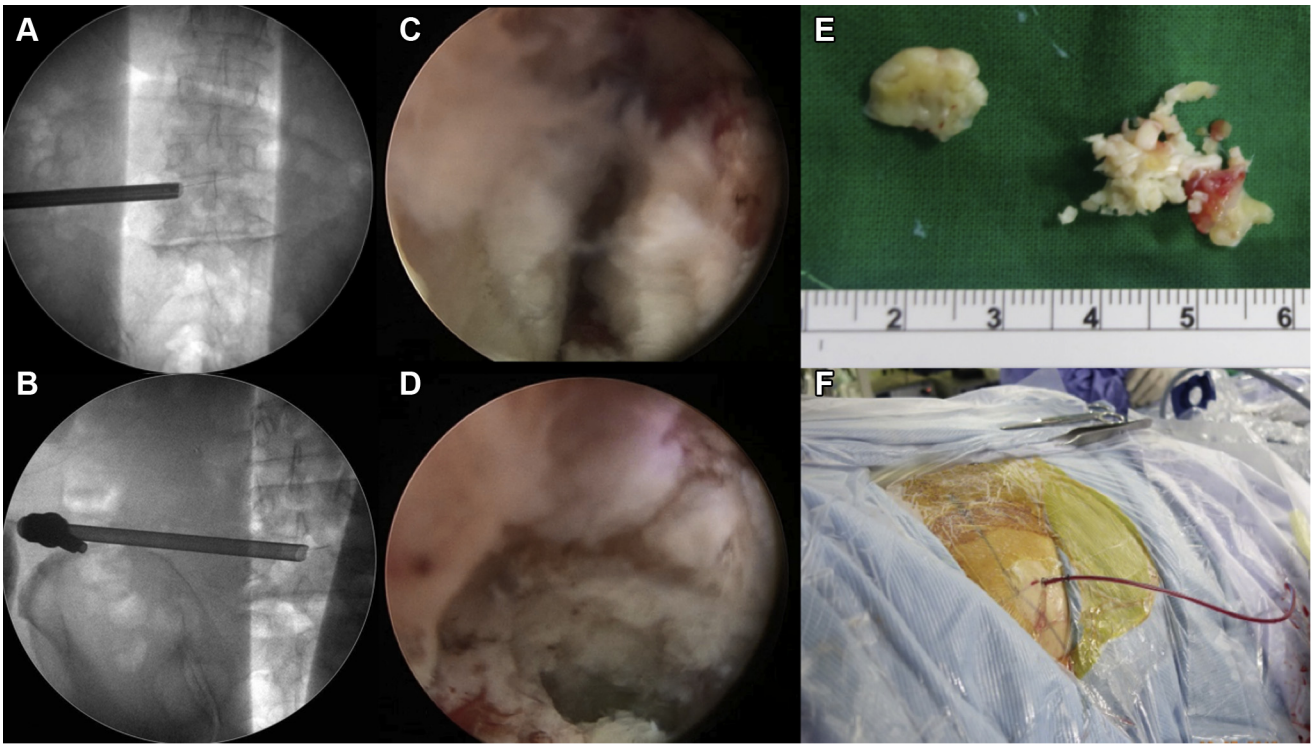


**Figure 1.** (**A**) and (**B**) Intraoperative fluoroscopic images during full endoscopic debridement and discectomy. After aggressive discectomy, endoscopic views (**C**) and (**D**) show clearance of diseased tissue; vertebral end plates on both sides are identifiable. (**E**) Infected tissue and end plate removal during full endoscopic debridement and discectomy. (**F**) Insertion of a negative-pressure Hemovac for continuous drainage.

organism.[12-14] However, to the best of our knowledge, no studies have investigated the effectiveness of this procedure for high-risk patients with spondylodiscitis. Hence, in this study, we evaluated the efficacy of this method for treatment of high-risk patients with spondylodiscitis.

## METHODS

### Patients' Data Collection

Between November 2015 and September 2017, 486 patients underwent full endoscopic spinal surgery at our institution. The same surgeon operated on all patients. Among these patients, we reviewed 21 who underwent FEDD for treatment of spondylodiscitis. Of these 21 patients, 7 were excluded from this study; these included 2 patients who underwent open fusion surgery because of kyphotic deformity, 1 patient who underwent FEDD at 2 levels, and 4 patients who were deemed to be low-risk cases for surgery and had no comorbidities. Fourteen high-risk patients with infectious single-level spondylodiscitis who were treated with FEDD were included in this analysis. All patients reported intractable severe back pain necessitating pain medication and bed rest. All patients had been treated by a previous physician with intravenous antibiotics for at least 6 weeks. Despite the intensive treatment, the spinal infection did not subside and severe back pain continued to persist; therefore, the patients were referred to our institution. All patients were followed up for a minimum period of 12 months. Data pertaining to demographic characteristics (including age and sex), smoking habit, infected level, duration of symptoms, surgical time, and hospital stay were reviewed.

### Surgical Procedures

The patients were positioned prone on a radiolucent frame suitable for fluoroscopy. All procedures were performed by a single senior surgeon. Under fluoroscopic guidance, the entry point was marked on the skin according to the targeted disease (Figure 1A). After local or intravenous anesthesia, the endoscope (SPINENDOS GmbH, Munich, Germany) was introduced directly into the center of the infected disk space (Figure 1B). A single portal approach was used in most patients. The infected disk and necrotic bone from the vertebrae were collected for culture before irrigation. Adequate tissue samples were collected using endoscopic microscissors and biopsy forceps to isolate the organisms. Subsequently, radical debridement was performed to remove the infected disk materials and vertebral bodies using rongeurs and burrs. Adequate debridement was performed until the intact caudal and cranial vertebral bodies were seen (Figure 1C and D). Subsequently, pressurized irrigation with saline was performed; irrigation was also performed around the paravertebral or epidural abscess. In cases in which the causative organism was

**Table 1.** Patient Summary 1

| Patient Number | Age (Years) | Gender | Level | Symptom Duration (Months) | Smoking | Major Medical Problem | Charlson Comorbidity Index | American Society of Anesthesiologists Score | Days of Admission | Macnab Criteria |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 67 | F | L4-5 | 30 | N | DM, hypertension, hyperlipidemia | 3 | 2 | 36 | Good |
| 2 | 83 | M | L1-2 | 14 | N | Liver tumor, hypertension, BPH, gout | 6 | 3 | 87 | Excellent |
| 3 | 72 | F | T6-7 | 3 | N | DM, liver disease, hypercalcemia, hypertension | 7 | 3 | 46 | Excellent |
| 4 | 66 | F | L1-2 | 7 | N | DM, hypertension, heart disease, hyperlipidemia | 4 | 3 | 71 | Good |
| 5 | 67 | M | L4-5 | 14 | Y | Rheumatoid arthritis, prostate cancer | 9 | 3 | 29 | Excellent |
| 6 | 84 | M | L1-2 | 14 | N | Limb cellulitis, hypertension | 5 | 1 | 24 | Excellent |
| 7 | 74 | F | L4-5 | 30 | N | Hypertension, DM, UTI | 5 | 2 | 52 | Poor |
| 8 | 66 | M | L3-4 | 5 | Y | DM, hypertension, old stroke, hyperlipidemia, right renal stone | 4 | 1 | 43 | Good |
| 9 | 62 | M | L4-5 | 7 | N | DM, BPH, Hypertension, moderate fatty liver, UTI | 6 | 1 | 16 | Good |
| 10 | 59 | M | L4-5 | 10 | N | Hepatitis B virus—related liver cirrhosis with liver failure, intracerebral hemorrhage at basal ganglion | 5 | 4 | 53 | Excellent |
| 11 | 64 | M | L3-4 | 35 | Y | Pneumonia, UTI, hypernatremia with hypokalemia | 4 | 2 | 65 | Poor |
| 12 | 71 | F | L4-5 | 60 | N | Hypertension | 3 | 1 | 34 | Good |
| 13 | 78 | M | T12-L1 | 78 | N | Chronic obstructive pulmonary disease, chronic renal disease, hypertension, BPH | 4 | 3 | 41 | Good |
| 14 | 81 | M | L4-5 | 14 | Y | Lung cancer, hypertension | 6 | 3 | 62 | Excellent |

F, female; N, no; DM, diabetes mellitus; M, male; BPH, benign prostatic hyperplasia; Y, yes; UTI, urinary tract infection.

**Table 2.** Patient Summary 2

| Patient Number | Epidural Abscess | Paravertebral Abscess | Operative Time (Minutes) | Culture | Antibiotics (Weeks) | Preoperative NRS | Postoperative NRS 1 Week | Postoperative NRS 12 months | Preoperative Oswestry Disability Index | Postoperative Oswestry Disability Index 12 Months |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | – | + | 79 | *Streptococcus pyogenes* | 2 IV; 3 oral | 7 | 3 | 2 | 27 | 10 |
| 2 | + | – | 30 | *Staphylococcus* | 3 IV; 8 oral | 8 | 3 | 0 | 32 | 22 |
| 3 | + | – | 70 | No grown | 2 IV; 5 oral | 8 | 3 | 2 | 30 | 18 |
| 4 | + | + | 45 | *Candida albicans* | 2 IV; 8 oral | 10 | 4 | 2 | 35 | 28 |
| 5 | + | + | 81 | *Mycobacterium tuberculosis* complex | 3 IV; 2 oral | 8 | 4 | 2 | 32 | 28 |
| 6 | + | + | 76 | *Escherichia coli* | 2 IV; 1 oral | 8 | 3 | 0 | 28 | 11 |
| 7 | + | + | 30 | Not grown | 2 IV; 5 oral | 10 | 3 | 0 | 32 | 22 |
| 8 | + | + | 49 | *Staphylococcus* | 2 IV; 4 oral | 8 | 2 | 2 | 33 | 16 |
| 9 | + | – | 58 | *Stenotrophomonas maltophilia* | 1 IV; 2 oral | 7 | 3 | 0 | 26 | 12 |
| 10 | + | + | 55 | *Candida albicans* | 2 IV; 6 oral | 8 | 2 | 2 | 29 | 18 |
| 11 | + | + | 38 | Not grown | 3 IV; 6 oral | 9 | 4 | 2 | 23 | 18 |
| 12 | + | + | 37 | Not grown | 12 days IV; 2 oral | 8 | 4 | 0 | 27 | 10 |
| 13 | – | + | 63 | Nontuberculous mycobacteria | 10 days IV; 4 oral | 8 | 6 | 4 | 38 | 22 |
| 14 | + | + | 29 | *Streptococcus pyogenes* | 3 IV; 6 oral | 8 | 4 | 2 | 30 | 12 |

NRS, numeric rating scale; IV, intravenous.

**Table 3.** Changes in Serologic Values Preoperatively and Postoperatively

| | White Blood Cells (× $10^9$/L) | | | | | Erythrocyte Sedimentation Rate (mm/hour) | | | | | C-Reactive Protein (mg/dL) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Patient Number | Pre-op | Post-op 1 Week | Post-op 2 Weeks | 1 Day Before Discharge | Post-op 12 Months | Pre-op | Post-op 1 Week | Post-op 2 Weeks | 1 Day Before Discharge | Post-op 12 Months | Pre-op | Post-op 1 Week | Post-op 2 Weeks | 1 Day Before Discharge | Post-op 12 Months |
| 1 | 11.5 | 8.5 | 8.3 | 7.2 | 6.4 | 88 | 53 | 35 | 33 | 43 | 2.89 | 0.78 | 0.5 | 0.34 | 0.79 |
| 2 | 9 | 8.5 | 7 | 6.1 | 6.4 | 59 | 50 | 45 | 25 | 26 | 10.25 | 3.4 | 2.23 | 0.56 | 3.7 |
| 3 | 12.6 | Nil | Nil | 9.5 | 7.5 | 46 | Nil | Nil | 30 | 28 | 28.61 | Nil | Nil | 5.67 | 5.4 |
| 4 | 7.8 | 7.3 | 6.5 | 5.3 | 5.9 | 56 | 45 | 35 | 15 | 20 | 26.13 | 10.25 | 5.5 | 1.56 | 0.76 |
| 5 | 7.3 | 7.5 | 7.3 | 6.7 | 7.5 | 66 | 35 | 30 | 18 | 13 | 5.86 | 1.56 | 2.45 | 1.12 | 1.84 |
| 6 | 13.2 | 10.2 | 9.2 | 7.5 | 8.2 | 64 | 45 | 40 | 25 | 37 | 0.75 | 0.35 | 0.56 | 0.24 | 2.07 |
| 7 | 7.5 | 7 | 7.2 | 7.6 | 7.6 | 86 | 56 | 40 | 28 | 38 | 6.41 | 2.23 | 1.15 | 1.11 | 1.53 |
| 8 | 13.3 | 8.6 | 8.3 | 5.5 | 4.7 | 54 | 30 | 25 | 10 | 7 | 3.81 | 1.1 | 1 | 0.24 | 0.06 |
| 9 | 4.7 | 5.3 | Nil | 4 | 4.3 | 36 | 32 | Nil | 22 | 30 | 2.54 | 0.5 | Nil | 0.24 | 1.2 |
| 10 | 6.7 | 6 | 6.2 | 5.5 | 5.7 | 37 | 33 | 20 | 26 | 23 | 8.56 | 3.3 | 3.32 | 1.12 | 1.25 |
| 11 | 4.7 | 4.3 | 5.2 | 5.1 | 8.1 | 75 | 56 | 35 | 22 | 25 | 5.3 | 1.23 | 0.5 | 0.24 | 0.15 |
| 12 | 11 | 8.2 | 7.3 | 7.5 | 8.1 | 62 | 35 | 30 | 30 | 34 | 6.45 | 2.25 | 1.23 | 0.55 | 0.19 |
| 13 | 7.5 | 6.3 | 5.6 | 6.3 | 7.5 | 55 | 50 | 33 | 28 | 22 | 5.53 | 4.56 | 4.53 | 4.4 | 5.5 |
| 14 | 9.3 | 8.8 | 8.3 | 8.2 | 7.7 | 60 | 35 | 30 | 28 | 33 | 8.67 | 4.43 | 2.43 | 1.12 | 0.53 |

Pre-op, preoperative; post-op, postoperative.

**Table 4.** Changes in Local Cobb Angle with Time after Full Endoscopic Discectomy and Debridement

| Patient Number | Level | Preoperative (°) | Before Discharge (°) | Last Follow-Up (°) |
|---|---|---|---|---|
| 1 | L4-5 | 6.6 | 5.9 | 7.2 |
| 2 | L1-2 | 6.0 | 2.3 | 1.2 |
| 3 | T6-7 | 8.7 | 7.8 | 5.6 |
| 4 | L1-2 | 7.2 | 8.1 | 10.2 |
| 5 | L4-5 | 7.8 | 7.5 | 8.8 |
| 6 | L1-2 | 14.2 | 15.3 | 12.5 |
| 7 | L4-5 | 12.3 | 14.2 | 15.7 |
| 8 | L3-4 | 8.3 | 9.3 | 11.2 |
| 9 | L4-5 | 6.6 | 7.6 | 6.8 |
| 10 | L4-5 | 11.2 | 13.2 | 14.5 |
| 11 | L3-4 | 3.1 | 3.5 | 4.8 |
| 12 | L4-5 | 8.4 | 10.2 | 12.1 |
| 13 | T12-L1 | 13.2 | 13.4 | 10.3 |
| 14 | L4-5 | 15.3 | 17.6 | 22.5 |
| Average (mean ± standard deviation) | | 9.2 ± 3.5 | 9.7 ± 4.5* | 10.2 ± 5.3† |

*$P = 0.75$; compared with the preoperative value.
†$P = 0.55$; compared with the preoperative value.

already identified by blood culture or needle biopsy, sensitive antibiotic solution was added to the irrigation fluid. A Hemovac drain (Zimmer Biomet, Swindon, United Kingdom), was placed under negative pressure (Figure 1F); the drain was retained until the drainage had stopped or reduced to <10 mL per day for 3 consecutive days.

### Outcome Assessment

Clinical outcomes were evaluated using numeric rating scale pain score, Oswestry Disability Index (ODI), modified Macnab criteria, and postoperative radiographic images.

In the immediate postoperative period and at the time of discharge, blood markers of inflammation (i.e., erythrocyte sedimentation rate [ESR], C-reactive protein [CRP], and white blood cell counts) were evaluated.

All patients had serious comorbidities, such as cardiac problems, immune system diseases, or cancer. Preoperative evaluation of the general condition was performed according to the grading system of the American Society of Anesthesiologists. The Charlson Comorbidity Index (CCI) was used for a comprehensive assessment of comorbidity levels.

The local Cobb angle, defined as the angle between the superior end plate of the upper infected vertebrae and the inferior end plate of the lower infected vertebrae, was measured on plain lateral radiographs.

### Statistical Analysis

Quantitative variables are presented as mean ± standard deviation, whereas qualitative variables are presented as frequency and ratio. A 2-sample t test was used for analysis of continuous variables, whereas categorical variables were evaluated using the $\chi^2$ test or Fisher exact test. $P$ values $< 0.05$ were considered indicative of a statistically significant difference.

## RESULTS

Fourteen patients (9 males and 5 females) were included in the final analysis; 1 patient had a thoracic lesion, 1 patient had a thoracolumbar lesion, and 12 patients had lumbar lesions. The mean age of patients was 69.3 ± 8.2 years (range, 57–84 years). The mean duration of follow-up was 20.9 ± 6.7 months (range, 12–34 months). Tables 1 and 2 summarize the characteristics of patients. The most commonly involved level was L4-5. The mean duration of symptoms was 17.9 ± 15.7 months (range, 3–60 months). The average CCI was 5.1 ± 1.6 points. The mean operative time was 52.9 ± 18.8 minutes (range, 29–81 minutes). Intraoperative blood loss was minimal in all patients. All patients reported immediate relief from pain (especially back pain) after FEDD; the numeric rating scale reduced from an average of 8.2 ± 0.9 to 3.4 ± 1.1 at 1 week after surgery and 1.4 ± 1.2 at 12 months after surgery. ODI at 12 months after surgery (17.6 ± 6.2) was significantly lower than the preoperative ODI (30.1 ± 3.9; $P < 0.05$).

No procedure-related complications occurred in the entire cohort. However, 6 of the 14 patients required repeat endoscopic debridement because of failure of isolation of pathogens. After FEDD and subsequent antibiotic treatment, 12 of the 14 patients (85.7%) showed excellent or good outcome based on the Macnab criteria.

The causative organisms were successfully identified in 10 of the 14 patients (71.4%) (Table 2). Twelve patients (85.7%) had

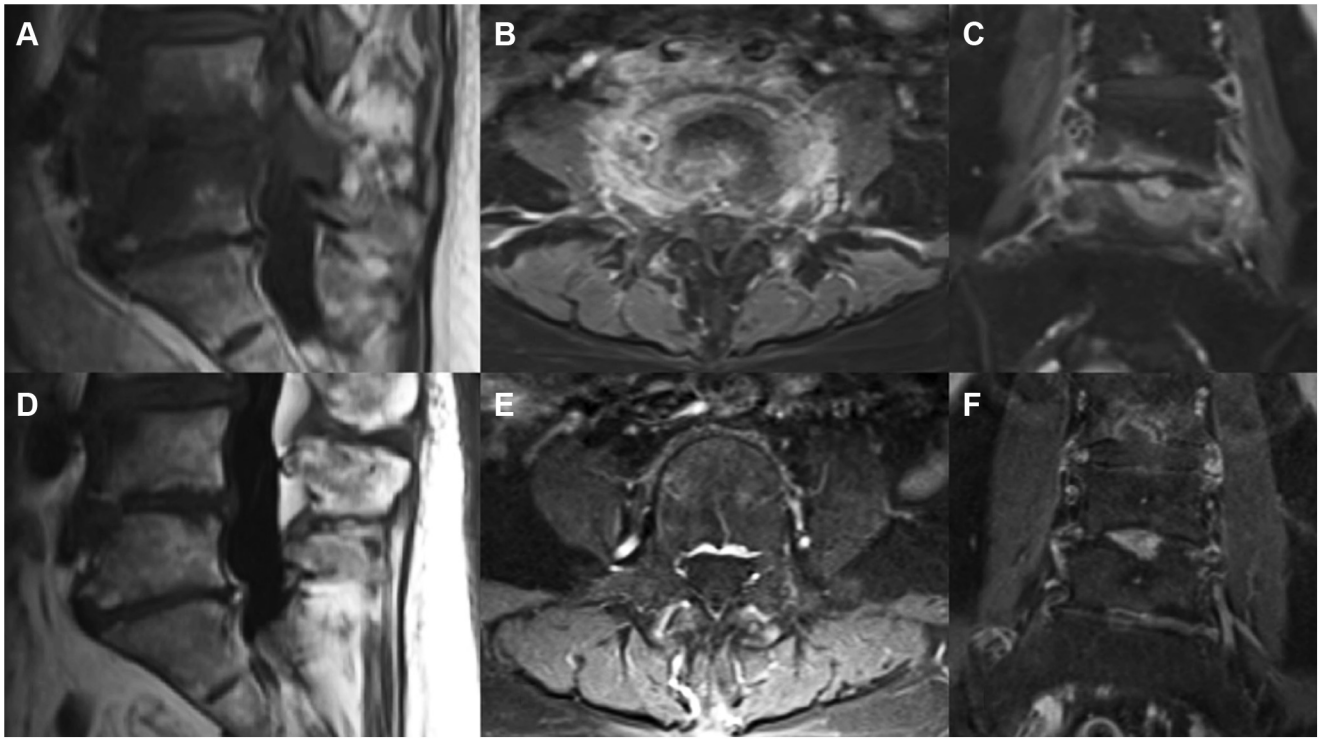


**Figure 2.** A 71-year-old female patient (patient number 12) with L4/L5 spondylodiscitis and left radiculopathy. Preoperative sagittal (**A**), axial (**B**), and coronal (**C**) T1-weighted magnetic resonance imaging showing L4-5 infectious spondylodiscitis. Four months after percutaneous endoscopic debridement and discectomy, sagittal (**D**), axial (**E**), and coronal (**F**) magnetic resonance imaging shows healing response of the subchondral bone and good control of infection.

preoperative neurologic deficit caused by epidural abscess; the neurologic function improved after FEDD in all 12 patients. Empirical antibiotic therapy was initiated in patients with suspected spondylodiscitis based on the clinical symptoms, laboratory parameters, and radiographic findings; the treatment was later switched to organism-specific antibiotics once the pathogen was cultured. The mean duration of antibiotic administration was 6.7 weeks (range, 3–11 weeks); 3 and 8 patients received antibiotic therapy for <4 weeks and >6 weeks, respectively.

The mean CRP level (mg/dL) decreased from 8.7 ± 8.3 preoperatively to 1.3 ± 1.7 at 1 day before discharge and 1.8 ± 1.8 at 12 months after surgery. In 12 of the 14 patients, the CRP level returned to the reference range within 1 week. The mean ESR (mm/hour) was 60.3 ± 15.5 before surgery, which decreased to 24.3 ± 6.4 at 1 day before discharge and 27.1 ± 9.9 at 12 months after surgery. The pattern of postoperative reduction in ESR level after antibiotic treatment was uneven. Some patients returned to the reference range in a short time; however, some patients required >10 weeks. The ESR and CRP levels of all patients decreased significantly after FEDD and antibiotic therapy ($P < 0.05$). White blood cell count was increased in only 5 of these patients (35.7%) and seemed to be a relatively poor indicator of spondylodiscitis (Table 3).

None of the patients developed spinal instability or kyphotic deformity during the follow-up period (Table 4); in addition, none of the patients required additional open spinal surgery.

## DISCUSSION

Spondylodiscitis is an uncommon disease. Timely diagnosis and treatment of this condition are typically challenging because of the nonspecific initial signs and symptoms. Elderly and immunocompromised patients are at a relatively higher risk.[15] Conservative treatment with antibiotics and bed rest is sufficient in patients with mild infection. However, patients with advanced bone destruction, deformity, severe neurologic deficit, or progressive infection require surgical treatment for pain relief and functional improvement.[16] Surgical intervention for spondylodiscitis comprises a multidisciplinary approach that includes antibiotics, open/percutaneous biopsy, and open/minimally invasive debridement surgery with or without instrumentation. CT-guided needle biopsy is a good approach to identify the causative organism.[17] However, the aspirate is often inadequate and often no organism is isolated. Regarding open surgery with or without instrumentation, several clinical reports have indicated good results with spinal reconstruction; however, the procedures are often associated with relatively high complication rates.[18,19]

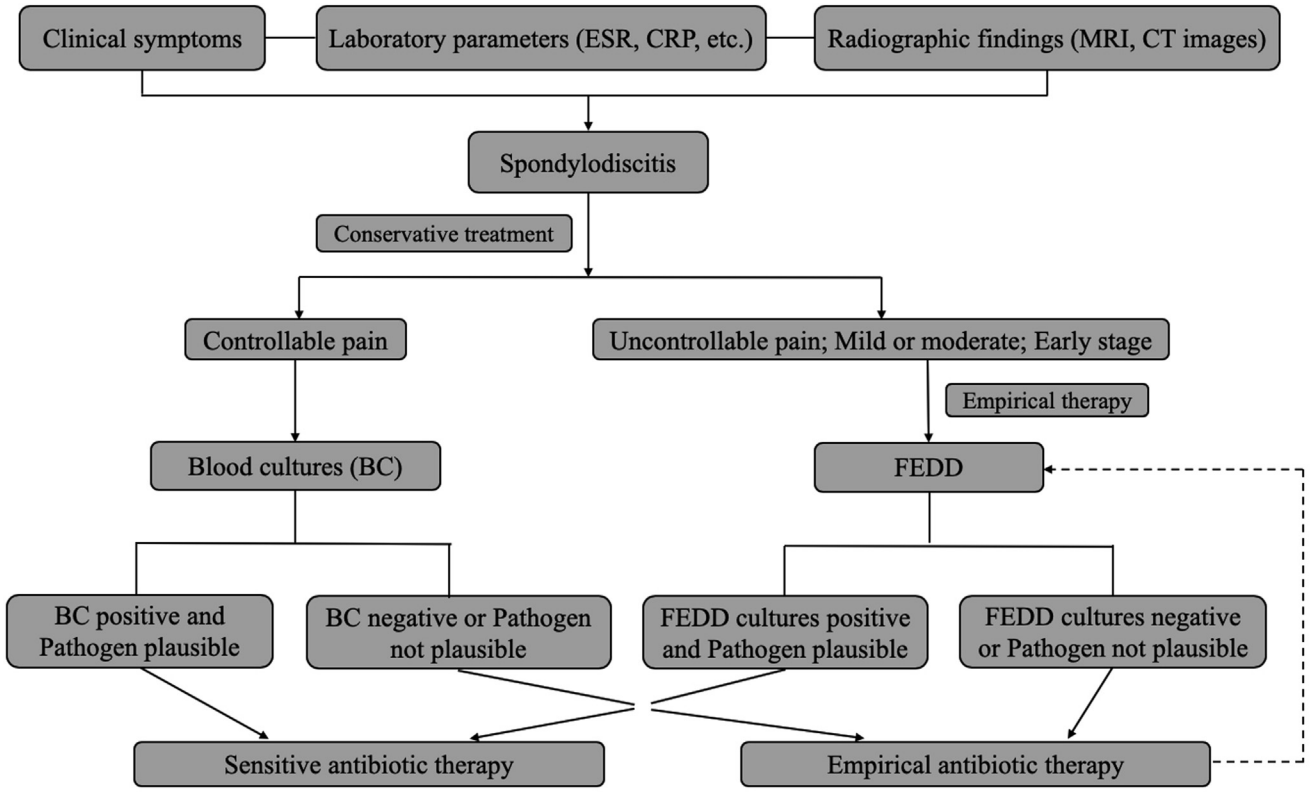


**Figure 3.** Algorithm for treatment of spondylodiscitis by full endoscopic discectomy, debridement, and drainage. CRP, C-reactive protein; CT, computed tomography; ESR, erythrocyte sedimentation rate; FEDD, full endoscopic debridement and drainage; MRI, magnetic resonance imaging.

Percutaneous endoscopic surgical treatment for lumbar disk herniation was first reported in the early 1980s. Because of the continuous technological advances and development of endoscopic instruments, endoscopy has since become a well-established surgical approach. Full endoscopic surgery is a minimally invasive, simple, safe, and effective approach for treatment of infectious spondylodiscitis. A full endoscopic system provides real-time images that allow direct visualization of the disc space and epidural space. Thus, full endoscopic spine surgery can help remove and flush the infected and necrotic tissue from the intervertebral disc space or even the epidural space; studies have shown that it may be better than open debridement in this respect.[20,21] Moreover, a sufficient amount of sample for culture can be acquired directly from the infected area. Furthermore, epidural or paravertebral abscesses initiating from the anterior spinal column can also be successfully dealt with via this technique. It achieves results similar to open/minimally invasive spine surgery in terms of clearance of the infected tissue and radical debridement.

Several reports have shown good therapeutic efficacy of these techniques to treat spondylodiscitis. One study[22] reported the outcomes of percutaneous lumbar discectomy in 16 patients with spondylodiscitis. Although the causative pathogen was isolated in only 45% of patients, the investigators reported satisfactory results of percutaneous treatment of spondylodiscitis. A recent study[23] evaluated the outcomes of FEDD with an irrigation system in 32 patients with single-level lumbar infectious spondylodiscitis. The investigators concluded that the procedure helped achieve a definitive diagnosis (causative bacteria were identified in 87.5% of patients) and afforded adequate pain relief (84.4% of patients showed satisfactory outcomes) with no procedure-related complications. Others[24] have proposed that the indications for FEDD may be extended to include treatment of infectious disease, including paraspinal, psoas, and epidural abscesses. The investigators also opined that patients with multisegment infection may not benefit from FEDD because of poor infection control and mechanical instability at the affected segments. Furthermore, a recent study[25] reported the results of CT-guided percutaneous endoscopic surgery for treatment of infectious spondylodiscitis at the thoracolumbar level in immunocompromised patients. These investigators found that the pathologic bacteria were identified in 77% of patients and the inflammatory indices reduced to the reference range after adequate antibiotic therapy.

In the present study, we retrospectively reviewed 14 high-risk patients with single-level infectious spondylodiscitis with high American Society of Anesthesiologists and CCI scores. Although

patients had serious medical problems, including cancer, multiple organ failure, or long-term use of steroids, this procedure was safely and effectively performed under local or intravenous anesthesia. All patients had a history of intravenous intensive antibiotic therapy for >6 weeks before their referral to our institution. Perhaps because of previous antibiotic therapy, the causative organisms were not identified on culture in 4 patients. The causative bacteria were identified in the remaining 10 patients (71.5%), and, hence, a combination of intravenous and oral antibiotics was administered based on the sensitivity analyzes of pathogens. Six of the 14 patients required additional procedure because of lack of bacteriologic diagnosis; however, all patients reported immediate relief of back pain and showed improved functional outcomes after FEDD and antibiotic therapy (**Figure 2**); 85.7% of the 14 patients were found to have achieved excellent or good results according to the Macnab criteria. Previously, antibiotic therapy for 6–12 weeks was recommended for treatment of nonspecific spondylodiscitis.[3,4,26] However, there is no consensus on the optimal duration of antibiotic therapy. We suggest that the duration of antibiotic therapy should depend on the infectious pathogen, clinical improvement, recovery of inflammatory indices (ESR and CRP), radiologic findings, and the degree of remission of abscess; in addition, the scope of surgical treatment should also be considered. In high-risk patients, the duration of antibiotic therapy also depends on the condition of the individual patient.

We recommend that this procedure is best indicated in patients with early-stage spondylodiscitis who show mild to moderate destructive changes in the vertebrae. Urgent surgical intervention is required in patients with neurologic deficit or sepsis. In addition, the relative indications for FEDD include intractable back pain or failure of conservative treatment. Nevertheless, this procedure may have limited effectiveness in patients with extensive destruction of multiple vertebral bodies. **Figure 3** shows a detailed decision algorithm for the treatment of spondylodiscitis.

Some limitations of this study should be considered. First, because of the small sample size and the relatively short duration of follow-up, our results may not be entirely generalizable. The second limitation is the retrospective nature of the study. A prospective randomized study should be conducted to examine the optimal techniques for treatment of infectious spondylodiscitis. Third, there were no control groups to compare the results.

## CONCLUSIONS

FEDD can help obtain adequate samples to improve the identification of causative bacteria and facilitate effective antibiotic therapy. Concurrently, FEDD may be an effective alternative to extensive open surgery for spinal infections, especially in high-risk patients (i.e., elderly patients with multiple comorbidities and patients with poor general condition).

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