Observational Study

New Strategy for Minimally Invasive Endoscopic Surgery to Treat Infectious Spondylodiscitis in the Thoracolumbar Spine

Chia-Yu Lin, MD[1], Chien-Chun Chang, MD[1,2], Yen-Jen Chen, MD[1,4], Chun-Hao Tsai, MD, PhD[1,3], Hsi-Kai Tsou, MD, PhD[5,6], Chih-Sheng Lin, PhD[2], Mao-Wang Ho, MD[7], Hsien-Te Chen, MD, PhD[1,3], and Horng-Chaung Hsu, MD, PhD[1,4]

From: : [1]Department of Orthopaedic Surgery, China Medical University Hospital, China Medical University, Taichung, Taiwan, R.O.C.; [2]Department of Biological Science and Technology, National Chiao Tung University, Hsinchu, Taiwan, R.O.C.; [3]Department of Sports Medicine, College of Health Care, China Medical University, Taichung, Taiwan, R.O.C.; [4]School of Medicine, China Medical University, Taichung, Taiwan, R.O.C.; [5]Functional Neurosurgery Division, Neurological Institute, Taichung Veterans General Hospital, Taichung, Taiwan, R.O.C.; [6]Department of Rehabilitation, Jen-Teh Junior College of Medicine, Nursing and Management, Miaoli County, Taiwan, R.O.C.; [7]Division of Infectious Disease, Department of Internal Medicine, China Medical University Hospital, China Medical University, Taichung, Taiwan, R.O.C.

Address Correspondence:
Hsien-Te Chen, MD, PhD
School of Chinese Medicine, College of Chinese Medicine, China Medical University
No. 91 Hsuehshih Road
North District, Taichung 40402
Taiwan, R.O.C.
E-mail: bonekid1@gmail.com

Disclaimer: Chia-Yu Lin, MD and Chien-Chun Chang, MD both contributed equally to this work. There was no external funding in the preparation of this manuscript. Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 06-26-2018
Revised manuscript received: 10-03-2018
Accepted for publication: 10-15-2018

Free full manuscript: www.painphysicianjournal.com

Background: Eradicating infection, protecting neurologic function, and maintaining structural alignment are the 3 objectives of treatment for infectious spondylodiscitis. For some patients, surgery may be necessary to achieve these goals; however, open surgeries are associated with high morbidity and mortality in elderly patients and those with multiple comorbidities. Endoscopic surgery provides a minimally invasive surgical option for obtaining a culture sample to aid identification of pathogens, while also providing a route for adequate decompression and drainage. The clinical results of this study were analyzed.

Objectives: To evaluate the efficacy and safety of spinal endoscopic surgery, the basic characteristics of patients analyzed and their inflammatory markers, pain levels, and local kyphotic angles were recorded before surgery and at regular intervals after surgery. The patients' cultured pathogens and previous antibiotic treatments were also recorded and analyzed.

Study Design: Retrospective observational study (institutional review board: CMUH 105-REC2-101).

Setting: Inpatient surgery center.

Methods: From October 2006 to March 2017, of 508 patients who received spinal endoscopic surgery, 60 with infectious spondylodiscitis were treated using this new strategy. All 60 patients underwent plain film radiography and enhanced magnetic resonance imaging of the affected region to obtain evidence of infectious spondylodiscitis. The role of a computed tomography-guided biopsy and some indications for open surgery were replaced with endoscopic surgery.

Results: All the patients reported rapid pain relief after endoscopic surgery and antibiotic treatment. No significant changes in sagittal alignment were observed in final follow-up radiography images. Causative pathogens were identified in 34 patients (culture rate: 77.27%) without previous antibiotic treatment. The patients' erythrocyte sedimentation rates and C-reactive protein levels had decreased significantly 3 months after endoscopic surgery. Two patients (3.3%) experienced infection relapse following initial endoscopic surgery; both of them were efficiently resolved through a second round of endoscopic surgery. No surgery-related complications were observed and no open spinal surgery was required during the follow-up period.

Limitations: This was a retrospective study; bias was unavoidable because of the single-center nature of the study design.

Conclusions: Regarding the culture rate, recurrence rate, kyphotic change, and surgery-related complications, this new strategy for endoscopic surgery is safe and effective for treating infectious spondylodiscitis in the thoracic or lumbar spine and may be considered a new trend in treating diseases of this type.

Key words: Spine, endoscopic, discectomy, spondylodiscitis, minimally invasive surgery

Pain Physician 2019: 22:281-293

Most spinal infections involve the intervertebral discs and vertebrae, and sometimes the adjacent intraspinal and paraspinal soft tissue. Such infections often begin as subtle clinical signs and symptoms but rapidly develop into debilitating and, in some cases, life-threatening diseases (1). Spinal infection can occur spontaneously in patients who are immunocompromised due to hematogenous spread from other infective foci or following interventional or surgical procedures.

The incidence of spinal infections has increased along with the numbers of spinal surgical procedures and individuals who are elderly or immunocompromised (2-7). The successful treatment of infectious spondylodiscitis involves 3 aspects: eradicating the infection, protecting neurologic function, and maintaining structural alignment. When no neurologic deficit or considerable kyphotic deformity or instability is present, spinal infection may be managed without surgical intervention (8). Antibiotics are the mainstay of nonsurgical treatment, which is effective in approximately 75% of patients. The common standard for treatment is at least 6 weeks of intravenous antibiotics followed by a variable period of oral antibiotic therapy. Susceptibilities are determined based on the organism identified and ideal antibiotic tested. If no organism is identified, broad-spectrum antibiotic coverage is necessary. Most patients for whom nonsurgical treatment is successful develop spontaneous interbody fusion 6-24 months after the initial onset of symptoms (9). However, approximately 30% of patients develop a deformity during the first 6-8 weeks (10). Conservative treatment for spinal infection is considered unsuccessful if symptoms and inflammatory markers persist or worsen, or imaging studies reveal no improvement or a decline in the patient's condition after 1 month of therapy (11). One study reported a relapse rate of 14%, with relapse typically occurring within 6 months of the discontinuation of therapy (12).

Carragee (13) reported that the success of nonsurgical treatment can be predicted by 4 independent variables: age < 60 years, a fully functioning immune system, infection with Staphylococcus aureus, and a decreasing erythrocyte sedimentation rate (ESR) within the first month. The following conditions are associated with an increased risk of relapse: corticosteroid use, rheumatoid arthritis, concomitant endocarditis or intravascular infectious focus, high C-reactive protein (CRP) level, longer treatment duration, and infection with methicillin-resistant S. aureus (14).

Despite recent advances in treatment techniques and experiences, the optimal indication and timing for surgical management remain unclear, seemingly because of a lack of research on the subject. Traditionally, surgery is indicated for a neurologic deficit, structural deformity, or nonsurgical treatment failure (1,8,15,16). The main goals of surgical treatment are the maximal preservation of neurologic function, the maintenance of structural alignment, and the elimination of the infection (17,18). The selection of optimal surgical techniques, approaches, and instrumentation level for the successful treatment of infectious spondylodiscitis is controversial. However, surgical interventions are associated with a considerable number of comorbidities (19). Therefore, in recent years, minimally invasive surgery has been reported as an effective and efficient treatment option, especially for patients who are elderly or immunocompromised or those with multiple comorbidities.

Spinal endoscopic surgery has been reported, notably for managing the early stages of uncomplicated spondylodiscitis and achieving local infection control and immediate pain relief prior to kyphotic deformity formation. This approach is contraindicated in patients with advanced infections involving excessive neurocompression or extensive bone destruction (20).

This article reviews our protocol for treating infectious spondylodiscitis with endoscopic surgery, focusing on technique, indications, and clinical results.

Methods

Study Design

A retrospective chart review of patients who underwent our treatment protocol of endoscopic surgery for infectious spondylodiscitis was conducted to evaluate the locations, symptoms and signs, risk factors, and outcomes, including the rate of recurrence, kyphotic angle changes, and residual neurologic deficits.

Setting

Patient Population

From October 2006 to March 2017, of 508 patients who received endoscopic surgery, 64 patients were diagnosed with infectious spondylodiscitis. Four of these patients were excluded from this study—3 because of implant retention and one because of loss of follow-up within 3 months. A total of 60 patients (39 men and 21 women; mean age: 60 years, range: 27-84 years) were

included in our study and treated following the endoscopic surgical protocol.

Surgical Technique Considerations

For patients with lesions on the upper lumbar or thoracic spine, a computed tomography (CT)-guided angiographic catheter was applied before endoscopic surgery as a guide to avoid injury to visceral organs, major vessels, or the spinal cord (Fig. 1).

During the procedure, the patients were awake and under pain control with local anesthesia of 1% lidocaine combined with intravenous fentanyl. Therefore, the patients were able to provide feedback when nerves were irritated. All patients were in a prone position on a radiolucent U-shaped frame to reduce abdominal pressure and lumbar lordosis.

A spinal needle was inserted into the infected area through a triangular working zone at the posterolateral corner under fluoroscopic monitoring. We infused 5-10 mL of 1% lidocaine to anesthetize the working area before the guide wire and dilator were sequentially introduced into the infected area. The working sheath was advanced along the dilator. The infected fluid, abscess, and tissue were aspirated and subjected to microbial examination (for Mycobacterium tuberculosis (MTB), fungi, and other bacteria). A small amount of normal saline solution was infused through the sheath to provide a better view, and then, the infected soft tissue and dead bone were excised using an endoscopic microrongeur and microscissors under direct endoscopic vision for subsequent microbial and pathological examination. After adequate sampling, debridement, and sequestrectomy, at least 4 L of normal saline solution (containing 1g of cefazolin per L) was used to irrigate the surgical field until healthy bone of upper and lower vertebral bodies were visible. A quarter-inch drainage tube was inserted and maintained in the surgical site for active drainage of infective materials, pus, and exudate through a Hemovac.

Surgitron, a high-voltage bipolar probe (Ellman Innovations, New York, NY), was used for the thermocoagulation of the infected tissue and bleeders. All operating instruments and endoscopic systems were supplied by Richard and Wolf (Knittlingen, Germany). The high-resolution endoscope used had a diameter of 8 mm with a 4.1-mm intraendoscopic working channel. The angle of vision was 25°. The working sheath had an 8.0-mm outer diameter and a beveled opening to provide visual and working fields in areas that lacked clear anatomically preformed cavities.

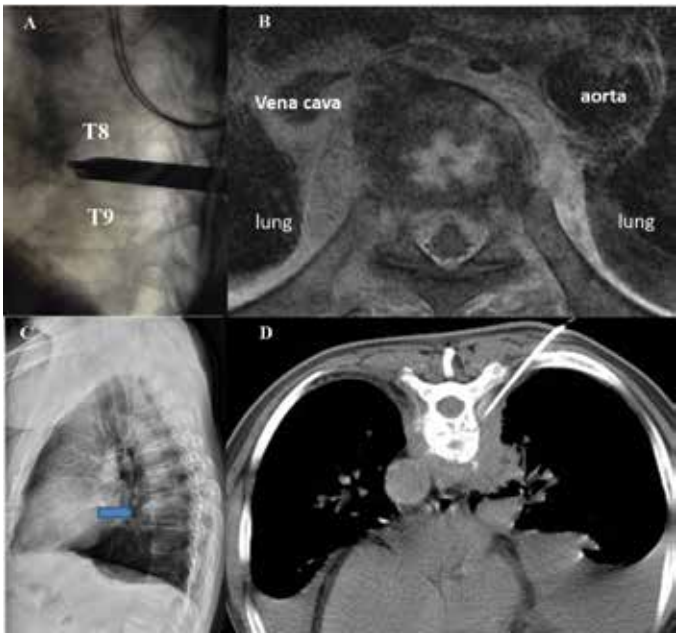

Fig. 1. *A 72-year-old male patient with T8-9 infectious spondylodiscitis. (A, B, and C) To prevent injury to major vessels, vital organs, or the spinal cord, a preoperative CT guide tube was established for subsequent endoscopic surgery. (D) Bony ankyloses after endoscopic surgery; 1-year follow-up x-ray.*

Because of the high risks of visceral organ damage, major vessel damage, and spinal cord injury, endoscopic surgery played only a limited role in the upper lumbar and thoracic spine in a previous study (21). To improve accuracy and avoid these complications, a CT-guided catheter can be introduced by an experienced radiologist as a guide on the day of or day before surgery. The CT-guided endoscopic procedure requires a 6-inch long no. 11-gauge bone puncture needle with multiple wide side holes to be inserted into the lesion under the guidance of a CT scan. In this study, following the aforementioned insertion, a J guide wire was inserted via the bone biopsy needle. Finally, a no. 5 Fr C1 angiographic catheter (Cook, Bloomington, IN) was inserted along the J guide wire and maintained in the infected area after the removal of the guide wire. A spinal endoscopic guide wire was then inserted

directly through the angiographic catheter and slowly advanced with the assistance of fluoroscopy, to ensure that the wire was targeting the infected area without penetrating the angiographic catheter wall and injuring adjacent structures. After the guide wire had been set in the infected area, the no. 5 Fr C1 angiographic catheter was removed. A dilator was then inserted along the endoscopic guide wire, and the subsequent endoscopic surgery was identical to that performed for the lumbar spine.

Postoperative Care

The quarter-inch drainage tube was maintained in place for 7-14 days until the daily drainage amount was < 5 mL. Specified antibiotics were administered intravenously for patients with known causative pathogens before surgery, and empirical broad-spectrum antibiotics were administered after surgery for patients with unknown causative pathogens; these were switched to specific antibiotics after the pathogens had been identified. Intravenous antibiotics were used for 4-6 weeks in accordance with the weekly monitoring of white cell count, inflammation markers (CRP and ESR), and pathogens. Patients were then switched to oral antibiotics after their CRP values had normalized, and antibiotic treatment was discontinued when both inflammatory markers (CRP and ESR) were within their normal ranges (28-31).Patients remained bed bound for 2 weeks after endoscopic surgery for pain relief and to maintain structural alignment. A rigid thoracolumbar spinal orthosis was then employed to protect the infected site during ambulation; use of the orthosis was continued until the evidence of bone union or prominent syndesmophyte formation was observed along the anterolateral aspect of the affected site.

Variables, Data Sources, Measurement, Bias, and Study Size

All the patients underwent plain film radiography and enhanced magnetic resonance imaging of the affected spinal region; these techniques revealed evidence of infectious spondylodiscitis. Most patients exhibited evidence of high inflammation, illustrated by the elevation of the CRP level and ESR, and complained of severe back pain. They also had a variety of comorbidities, including renal failure, heart failure, rheumatic arthritis, liver cirrhosis, polycystic liver post-transplantation, and diabetes (Table 1).

Preoperative clinical symptoms and signs were recorded. Pain was evaluated using a visual analog scale ([VAS]; 0–10) before surgery and at 1, 3, and 6 months after surgery. ESR and CRP levels were recorded before surgery, weekly after surgery, and subsequently monthly for outpatient department follow-up. Plain radiography was performed immediately after surgery and at 1, 3, 6, and 12 months after surgery. The kyphotic angle was measured as the angle between the upper end plate of the first vertebral body above the involved level and the lower end plate of the first vertebral body below the involved level. Any evidence of spinal kyphotic deformity due to infectious spondylodiscitis was recorded.

Table 1. *Patient characteristics (demographic and culture results).*

Number	Age (yrs)/ Gender	Level	Previous antibioitc/bacteria culture	Associated medical illness
1	27/F	L3-4	(-) No growth	None
2	55/M	L4-5	(-) Strep. anginosus	LC
3	68/M	L2-3	(-) E coli (ESBL)	None
4	73/F	L2-3	(-) Staph. aureus	None
5	71/F	L1-2	(+) Delftia acidovorans	CKD, CHF, RHD
6	60/M	T11-12	(+) No growth	DM, CHF, CAD
7	67/F	T12-L1	(+) No growth	CKD, DM, T12 burst fracture S/P VP
8	72/M	L5-S1	(+) No growth	LC, gouty arthritis
9	58/F	L3-4	(+) Staph. epidermidis	DM, HTN
10	65/F	L1-2	(-) E coli (ESBL)	HTN
11	60/M	L4-5	(-) No growth	CKD, DM, HTN, DDD L4-L5 S/P TLIF
12	47/F	L3-4	(-) No growth	None

Table 1 con't. *Patient characteristics (demographic and culture results).*

Number	Age (yrs)/ Gender	Level	Previous antibioitc/bacteria culture	Associated medical illness
13	68/F	L3-4	(-) No growth	CKD, DM, CHF
14	70/M	L5-S1	(-) Strep. bovis	IE
15	55/F	T11-12	(-) Staph. aureus	DM, HTN
16	73/F	T12-L1	(+) Staph. aureus (MRSA)	DM
17	71/F	T11-12	(-) No growth	DM, LC, T11 burst fracture
18	77/M	L4-5	(-) Candida albicans	Colon ca.
19	49/M	L2-3	(+) No growth	DM
20	57/F	L4-5	(-) P. prevotii	DM, HTN
21	71/M	L1-2	(-) Strep. anginosus	None
22	36/M	L4-5	(-) Staph. aureus	Drug abuse, HBV, HCV
23	61/M	L3-4	(-) P. asaccharolyticus	Gouty arthritis
24	66/M	L4-5	(-) Strep. agalactiae	HTN
25	62/M	L3-4	(-) Strep. anginosus and viridians	HTN
26	48/M	L5-S1	(-) Pseudomonas aeruginosa	HTN, DM, COPD
27	84/F	T9-10	(-) MTB	HTN, CHF
28	36/F	L5-S1	(-) Staph. aureus	Drug abuse
29	63/M	T12-L1	(-) Klebsiella pneumoniae	LC, asthma
30	52/M	L2-3	(-) No growth	LC
31	52/M	L1-2	(-) Staph. aureus	None
32	60/M	L3-4	(-) Fusobacterium nucleatum	HTN, DM, LC
33	49/F	L1-2	(-) Candida albicans, E coli	Polycystic liver, kidney S/P liver transplantation
34	58/M	L3-4	(-) No growth	Esophageal ca., Laryngeal ca., HTN
35	63/F	L3-4	(-) No growth	HTN
36	70/F	L3-4	(-) E coli	Acute pyelonephritis, DM, HTN
37	60/M	L2-3	(-) Staph. aureus	Drug abuse, HTN
38	54/M	L3-4	(-) Strep. mitis	LC
39	77/F	L5-S1	(-) No growth	HTN
40	72/M	T8-9	(+) Klebsiella pneumoniae	DM
41	39/M	L2-3	(-) No growth	CHF, CKD, PU, HTN, DM
42	45/M	L4-5	(-) Staph. aureus	Compression fracture L2
43	36/M	L3-4	(+) Staph. aureus	Staph. aureus bacteremia, asthma
44	77/M	L4-5	(+) No growth	LC, HTN, CKD, PU
45	78/F	L3-4	(-) Staph. lugdunensis	HTN, CHF
46	38/M	L1-2	(+)Enterococcus faecium	None
47	65/M	L1-2	(-) Strep. agalactiae	DM, CKD, HTN, adrenal insufficiency
48	55/M	L5-S1	(-) Parvimonas micra	HTN
49	64/F	L4-5	(-) E coli	DM, HTN, UTI
50	84/M	L2-3	(+) MTB	Old MTB, lung ca., HTN, gouty arthritis, CAD
51	62/F	L4-5	(+) E coli	UTI, DM, HTN, anemia, PID
52	35/M	L3-4	(-) Staph. aureus	None
53	59/M	L4-5	(+) Strep. gallolyticus	IE, AR, hepatic sclerosis, GERD
54	35/M	L4-5	(-) Staph. aureus	AIDS, HCV
55	50/M	L1-2	(-) Propionibacterium acnes	None

Table 1 con't. *Patient characteristics (demographic and culture results).*

Number	Age (yrs)/ Gender	Level	Previous antibioitc/bacteria culture	Associated medical illness
56	60/M	L4-5	(+) No growth	IE, pneumonia, HTN
57	76/M	L4-5	(-) Parvimonas micra	HTN, DM, BPH, UTI
58	87/M	L2-3	(+) No growth	PU
59	69/M	L1-2	(-) MTB	HTN, BPH
60	52/M	L4-5	(-) Staph. epidermidis	PU, CAD, CKD, DM, HTN

Abbreviations: AIDS, acquired immune deficiency syndrome; BPH, benign prostatic hypertrophy; ca., cancer; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DDD, degenerative disc disease; DM, diabetes mellitus; E coli, Escherichia coli; HBV, hepatitis B; HCV, hepatitis C; HTN, hypertension; IE, infective endocarditis; LC, liver cirrhosis; P, Peptostreptococcus; PU, peptic ulcer; RHD, rheumatic heart disease; Staph., Staphylococcus; Strep., Streptococcus; MTB, Mycobacterium tuberculosis; ESBL, Extended-spectrum β-lactamases; MRSA, methicillin-resistant Staphylococcus aureus; S/P, Post-surgical; VP, vertebroplasty; TLIF, Transforaminal Lumbar Interbody Fusion; UTI,Urinary tract infection; PID,Pelvic inflammatory disease; AR,aortic regurgitation; GERD, Gastro-esophageal reflux disease.

Results

Patients

The mean age of the patients was 60 years (range: 27-84 years). The study sample consisted of 39 men and 21 women.

Data and Main Results

The results revealed 25 lesions located on the thoracic or upper lumbar spine (between T8-T9 and L2-L3, 41.67%) and 35 located between L3-L4 and L5-S1 (58.33%, Table 1).

All the patients experienced prominent back pain (VAS = 9.17), and some experienced leg pain (VAS = 7.50) before surgery. All reported rapid relief of back pain (VAS = 2.78) and leg pain (VAS = 2.50) after endoscopic surgery and antibiotic treatment.

Pathogens were identified in 43 patients with a culture rate of 71.67% (Table 1), including 34 patients without previous antibiotic treatment (culture rate: 77.27%), and 9 with previous antibiotic treatment (culture rate: 56.25%). Effective antibiotics were administered in accordance with the sensitivity testing of the isolated pathogen. The remaining 17 patients were administered empirical antibiotics until all inflammatory parameters returned to their normal ranges. Patient number 27 took anti-MTB medication for 9 months.

The ESR and CRP levels of all the patients decreased considerably within the 3 months following surgery, after the patients had received intravenous antibiotics for 4-6 weeks, followed by oral antibiotic treatment (Table s 2 and 3). Two patients had relapse of infection owing to the early cessation of oral antibiotics; both underwent a second round of endoscopic surgery—one under the interlaminar approach at L5-S1 (Fig. 2) and the other under the transforaminal approach at L3-4—to excise an extruded disc and drain out an epidural abscess. No further relapse was recorded in these patients' final follow-up examinations, and no other patients had relapse of infection after treatment.

Deformity of the spine was evaluated based on plain film radiographs obtained before and after surgery and at the final follow-up.

No considerable changes in the sagittal alignment were observed (mean change of kyphotic angle: 0.5°) in final follow-up radiographs (Table 4); however, comparisons between the patients with infection in the thoracic and upper lumbar spine (L1-2 and L2-3), and those with infection in the lower lumbar spine, revealed that infections in the lower lumbar spine generated a significantly higher risk of kyphotic changes (48.6% vs. 20%, $P < 0.05$; Table 5).

No surgery-related complications were noted during the follow-up period (average follow-up duration: 42-46 months; range: 8-70 months) and no anterior open spinal surgeries were required.

Discussion

Infectious spondylodiscitis is increasingly prevalent, especially in patients who are elderly, patients who are immunocompromised, and those with comorbidities. Conservative treatment with antibiotics and bed rest are the treatment of choice for patients with known pathogens and no neurologic or structural compromise. A CT-guided biopsy is a relatively noninvasive procedure for obtaining samples for pathogen identification and drainage and also contributes to infection control. However, successful pathogen identification

Table 2. *Inflammatory markers before and after surgery.*

Patient Number	ESR (mm/1 hr)				CRP (mg/dL)		
	Pre	1 m	3 m	Last F/U	Pre	1 m	3 m
1	90	23	7	5	3.31	0.35	0.08
2	13	23	20	19	1.34	0.23	0.29
3	44	43	34	25	2.98	0.2	0.12
4	99	51	18	8	12.52	0.81	0.35
5	51	67	20	37	6.62	0.38	0.67
6	76	18	21	13	22.16	0.15	0.18
7	115	86	78	72	32.11	2.7	0.6
8	97	62	87	18	3.48	0.98	0.64
9	14	12	11	12	0.55	0.13	0.09
10	79	41	9	8	4.96	0.45	0.03
11	45	59	36	13	4.13	0.91	0.52
12	90	29	8	9	3.3	0.12	0.05
13	27	36	34	13	2.79	0.04	0.15
14	74	52	38	38	12.52	4.39	0.78
15	108	71	25	21	6.33	0.31	0.08
16	123	115	64	36	23.72	1.24	0.55
17	112	93	86	84	1.44	0.18	0.29
18	5	5	3	3	1.44	0.04	0.02
19	140	34	54	37	38	1.36	0.98
20	98	80	32	19	11.07	0.4	0.36
21	75	42	14	7	18.19	2.8	0.95
22	45	45	9	8	10.51	4.72	0.74
23	109	54	10	5	6.09	0.63	0.13
24	92	64	21	21	18.77	0.88	0.04
25	140	28	10	13	2.59	0.3	0.04
26	88	44	12	17	3.31	0.54	0.63
27	53	28	18	28	6.61	1.94	0.75
28	73	34	74	20	4.27	0.19	0.3
29	125	85	37	30	0.19	0.07	0.06
30	97	36	24	24	1.19	0.19	0.05
31	92	16	2	2	7.45	0.23	0.12
32	76	82	36	36	25.39	0.5	0.11
33	108	74	50	9	4.84	0.7	0.11
34	108	63	17	13	13.42	0.95	0.39
35	67	43	42	17	1.87	0.95	0.35
36	83	58	23	20	6.98	1.78	0.63
37	45	12	12	8	4.69	0.45	0.36
38	44	26	31	17	4.78	1.01	0.14
39	94	97	71	34	24.79	0.62	0.03
40	104	12	11	11	16.53	0.25	0.35
41	8	58	28	4	0.72	1.46	0.8
42	57	42	81	74	1.73	0.57	1.08

Table 2 con't. *Inflammatory markers before and after surgery.*

Patient Number	ESR (mm/1 hr)				CRP (mg/dL)		
	Pre	1 m	3 m	Last F/U	Pre	1 m	3 m
43	85	44	7	7	7.39	1.76	0.25
44	80	81	42	28	23.11	2.12	0.49
45	109	28	12	25	6.86	0.28	0.06
46	2	13	2	6	0.03	0.05	0.02
47	113	64	53	48	7.9	2.56	0.2
48	89	23	2	2	11.04	0.36	0.07
49	8	4	11	10	0.05	0.18	0.09
50	11	30	16	16	12.12	5.15	17.96
51	108	97	71	49	36.68	5.16	0.42
52	81	21	14	14	22.85	0.95	0.29
53	106	43	25	58	3.76	0.8	0.28
54	60	39	16	16	6.86	1.89	0.48
55	30	6	2	1	1.67	0.18	0.24
56	35	28	5	2	26.2	3.32	0.19
57	87	14	25	8	0.52	0.06	0.75
58	64	26	24	21	5.54	1.02	0.8
59	100	74	4	12	2.68	2.8	0.11
60	119	104	110	110	11.94	5.64	2.71

Gray squares represent abnormal data; Abbreviations: F/U, follow-up..

ranges from 36% to 91% (22-24), and the levels of success for infection control are unsatisfactory. When conservative treatment fails, physicians turn to open surgery; however, traditional anterior debridement and reconstruction, with or without posterior instrumentation, is a major surgical procedure with high rates of postoperative complications, especially in patients who are immunocompromised, patients who are elderly, or those with multiple comorbidities. Endoscopic discectomy was first employed to treat lumbar disc herniation in the 1980s and is now a well-established surgical procedure for various spinal disorders. This procedure has also been applied to treat infectious spondylodiscitis in recent years and has proven as effective as open surgery for infection control (21,25-27). Our study verified this procedure as a safe and effective surgery with a high-positive culture rate and low postsurgical complication and recurrence rates.

In our study, the positive culture rate of the patients without presurgical antibiotic treatment was 77.27%, and the average amount all the patients was 71.67%. The positive culture rate could be improved through the application of a tissue sampling procedure and technique during endoscopic surgery. Intravenous antibiotic administration should be avoided until the completion of pathogen sampling, unless signs of severe sepsis are present. Pressurized fluid irrigation should also be avoided until a sufficient sampling volume has been obtained. Compared to open surgery, endoscopic surgery can be safely performed under local anesthesia with a comparable culture rate. In contrast to a CT-guided biopsy, endoscopic surgery provided the added benefits of discectomy and sequestrectomy of the infected site, and pressurized irrigation under direct endoscopic vision.

Endoscopic surgery can relieve patient symptoms while enabling adequate sampling for organism identification; paraspinal abscesses and epidural and psoas muscle abscesses can be successfully treated without opening the epidural space because abscesses and infected areas are almost always connected to one another (Fig. 3). Furthermore, the nerve roots in the lumbar spine can tolerate a greater mass effect from an epidural abscess than the nerves located in the thoracic and cervical regions. Therefore, emergent open decompression is unnecessary for treating epidural abscesses along the lumbar spine, except in the presence of motor weakness. In our study, the patients' inflammatory

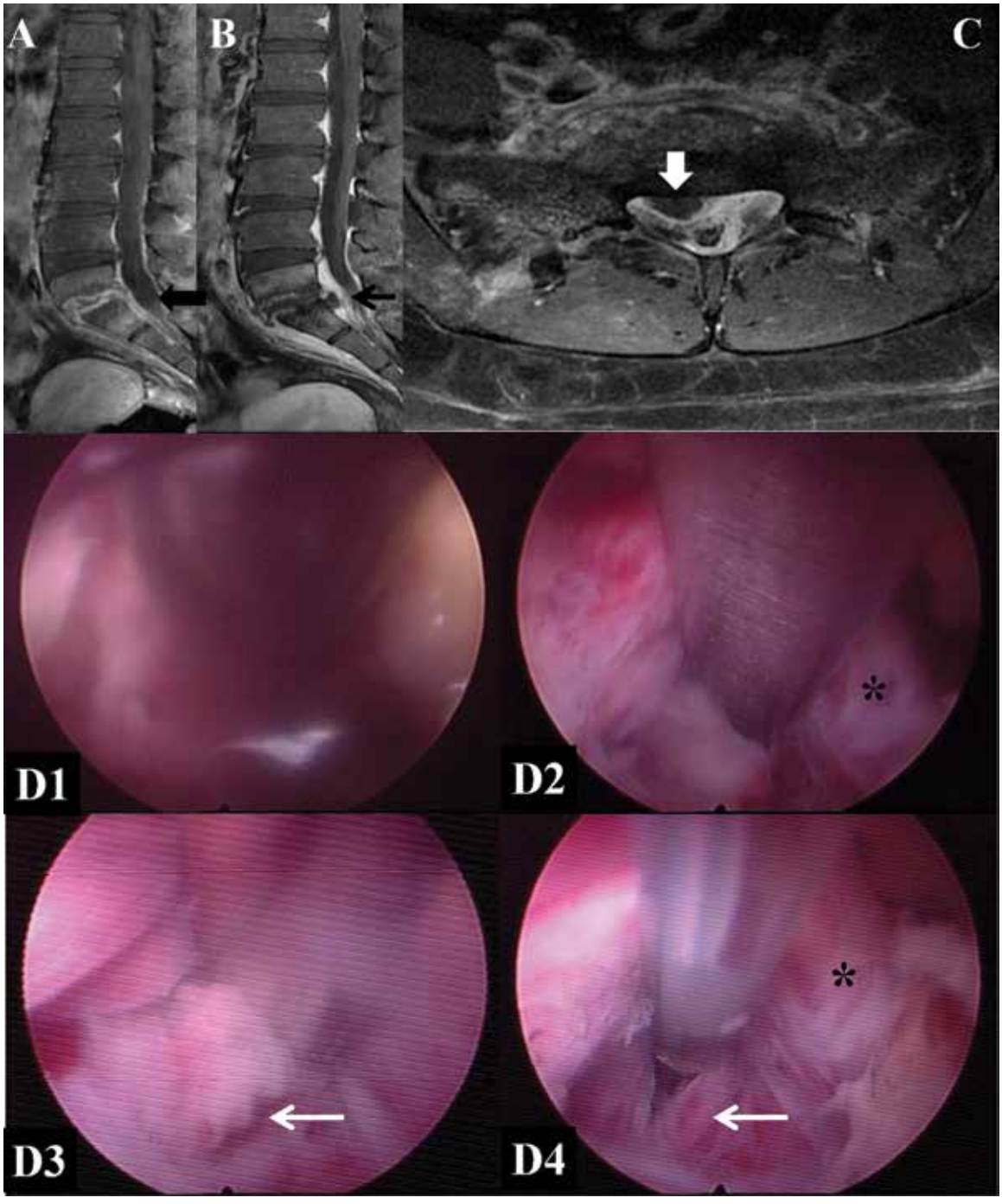

Fig. 2. *A 48-year-old female patient with L5-S1 infectious spondylodiscitis had a relapse of infection owing to early cessation of oral antibiotics. She received a second round of endoscopic surgery via the interlaminar approach. (A) Infectious spondylodiscitis at L5-S1 level. (B and C) Magnetic resonance imaging after relapse of infection revealed epidural abscess with downward migration disc. D1: Flooded abscess after incised epidural cystic lesion. D2: *: S1 Root. D3: Extruded disc after drained out abscess; arrow: extruded disc. D4: *: S1 Root; arrow: epidural space.*

Table 3. *Statistical normalization rate of inflammatory marker after operation.*

Level	CRP (Patient number/%)			ESR (Patient number/%)	
	Postop 1 m	Postop 3 m	Last F/U	Postop 1 m	Postop 3 m
Normal	10 (16.67%)	29 (48.33%)	42 (70.00%)	39 (65.00%)	58 (96.67%)
Abnormal	50 (83.33%)	31 (51.67%)	18 (30.00%)	21 (35.00%)	2 (3.33%)

Abbreviations: F/U, follow-up; Postop, postoperative.

Table 4. *Kyphotic angle changes in infective level.*

Patient Number	Level	Pre	Post	Last	Op change	Final change
1	L3-4	–9	–8	–9	1	0
2	L4-5	–18	–23	–28	–5	–10
3	L2-3	–23	–22	–21	1	2
4	L2-3	4	–5	–7	–9	–11
5	L1-2	–6	–2	–1	4	5
6	T11-12	10	8	10	–2	0
7	T12-L1	16	19	19	3	3
8	L5-S1	–49	–44	–46	5	3
9	L3-4	–9	–17	–18	–8	–9
10	L1-2	2	–2	–1	–4	–3
11	L4-5	–34	–37	–33	–3	1
12	L3-4	–10	–7	–7	3	3
13	L3-4	–8	–7	–8	1	0
14	L5-S1	–39	–39	–41	0	–2
15	T11-12	6	4	1	–2	–5
16	T12-L1	13	13	24	0	11
17	T11-12	11	14	12	3	1
18	L4-5	–45	–40	–40	5	5
19	L2-3	–20	–23	–21	–3	–1
20	L4-5	–13	–31	–17	–18	–4
21	L1-2	12	5	4	–7	–8
22	L4-5	–25	–35	–33	–10	–8
23	L3-4	–9	–29	–16	–20	–7
24	L4-5	–4	–15	–15	–11	–11
25	L3-4	–22	–24	–22	–2	0
26	L5-S1	–33	–44	–45	–11	–12
27	T9-10	0	3	3	3	3
28	L5-S1	–15	–8	–23	7	–8
29	T12-L1	–13	–12	–12	1	1
30	L2-3	–7	–7	–3	0	4
31	L1-2	7	8	12	1	5
32	L3-4	–42	–42	–23	0	19
33	L1-2	14	15	16	1	2
34	L3-4	1	–3	–2	–4	–3
35	L3-4	–10	–9	–7	1	3
36	L3-4	1	8	6	7	5
37	L2-3	1	1	11	0	10
38	L3-4	–2	–3	–5	–1	–3
39	L5-S1	–29	–32	–20	–3	9
40	T8-9	12	14	15	2	3
41	L2-3	10	8	17	–2	7
42	L4-5	–9	–13	–14	–4	–5
43	L3-4	3	–7	3	–10	0
44	L4-5	–6	–8	–3	–2	3
45	L3-4	10	11	5	1	–5
46	L1-2	34	43	38	9	4
47	L1-2	5	1	22	–4	17
48	L5-S1	–5	–8	–6	–3	–1
49	L4-5	1	9	5	8	4
50	L2-3	9	2	21	–7	12
51	L4-5	–19	–18	–14	1	5
52	L3-4	–2	–1	–9	1	–7
53	L4-5	2	–17	–11	–19	–13
54	L4-5	–12	–14	–4	–2	8
55	L1-2	–14	–9	–14	5	0
56	L4-5	–14	–16	–6	–2	8
57	L4-5	–27	–18	–38	9	–11
58	L2-3	3	5	6	2	3
59	L1-2	26	22	31	–4	5
60	L4-5	3	–10	7	–13	4
Avg. change					–1.85	0.52

Table 5. *Differences in kyphotic change among the thoracic, upper lumbar, and lower lumbar spine.*

Patient number (%)	Kyphotic change	No kyphotic change	*P* value
T and upper L-spine	5 (20%)	20 (80%)	0.0310
Lower L-spine	17 (48.57%)	18 (51.43%)	

Fisher exact test. Abbreviations: L, lumbar; T, thoracic.

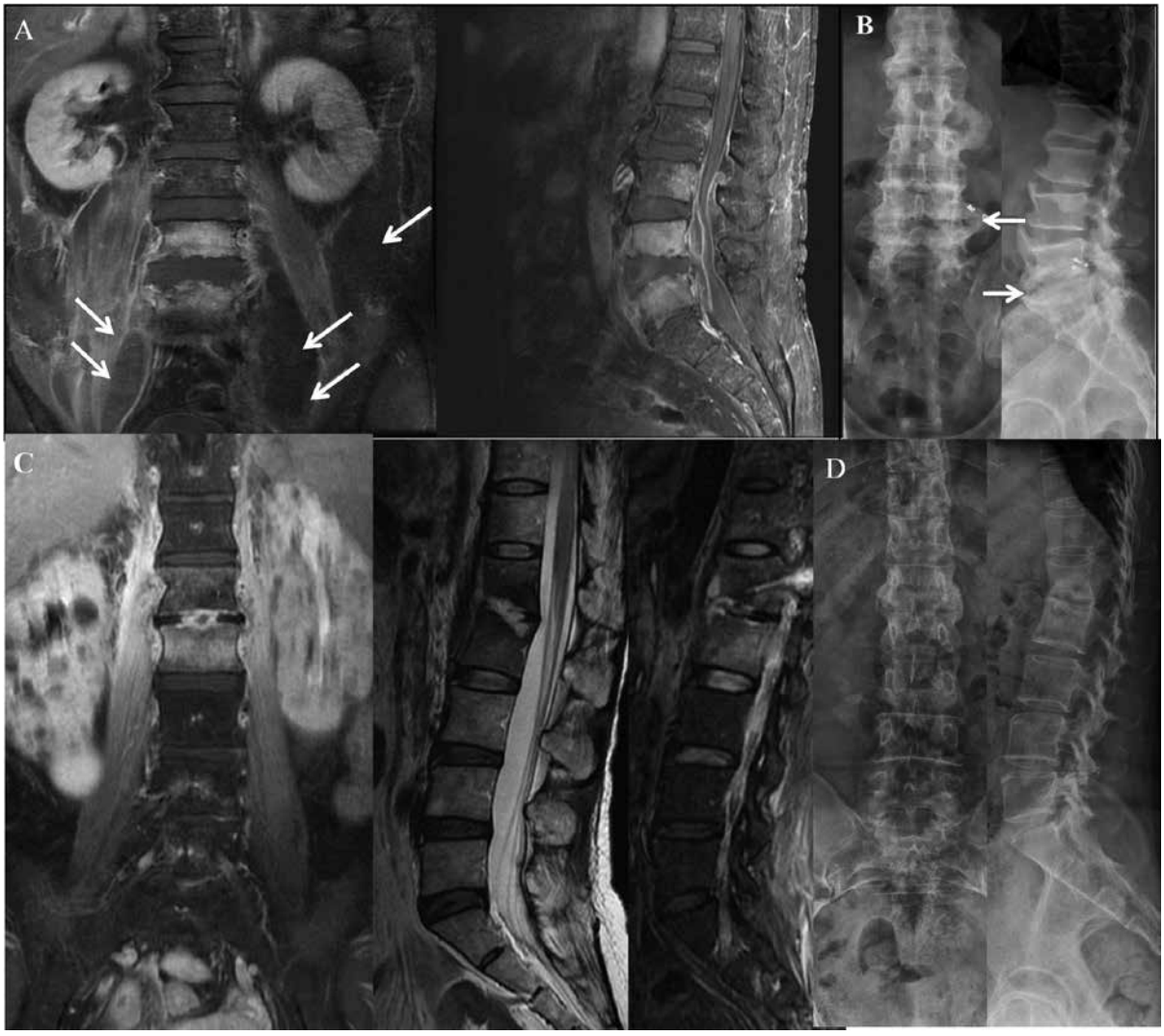

Fig. 3. *(A) A 60-year-old male patient with L3-4-5 infectious spondylodiscitis and paraspinal and epidural abscess was treated successfully following our surgical strategy. (B) Bony ankylosis can be observed in the 1-year postsurgical radiography. (C) A 49-year-old female patient who underwent a liver transplant because of a polycystic liver and kidney had L1-2 infectious spondylodiscitis. (D) Bony ankyloses without evident kyphosis in the 1-year postsurgical radiography.*

markers decreased gradually and remained elevated only in a small number of patients because of comorbidities; however, despite their elevated inflammatory markers, these few patients were somewhat relieved of their back pain and neurologic deficits. Radiographic images revealed local osteogenesis with evident syndesmophyte formation along the anterior lateral aspect of the intervertebral space. In such cases, we concluded that the infection was under control without relapse; abnormal data may have been associated with comorbidities in such patients, including gouty arthritis, rheumatic heart disease, neoplasm, and other infectious diseases.

Compared with pre- and post-operative radiography, the final follow-up examination revealed an average 0.5° change in the local kyphotic angle. The 3 rapid healing mechanisms may have been regarded as the reasons for nonsignificant changes in the sagit-

tal alignment. First, mesenchymal cells are abundant at the junction of the annulus, vertebral ligaments, and perichondrial endplate, and repetitive mechanical stimulation or local inflammation could induce rapid local osteogenesis (32,33). Second, the cranial vertebral endplate promptly comes into contact with the caudal endplate at the middle spinal column because of disc-space narrowing; the cranial vertebral endplate behaves as a buttress on the posterior side of the intervertebral joint. Third, the posterior ligamentous complex usually remains intact in infectious spondylodiscitis and functions as a tension band to prevent the progression of kyphotic deformity. We found that the lower lumbar spine was at a relatively high risk of kyphotic change and determined 2 causative reasons for this. First, the ribs and sternum at the thoracic segment form a thoracic cage that provides stable structural support for the thoracic spine. Second, the lower lumbar spine has higher axial loading, which causes greater instability. The retained drainage tube and 2 weeks of bed rest after surgery for pain relief and inflammation control likely contributed substantially to rapid bone healing in the context of enhanced sagittal alignment. The aforementioned rigid thoracolumbar spinal orthosis used during ambulation may also have played a contributing role. These key practices applied in our treatment protocol may explain the lack of kyphotic deformation observed in this study compared with that observed in previous studies (25,26,33).

No mortality and only one case of morbidity due to gastrointestinal bleeding was observed in our study. This low morbidity rate may have been a result of 3 main factors. First, the patients underwent surgery under local anesthesia; we minimize the risk of pulmonary complications associated to intubation. Second, only minor blood loss occurred; we were able to maintain stable hemodynamic levels during surgery without transfusion or fluid challenge. Third, in our procedure, the wound is small and relatively painless, and we can prescribe a relatively low amount of opioid medication, which is associated with postsurgical delirium and respiratory depression. After undergoing our surgical procedure, patients can start rehabilitation while undergoing bed rest to conserve muscle strength immediately after surgery.

Conclusions

Our study results revealed the endoscopic surgery described herein to be an effective and safe treatment for infectious spondylodiscitis in the thoracic and lumbar regions, as well as for cases with epidural or paraspinal abscesses. The surgical outcomes were the same for patients with varying degrees of infection severity. Motor deficit due to infectious spondylodiscitis is the only contraindication of this procedure. Open surgery is recommended as a secondary approach if endoscopic surgery has proven unsuccessful.

Acknowledgments

The authors thank Dr. Tai Shan Shen and Hsuan Ju Chen for performing the statistics and translation.

References

1. Stoffel M, Stuer C, Ringel F, Meyer B. Treatment of infections of the spine. *Adv Tech Stand Neurosurg* 2011; 37:213-243.
2. Choi EJ, Kim SY, Kim HG, Shon HS, Kim TK, Kim KH. Percutaneous endoscopic debridement and drainage with four different approach methods for the treatment of spinal infection. *Pain Physician* 2017; 20:E933-940.
3. Chuo C-Y, Fu Y-C, Lu Y-M, Chen JC, Shen WJ, Yang CH, Chen CY. Spinal infection in intravenous drug abusers. *J Spinal Disord Tech* 2007; 20:324-328.
4. Pull ter Gunne AF, Cohen DB. Incidence, prevalence, and analysis of risk factors for surgical site infection following adult spinal surgery. *Spine* 2009; 34:1422-1428.
5. Rayes M, Colen CB, Bahgat DA, Higashida T, Guthikonda M, Rengachary S, Eltahawy HA. Safety of instrumentation in patients with spinal infection. *J Neurosurg Spine* 2010; 12:647-659.
6. havan KP, Marschall J, Olsen MA, Fraser VJ, Wright NM, Warren DK. The epidemiology of hematogenous vertebral osteomyelitis: A cohort study in a tertiary care hospital. *BMC Infect Dis* 2010; 10:158.
7. Urrutia J, Bono CM, Mery P, Rojas C, Gana N, Campos M. Chronic liver failure and concomitant distant infections are associated with high rates of neurological involvement in pyogenic spinal infections. *Spine (Phila Pa 1976)* 2009; 34:E240-244.
8. Pola E, Logroscino CA, Gentiempo M, Colangelo D, Mazzotta V, Di Meco E, Fantoni M. Medical and surgical treatment of pyogenic spondylodiscitis. *Eur Rev Med Pharmacol Sci* 2012; 16(Suppl 2):35-49.
9. Ozuna RM, Delamarter RB. Pyogenic vertebral osteomyelitis and postsurgical disc space infections. *Orthop Clin North Am* 1996; 27:87-94.
10. Frederickson B, Yuan H, Olans R. Management and outcome of pyogenic vertebral osteomyelitis. *Clin Orthop Relat Res* 1978; 160-167.
11. Tsiodras S, Falagas ME. Clinical assessment and medical treatment of spine infections. *Clin Orthop Relat Res* 2006; 444:38-50.
12. Bettini N, Girardo M, Dema E, Cervellati S. Evaluation of conservative treatment of non specific spondylodiscitis. *Eur Spine J* 2009; 18(Suppl 1):143-150.
13. Carragee EJ. Pyogenic vertebral osteomyelitis. *J Bone Joint Surg Am* 1997; 79:874-880.
14. Roblot F, Besnier JM, Juhel L, Vidal C, Ragot S, Bastides F, Le Moal G, Godet C, Mulleman D, Azaïs I, Becq-Giraudon B, Choutet P. Optimal duration of antibiotic therapy in vertebral osteomyelitis. *Semin Arthritis Rheum* 2007; 36:269-277.
15. Rodts GE Jr. Treatment of spinal infections. *Neurosurgical Focus* 2004; 17:Introduction.
16. Quinones-Hinojosa A, Jun P, Jacobs R, Rosenberg WS, Weinstein PR. General principles in the medical and surgical management of spinal infections: A multidisciplinary approach. *Neurosurg Focus* 2004; 17:E1.
17. Mann S, Schutze M, Sola S, Piek J. Nonspecific pyogenic spondylodiscitis: Clinical manifestations, surgical treatment, and outcome in 24 patients. *Neurosurg Focus* 2004; 17:E3.
18. Schinkel C, Gottwald M, Andress HJ. Surgical treatment of spondylodiscitis. *Surg Infect* 2003; 4:387-391.
19. Deininger MH, Unfried MI, Vougioukas VI, Hubbe U. Minimally invasive dorsal percutaneous spondylodesis for the treatment of adult pyogenic spondylodiscitis. *Acta Neurochir* 2009; 151:1451-1457.
20. Hadjipavlou AG, Katonis PK, Gaitanis IN, Muffoletto AJ, Tzermiadianos MN, Crow W. Percutaneous transpedicular discectomy and drainage in pyogenic spondylodiscitis. *Eur Spine J* 2004; 13:707-713.
21. Chen HC, Huang TL, Chen YJ, Tsou HK, Lin WC, Hung CH, Tsai CH, Hsu HC, Chen HT. A minimally invasive endoscopic surgery for infectious spondylodiscitis of the thoracic and upper lumbar spine in immunocompromised patients. *Biomed Res Int* 2015; 2015:780451.
22. Chew FS, Kline MJ. Diagnostic yield of CT-guided percutaneous aspiration procedures in suspected spontaneous infectious diskitis. *Radiology* 2001; 218:211-214.
23. Rankine JJ, Barron DA, Robinson P, Millner PA, Dickson RA. Therapeutic impact of percutaneous spinal biopsy in spinal infection. *Postgrad Med J* 2004; 80:607-609.
24. Staatz G, Adam GB, Keulers P, Vorwerk D, Günther RW. Spondylodiskitic abscesses: CT-guided percutaneous catheter drainage. *Radiology* 1998; 208:363-367.
25. Ito M, Abumi K, Kotani Y, Kadoya K, Minami A. Clinical outcome of posterolateral endoscopic surgery for pyogenic spondylodiscitis: Results of 15 patients with serious comorbid conditions. *Spine (Phila Pa 1976)* 2007; 32:200-206.
26. Yang SC, Fu TS, Chen HS, Kao YH, Yu SW, Tu YK. Minimally invasive endoscopic treatment for lumbar infectious spondylitis: A retrospective study in a tertiary referral center. *BMC Musculoskelet Disord* 2014; 15:105.
27. Fu TS, Chen LH, Chen WJ. Minimally invasive percutaneous endoscopic discectomy and drainage for infectious spondylodiscitis. *Biomed J* 2013; 36:168-174.
28. Chelsom J, Solberg CO. Vertebral osteomyelitis at a Norwegian university hospital 1987-97: Clinical features, laboratory findings and outcome. *Scand J Infect Dis* 1998; 30:147-151.
29. Legrand E, Flipo RM, Guggenbuhl P, Masson C, Maillefert JF, Soubrier M, Noël E, Saraux A, Di Fazano CS, Sibilia J, Goupille P, Chevalie X, Cantagrel A, Conrozier T, Ravaud P, Lioté F; Rheumatology Network Organization. Management of nontuberculous infectious discitis. Treatments used in 110 patients admitted to 12 teaching hospitals in France. *Joint Bone Spine* 2001; 68:504-509.
30. Bernard L, Dinh A, Ghout I, Simo D, Zeller V, Issartel B, Le Moing V, Belmatoug N, Lesprit P, Bru JP, Therby A, Bouhour D, Dénes E, Debard A, Chirouze C, Fèvre K, Dupon M, Aegerter P, Mulleman D; Duration of Treatment for Spondylodiscitis (DTS) Study Group. Antibiotic treatment for 6 weeks versus 12 weeks in patients with pyogenic vertebral osteomyelitis: An open-label, non-inferiority, randomised, controlled trial. *Lancet* 2015; 385:875-882.
31. Jin ZW, Song KJ, Lee NH, Nakamura T, Fujimiya M, Murakami G, Cho BH. Contribution of the anterior longitudinal ligament to ossification and growth of the vertebral body: An immunohistochemical study using the human fetal lumbar vertebrae. *Surg Radiol Anat* 2011; 33:11-18.
32. Berthelot JM, Le Goff B, Maugars Y. Pathogenesis of hyperostosis: A key role for mesenchymatous cells? *Joint Bone Spine* 2013; 80:592-596.
33. Hsu LC, Tseng TM, Yang SC, Chen HS, Yen CY, Tu YK. Bilateral portal percutaneous endoscopic debridement and lavage for lumbar pyogenic spondylitis. *Orthopedics* 2015; 38:e856-863.