One-Stage Surgical Treatment for Consecutive Multisegment Thoracic Spinal Tuberculosis with Kyphosis by Posterior-Only Debridement, Interbody Fusion, and Instrumentation

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OBJECTIVE: **To evaluate the clinical efficacy and feasibility of one-stage surgical treatment for consecutive multisegment thoracic spinal tuberculosis with kyphosis by posterior-only debridement, interbody fusion, and instrumentation.**

METHODS: **Sixty-two patients who underwent posterior debridement, interbody fusion, and instrumentation were reviewed for radiographic fusion, region kyphosis, neurologic status, and clinical outcomes. Thoracic Cobb's angle and Frankel grading system were used to assess kyphosis and neurologic improvements, respectively. Operation time, blood loss, erythrocyte sedimentation rate, C-reactive protein, visual analogue scale score, and postoperative complications were recorded to evaluate efficacy and feasibility.**

RESULTS: **The surgery duration was 234.5 ± 91.3 minutes, with blood loss of 761.3 ± 598.5 mL. The levels of erythrocyte sedimentation rate and C-reactive protein in all patients decreased gradually to normal within 3 months after the surgery. Kyphosis angle was corrected from 16.9 ± 10.9° preoperatively to 10.4 ± 6.3° postoperatively ($P < 0.001$, $t = 5.2$) and remained at 12.0 ± 6.6° at final follow-up ($P < 0.001$, $t = 4.6$). Twenty-seven patients obtained neurologic improvement by 1–3 grades. The average visual analogue scale score decreased from preoperative 3.7 ± 1.0 to postoperative 0.7 ± 0.9 ($P < 0.001$, $t = 16.4$), and then to 0.5 ± 0.3 at final follow-up ($P < 0.001$, $t = 21.5$). All patients achieved bony fusion. Recurrence of tuberculosis was not found in all patients.**

CONCLUSIONS: **One-stage posterior surgery of debridement, interbody fusion and instrumentation could serve as an efficient way to cure patients with consecutive multisegment thoracic spinal tuberculosis.**

INTRODUCTION

As human immunodeficiency virus infection increases, spinal tuberculosis (TB) is on the rise in both developing and developed countries.[1] Spine is the most common extrapulmonary location of TB, accounting for 2% of all TB cases and 50% of skeletal TB cases, of which thoracic vertebra is the most common.[2,3] A certain number of patients may develop consecutive multisegment thoracic spinal TB as a result of insidious onset, delayed diagnosis, or multiple drug resistance. With the emergence of anti-TB chemotherapy, conservative treatment becomes the mainstay treatment and manages to cure most cases.[4,5] However, surgical debridement and reconstruction are required for patients who suffer from neurologic deficits, severe pain, kyphotic deformity, or segmental instability.[6] The anterior and anterior-posterior approaches have been performed by some researchers as an effective treatment for consecutive multisegment thoracic spinal TB.[7-9] However, the contribution of 1-stage posterior surgical treatment for consecutive multisegment thoracic spinal TB is not well investigated. Therefore, this study aimed to evaluate the clinical efficacy and feasibility of 1-stage surgical treatment for consecutive multisegment thoracic spinal TB with kyphosis by posterior-only debridement, interbody fusion, and instrumentation.

Key words
- Consecutive multisegment thoracic spinal tuberculosis
- Kyphosis
- Posterior-only approach

Abbreviations and Acronyms
CRP: C-reactive protein
ESR: Erythrocyte sedimentation rate
TB: Tuberculosis
VAS: Visual analogue scale

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Table 1. Parameters

Basic Demographic Data	*n* (%)
Sex	
Male	38 (61.3)
Female	24 (38.7)
Age, years, mean (range)	54 (21—82)
<60	29 (46.8)
≥60	33 (53.2)
BMI	
≤18.4	3 (4.8)
≥18.5 to ≤23.9	51 (82.3)
≥24.0 to ≤27.9	7 (11.3)
≥28.0	1 (1.6)
HIV status	
None	62 (100)
Yes	0 (0)
Smoking status	
None	54 (87.1)
Yes	8 (12.9)
Back pain	
None	3 (4.8)
Yes	59 (95.2)
Low-grade fever	
None	49 (79.0)
Yes	13 (21.0)
Night sweats	
None	56 (90.3)
Yes	6 (9.7)
Weight loss, kg	
None	36 (58.1)
≤5	24 (38.7)
>5 to ≤10	2 (3.2)
Number of affected vertebrae, *n* (%)	
2 segments	48 (77.4)
3 segments	9 (14.5)
4 segments	3 (4.9)
6 segments	1 (1.6)
9 segments	1 (1.6)
Abscess	
Left	16 (25.8)
Right	14 (22.6)
Both	32 (51.6)

BMI, body mass index; HIV, human immunodeficiency virus.

MATERIALS AND METHODS

Subjects

The study was approved by the ethics board committee of our hospital. A total of 73 patients who underwent posterior surgery for consecutive multisegment thoracic spinal TB in our hospital from January 2010 to June 2016 were reviewed retrospectively. The diagnosis was made based on clinical presentations, laboratory results, radiologic findings, and pathologic examination. Clinical presentations included symptoms such as back pain, low-grade fever, night sweats, and weight loss. Laboratory results included the tuberculin test, mycobacterium TB-specific T lymphocyte test, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP). Radiologic findings included the presence of abscess on radiographs, computed tomography, or magnetic resonance imaging. Pathologic examination included sequestrum and granulation tissue. The inclusion criteria of this study were patients with 1) more than 3 continuous thoracic vertebrae involved; and 2) a minimum follow-up period of 18 months. The exclusion criteria were those 1) with less than 2-week anti-TB chemotherapy; 2) with active pulmonary TB; and 3) lost to follow-up or died from disease except TB. As a result, 62 patients were enrolled. Their back pain was rated using the visual analogue scale (VAS). Thoracic kyphosis was calculated by measuring the Cobb's angle between the upper and lower end plate of the infected level. Neurologic status was evaluated according to the Frankel grading system.

Preoperative Procedure

Patients were administered anti-TB drugs from the HREZ regimen, including isoniazid (5 mg/kg/day), rifampicin (15 mg/kg/day), ethambutol (15—25 mg/kg/day), and pyrazinamide (15—30 mg/kg/day) for at least 2 weeks before surgery. Surgery was performed when the ESR and CRP had significantly decreased, the temperature returned to normal, anemia and hypoproteinemia were resolved completely, and no sever liver or kidney function impairment existed. The average preoperative ESR and CRP were 56.9 ± 26.1 mm/h and 45.7 ± 17.5 mg/L, respectively.

Surgical Treatment

All patients were placed in the prone position after general anesthesia. A posterior midline incision was made for the exposure of bilateral lamina, facet joints, and transverse processes.

Table 2. Neurologic Function before and after the Surgery

Grade	Preoperative	Postoperative	FFU	*P1* (χ^2)*	*P2* (χ^2)†
A	4	0	0	<0.0167	<0.0167
B	5	1	1		
C	5	3	2		
D	15	11	9		
E	33	47	50		

FFU, final follow-up.
*Analyzed by the Friedman test, postoperative compared with preoperative.
†Analyzed by the Friedman test, FFU compared with preoperative.

Table 3. Clinic Outcomes of Surgery

	Preoperative	Postoperative	FFU	*P*1 (t1)*	*P*2 (t2)†
Kyphosis angle, °	16.9 ± 10.9	10.4 ± 6.3	12.0 ± 6.6	<0.001 (5.2)	<0.001 (4.6)
VAS, score	3.7 ± 1.0	0.7 ± 0.9	0.5 ± 0.3	<0.001 (16.4)	<0.001 (21.5)
ESR, mm/h	56.9 ± 26.1	42.4 ± 16.0	21.1 ± 9.0	<0.001 (6.0)	<0.001 (12.1)
CRP, mg/L	45.7 ± 17.5	33.6 ± 13.1	19.4 ± 10.8	<0.001 (7.0)	<0.001 (13.9)

FFU, final follow-up; VAS, visual analogue scale; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein.
*Analyzed by the paired *t*-test, postoperative compared with preoperative.
†Analyzed by the paired *t*-test, FFU compared with preoperative.

Pedicle screws were placed in the adjacent 2 normal vertebrae above and below the debrided segments, followed by the placement of a rod to stabilize the spine temporarily. After the removal of spinous process, lamina, facet joint, and ligamentum flavum, the corpectomy was performed and abscess, granulation tissue, and sequestrum were debrided completely. After decompression, the titanium mesh cage filled with autologous iliac crest or allograft bone was placed to restore spine alignment. Posterolateral fusion also was performed to ensure spinal stability. Finally, deformity was corrected and secured by installation of permanent rods. Streptomycin (1.0 g) and isoniazid (0.2 g) were locally imbedded in the intervertebral area during the operation. The operation time and blood loss were recorded.

Postoperative Procedure and Follow-Up

The drainage tube was removed when the drainage was less than 50 mL/24 h. To lower the risk of wound dehiscence and other complications, patients were required to stay in bed for 2 weeks after surgery with instructions to exercise their limb muscles. Patients were instructed to wear an orthosis until the achievement of bone fusion according to Lee's standard.[10] Anti-TB chemotherapy, which was the same as the preoperative regimen, was continued for 6 months postoperatively, followed by a regimen of isoniazid, rifampicin, and ethambutol for another 9–12 months with periodic re-examination of ESR, CRP, and liver and kidney function. All patients were examined radiologically at 1 week, 3 months, and 6 and 12 months after surgery and then once a year thereafter.

Statistical Analysis

All continuous data were presented as means ±standard deviation. All data were statistically analyzed using SPSS 21.0 software (IBM Corp., Armonk, New York, USA). Pre- and postoperative comparisons of Cobb's angle, VAS score, ESR, and CRP were performed by the paired sample t test. Pre- and postoperative comparison of Frankel grade was performed using the Friedman test. A Bonferroni-adjusted P value below 0.0167 was considered statistically significant.

RESULTS

Preoperative Features of Patients

Characteristics of the 62 patients are shown in Table 1. Thirty-eight male patients and 24 female patients were enrolled in the present study. There were 29 patients (46.8%) <60 years old and 33 patients (53.2%) ≥60 years old, with an average age of 54.27 ± 17.53 years (range, 21–82 years). With regard to the number of affected vertebrae, involvements of 2–4 segments were noted in 48 cases, 9 cases, and 3 cases respectively. Of the remaining 2 cases, one had an involvement of 6 segments and the other had an involvement of 9 segments. Abscess was observed on the magnetic resonance imaging scans of all patients, with 16 patients on the left side, 14 on the right side, and 32 on both sides (Table 1). The Frankel grading system was employed to assess neurologic status, with 4 patients being grade A, 5 patients being grade B, 5 patients being grade C, 15 patients being grade D, and 33 patients being grade E preoperatively (Table 2).

Postoperative Outcome of Patients

The average surgery duration was 234.5 ± 91.3 minutes, with mean intraoperative blood loss of 761.3 ± 598.5 mL. After an average follow-up period of 50.4 ± 18.1 months (range, 24–101 months), no recurrence of TB was found in all 62 patients. There was a significant improvement of thoracic deformity after the surgery. Kyphosis angle, which was 16.9 ± 10.9° preoperatively, was corrected to 10.4 ± 6.3° postoperatively ($P_1 < 0.001$, $t = 5.2$), followed by the level of 12.0 ± 6.6° at the final follow-up ($P_2 < 0.001$, $t = 4.6$). With regard to neurologic status, there were 18 patients who had improvement by 1 grade, 5 patients by 2 grades, and 4 patients by 3 grades, whereas the remaining 35 patients showed no improvement in neurologic status. Back pain was relieved postoperatively, with the average preoperative VAS score of 3.7 ± 1.0 decreased to 0.7 ± 0.9 postoperatively ($P_1 < 0.001$, $t = 16.4$) and then to 0.5 ± 0.3 at the final follow-up ($P_2 < 0.001$, $t = 21.5$) (Table 3). In all patients, the symptoms of low-grade fever and night sweat disappeared 2 weeks after the surgery. ESR and CRP values decreased gradually within 3 months after surgery and returned to normal at the final follow-up in all patients (Table 3). There was no complications related to the instrumentation at the follow-up. All patients achieved bony fusion within average 7.7 ± 1.5 months (range 6–9 months) after surgery (Figures 1 and 2).

DISCUSSION

Consecutive multisegment thoracic spinal TB, which has more extensive lesions and more severe destruction of vertebrae, is more prone to spinal cord compression, instability, and kyphotic deformities. In addition, due to limited space in thoracic spinal canal

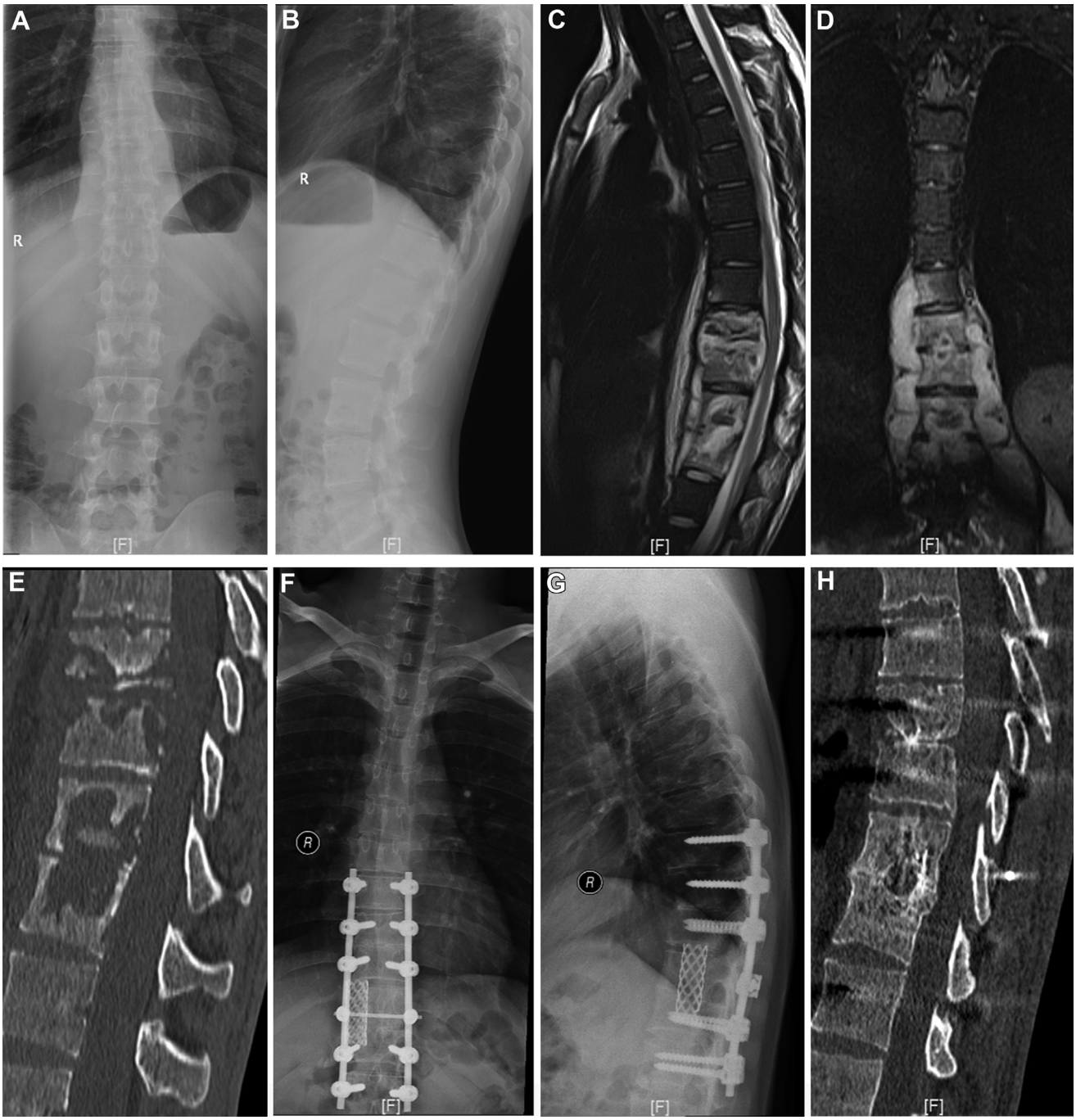

Figure 1. Preoperative (**A** and **B**) radiography, (**C** and **D**) magnetic resonance imaging, and (**E**) computed tomography (CT) of a 24-year-old male patient with tuberculosis at T8–T12 with extensive paravertebral abscesses. (**F** and **G**) Radiography and (**H**) CT at the final follow-up showed definitive bone fusion was achieved at T8–T12.

and relatively poor blood supply, thoracic spinal cord has poor tolerance to compression and intraoperative maloperation. Thus, identifying an ideal procedure with the achievement of debridement, deformity correction, and stability reconstruction for patients with consecutive multisegment thoracic spinal TB is of great significance. Although anterior, posterior, and combined approaches have been reported to be effective in the treatment for thoracic spinal TB,[11] a preferred one of them for consecutive

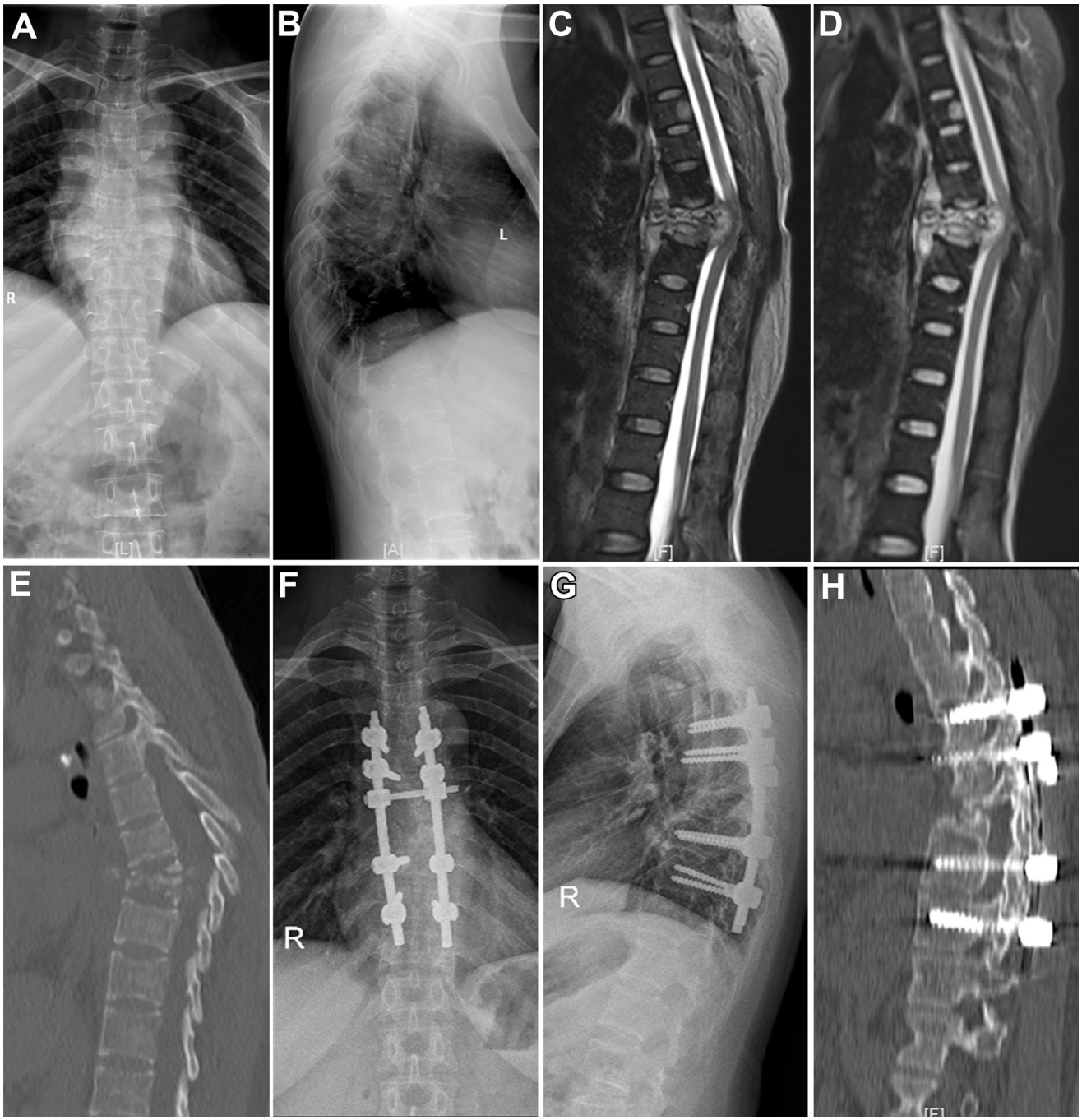

Figure 2. Preoperative (**A** and **B**) radiography, (**C** and **D**) magnetic resonance imaging, and (**E**) computed tomography (CT) of a 38-year-old female patient with tuberculosis at T6–T8 with extensive paravertebral abscesses. (**F** and **G**) Radiography and (**H**) CT at the final follow-up showed definitive bone fusion was achieved at T6–T8.

multisegment thoracic spinal TB is yet to be established. This study demonstrated that the posterior approach was able to achieve sufficient debridement, kyphosis correction, and spinal stability without surgery-related complications and TB recurrence.

The anterior approach has been successfully applied to remove TB focus and relieve spinal cord compression.[12,13] As TB infection frequently involves the anterior and middle columns, the anterior approach provides direct access to the lesions, which facilitates

radical lesion removal and easier spinal column reconstruction.[14,15] However, the anterior approach requires thoracotomy and laparotomy, which are associated with increased incidence of complications and mortality.[11,16] Moreover, anterior reconstruction is inferior in kyphosis correction due to inadequate leverage.[8] Combined surgery of anterior and posterior approaches not only possesses the same advantages as anterior approach but also overcomes the limitation of poor correction and provides better biomechanical stability through posterior instrumentation. Nonetheless, the combined approach is associated with massive trauma, prolonged surgery time and hospital stay, and comparatively greater cost.[17] Minimally invasive surgical strategy is a trend in spine surgery. A smaller incision and single approach have been advocated in the surgical treatment of spinal TB.[18,19] Single-stage posterior procedure was reported to provide satisfactory clinical outcome for patients with TB, with minimal surgical invasion and without anterior approach-related complications.[20] Consistent with this study, our results demonstrated the advantages of the posterior procedure of debridement, strut grafting, and instrumentation in sufficient kyphosis correction, and spinal stability recovery for patients with consecutive multisegment thoracic spinal TB.

Because kyphotic deformity is one of the causes for late-onset paraplegia, loss or undercorrection of kyphotic deformity may result in poor clinical outcomes.[21] In the posterior procedure, resection of posterior elements of spinal column assists the kyphosis correction. In addition, posterior instrumentation with pedicle screws could achieve 3-dimensional correction and 3-column stability. On the contrary, anterior instrumentation does not provide the same biomechanical strength as pedicle screws, which could result in hardware failure and loss of correction.[22] Many studies demonstrated that posterior instrumentation is superior in kyphosis correction.[23,24] Our study confirmed that posterior instrumentation was capable of correcting kyphosis and maintaining the correction in patients with consecutive multisegment thoracic spinal TB.

With regard to lesion debridement, a posterior approach was questioned for its effectiveness in cases with foci involving more than 2 consecutive segments.[25] In addition, some authors worried that the posterior procedure may result in intraspinal and central nervous system TB infection.[26,27] In our study, all patients with consecutive multisegment thoracic spinal TB recovered normal ESR and CRP levels within 3 months after posterior procedure and showed no signs of TB recurrence or dissemination until the final follow-up. The favorable outcome may be attributed to the greater operation space created for direct vision of lesions by resecting bilateral facet joints, lamina, and nerve roots. Furthermore, the standardized application of antitubercular chemotherapy helps to control the infection effectively.[28]

Some limitations should be noted in our study. First of all, the retrospective nature of data collection subjects the study to selection bias. Our study included a relatively small number of patients, and the follow-up time for evaluating patient outcome was relatively short. Moreover, a lack of comparisons between different surgical approaches may undermine the evidence level. A randomized controlled trial by different surgical approaches with a larger population and longer follow-up time is warranted to further confirm our findings.

CONCLUSIONS

One-stage posterior surgery of debridement, interbody fusion, and instrumentation is a feasible and effective procedure for consecutive multisegment thoracic spinal TB, with the advantages of efficient kyphosis correction, minimal surgical invasion, and low incidence of complications.

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