

One-Stage Debridement and Bone Grafting With Internal Fixation via Posterior Approach for Treatment of Thoracic Spine Tuberculosis

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The study aimed to investigate the clinical efficacy and feasibility of one-stage surgical treatment for thoracic spinal tuberculosis by internal fixation, debridement, and combined interbody and posterior fusion via a posterior-only approach. A total of 12 patients (8 male, 4 female) with thoracic tuberculosis whose lesions were confined to 2 adjacent segments were admitted to our hospital. The American Spinal Injury Association (ASIA) impairment scale was used to assess neurologic function. All patients were treated with one-stage surgical treatment by internal fixation, debridement, and combined interbody and posterior fusion via a posterior-only approach. Patients were evaluated preoperatively and postoperatively by measurement of thoracic kyphotic angles using Cobb angle evaluation, determination of erythrocyte sedimentation rate, evaluation of ASIA impairment scale, and radiologic examination. Operation time ranged from 60 to 150 minutes (average, 120 minutes). Intraoperative blood loss ranged from 300 to 850 mL (average, 500 mL). All patients were followed up for 24 to 48 months postoperatively (average, 32 months). No sinus tract formation, cerebrospinal meningitis, or recurrence of tuberculosis occurred. All patients had significant postoperative improvement in ASIA classification scores. The thoracic kyphotic angles were significantly decreased to 12° to 30° postoperatively, and at final follow-up were 14° to 28°. The erythrocyte sedimentation rate recovered to normal within 6 months postoperatively in all patients. Bone fusion was achieved within 3 to 6 months (average, 5 months). One-stage surgical treatment for thoracic spinal tuberculosis by internal fixation, debridement, and combined interbody and posterior fusion via a posterior-only approach can be an effective and feasible treatment method.

Key words: Thoracic tuberculosis – Internal fixation – Posterior

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As the most common extrapulmonary form of tuberculosis, spinal tuberculosis is a growing hazard worldwide and has an aggressive behavior of profound vertebral destruction and severe complications.¹ Patients with thoracic spinal tuberculosis often suffer from severe spinal cord damage and kyphotic deformity, requiring surgical treatment. Anterior debridement and bone grafting and either anterior or posterior internal fixation have been performed by many researchers as an effective treatment for thoracic spinal tuberculosis.^{2,3} However, this procedure may carry a risk of cardiopulmonary complications and prolong recovery time. In addition, exposure of the two thoracic vertebral segments remains a great challenge to surgeons. Orthopedic operations should be well tolerated, minimally invasive, and associated with only minor postoperative complications. The purpose of this study was to evaluate the clinical efficacy and feasibility of one-stage surgical treatment of thoracic tuberculosis by internal fixation, debridement, and interbody bone fusion via a posterior-only approach.

Patients and Methods

The study was approved by the ethics board committee of our hospital. From January 2006 to January 2012, a total of 36 patients with thoracic vertebral tuberculosis were admitted to our department, and 12 patients whose lesions were confined to two adjacent segments were involved in this study. Criteria included tuberculous spondylitis that was mainly confined to one side of the vertebrae without a wide range of tuberculosis abscessation. The patients were 8 men and 4 women with a mean age of 52 years (range, 12–68 years), and kyphosis as indicated by a Cobb angle of 36° to 72° (average, 50°). The diagnosis of tuberculosis spondylitis was based on clinical presentation, radiologic findings [plain X-rays, computed tomography (CT), and magnetic resonance imaging (MRI)], and hematologic and pathologic examinations. Clinical presentation manifested thoracodorsal pain, night sweats, low-grade fever, weight loss, thoracic kyphosis, and neurologic dysfunction. Diseased segments were observed at T5 to T6 in 2 patients, T6 to T7 in 3 patients, T7 to T8 in 5 patients, and T8 to T9 in 2 patients. The American Spinal Injury Association (ASIA) impairment scale⁴ was applied to evaluate preoperative neurologic dysfunction; 1 patient was grade A, 2 patients were grade B, 6 patients were grade C, and 3 patients were grade D. The

erythrocyte sedimentation rate (ESR) ranged from 48 to 78 mm/h (average, 60 mm/h). Paralysis was progressively aggravated in 10 patients; 2 patients had mild pleural thickening, and 2 had partial destruction in one side of the vertebral pedicle.

Indication for this study was that lesions were confined to two adjacent segments, were without a wide range of tuberculosis abscessation, and could be thoroughly debrided during the preoperative evaluation, besides having any of the following situations: (1) the presence of significant vertebral collapse caused by bone destruction and spinal instability; (2) severe kyphotic deformity (Cobb angle of >30°); (3) spinal cord compression by paravertebral/epidural abscesses, and severe or progressive neurologic dysfunction; or (4) the formation of a large hollow or significant sequestrum.

Preoperative procedure

Three to five weeks prior to the operation, the patients were administered the antituberculosis drugs isoniazid (5–10 mg/kg/d, no more than 300 mg/d), rifampicin (5–10 mg/kg/d, no more than 300 mg/d), and ethambutol (15 mg/kg/d, no more than 500 mg/d). Enhancement of nutrition and correction of anemia and hypoproteinemia were carried out. The extent of vertebral lesions and range of abscessation were determined by X-ray, CT, and MRI. We use preoperative halo traction for patients with severe kyphosis deformity, but not all patients undergo preoperative traction. If there is rigid oppression in the spinal canal or progressive neurologic dysfunction during halo traction, halo retraction must be terminated. It must also be terminated if patients cannot tolerate continuous traction.

Preoperative halo traction was usually adopted within 2 weeks, and the weight was 3 to 5 kg. Surgery was performed when the anemia and hypoproteinemia had been corrected according to ESR, and the temperature had returned to normal or had significantly decreased.

Operative procedure

The patients were placed in prone position under general anesthesia with somatosensory-evoked potential monitoring. Intraoperative halo traction of 3 kg was applied to lessen thoracic kyphosis deformity and to maintain spinal stability. Through a midline incision, extraperiosteal dissection at

both nonfusion and fusion levels was performed. The posterior spinal construction was exposed, including the spinous processes, lamina, facet joints, and transverse processes. The range of exposure at the level of decompression was expanded to include the bilateral costotransverse articulations and 3 to 5 cm of the medial ribs. With C-arm fluoroscopy assistance, pedicle screws or hooks were placed at least two levels superiorly and inferiorly to the level of decompression. First, a temporary rod on the mildly affected side of the lesion was placed to avoid spinal cord injury during decompression and focal debridement. Screws were also placed in diseased vertebrae if the upper part of the vertebral body was not destroyed. Second, costotransversectomy and removal of the articular process, pedicle, and transverse process on the more severely affected side of the lesion segment were performed to drain prevertebral abscesses and expose diseased vertebral bodies. The thoracic nerve roots on the focal side were sacrificed for better exposure. After the posterior longitudinal ligament was separated from the dural sac with a nerve dissector, a nerve root retractor was used to protect the spinal cord. A scalpel was used to incise the posterior longitudinal ligament. Spatulas of various sizes and angles were used from a posterolateral approach to remove lesions, including sequestra, abscesses, and granulation tissues. The abscesses were drained by suction and curettage as thoroughly as possible. If bilateral vertebrae were severely damaged, the temporary rod was switched to the other side, and the same debridement and decompression procedure was performed. Correction of the kyphosis deformity was accomplished by installing contoured permanent rods and exertion of decompression at the middle anchoring point with a cantilever bending maneuver. After sufficient spinal cord decompression was achieved, suitable strut grafts were used for stabilization. Tricortical rectangular grafts from the iliac crest were harvested from 4 patients, cortical allografts were used in 3 patients (Fig. 1), and titanium mesh cages filled with morselized autogenous bone were used in another 5 patients (Fig. 2). After internal fixation, debridement and interbody thoracic fusion were performed, and strip-sized autogenous bone or allograft bone was imbedded in the posterior body to fuse the segments that underwent decompression and focal debridement. Streptomycin (1.0 g) and isoniazid (0.3 g) were locally deposited, and drainage and placement of incisional sutures were

performed postoperatively. The debrided material underwent bacterial culture and histopathologic examination.

Postoperative management

Patients remained in bed for 2 weeks and then walked around under the effective support of a brace for 6 to 8 months. Nutritional improvement and support therapy were regularly performed. The drainage tube was pulled out when volume was <30 mL per 24 hours, which occurred within 3 days postoperatively in most patients. According to the general condition, early application of physical therapy and rehabilitation training was performed to prevent blood clots and restore nerve function. Antituberculosis chemotherapy was administered for 12 to 18 months postoperatively, and the patients were instructed to undergo monthly routine blood and hepatic function examinations to monitor for any adverse reactions to the antituberculosis agents. ASIA classification, ESR, and C-reactive protein were evaluated monthly, and X-ray and CT were examined every 3 to 6 months.

Statistical analysis

A paired *t*-test was used to evaluate preoperative and postoperative ESR, ASIA classification, and thoracic kyphosis according to the Cobb angle. Customarily, a *P* value of <0.05 was considered statistically significant using SPSS version 17.0 for Windows. Discrepancy of the normal distribution was evaluated by a rank-sum test with a significance level of 0.05.

Results

Surgical condition and neural recovery

The average operative time was 120 minutes (range, 60–150 minutes), and average blood loss was 500 mL (range, 300–850 mL). No perioperative complications related to instrumentation or decompression occurred. The duration of postoperative follow-up was 32 months (range, 24–48 months). No patients developed wound infection, sinus formation, or infectious meningitis, and none experienced tuberculosis relapse. Symptoms of tuberculosis disappeared. All patients had significant improvement in postoperative ASIA classification score (*P* < 0.001). Results are summarized in Table 1.

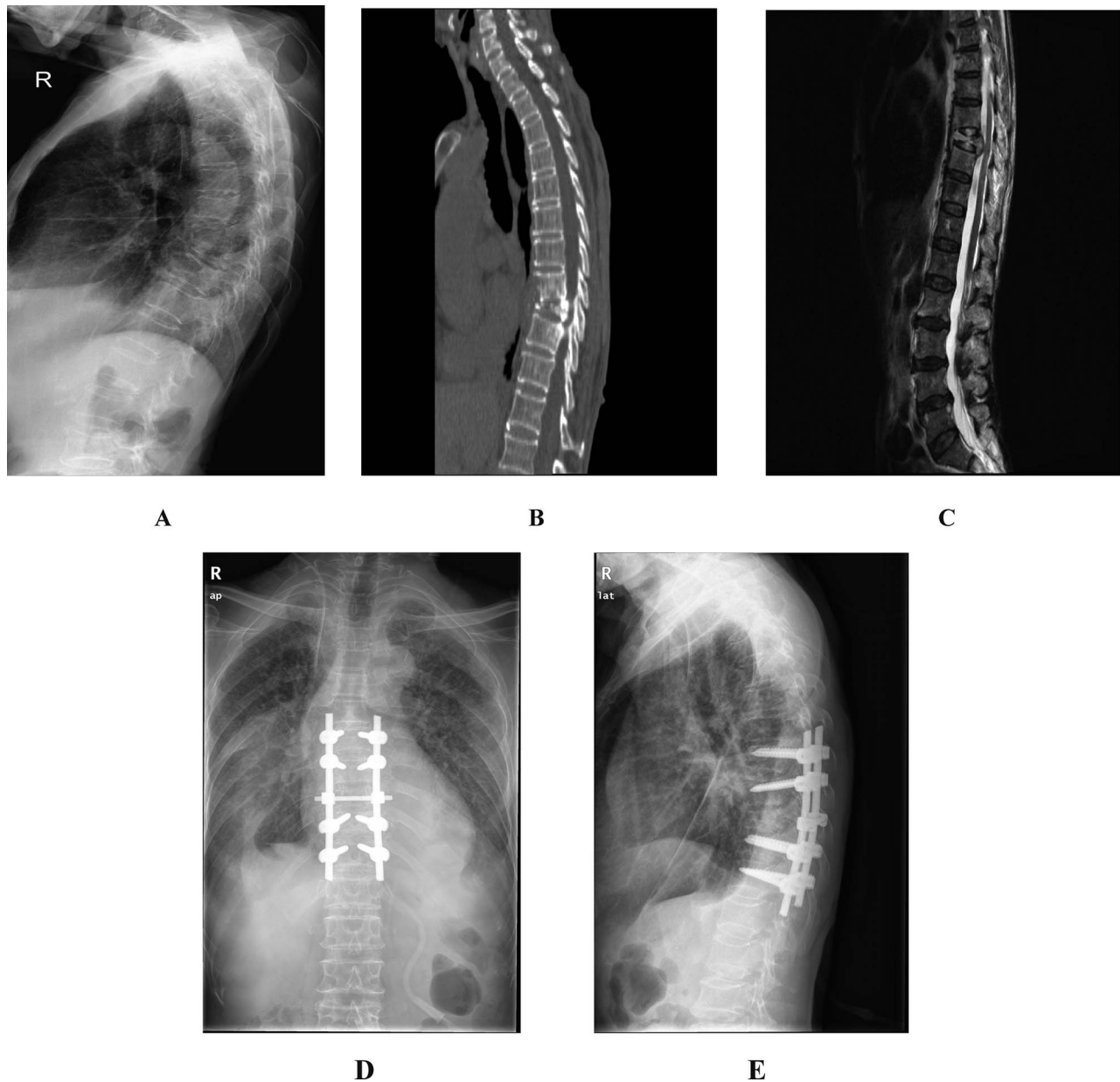


Fig. 1 A 38-year-old man with thoracic tuberculosis related to T8~9 disc. (A and B) X-ray and CT before operation showed that the substance of bone in the vertebral body of T9 was destructive, accompanied by narrowing of intervertebral space and kyphosis deformity of the spine column. (C) MRI before operation showed the spinal cord was compressed by tuberculosis lesion. (D and E) Anteroposterior X-ray film and lateral X-ray after operation showed the kyphosis angle recovered and internal fixation position was normal.

Laboratory data

Postoperative pathologic examination proved the presence of tuberculosis in all patients. The ESR and CRP returned to normal within 3 months postoperatively. The preoperative mean ESR value was 60 mm/h (range, 48–78 mm/h), which normalized within 3 months postoperatively in all patients ($P < 0.001$).

Radiologic data

The average thoracic Cobb angle was significantly decreased at 16° (range, 12°–30°) postoperatively and was 17.5° (range, 14°–28°) at final follow-up. The loss of correction was only 1.5°. There were statistically significant differences compared with the preoperative measurements ($P < 0.001$), but there was no significant difference between the postoperative

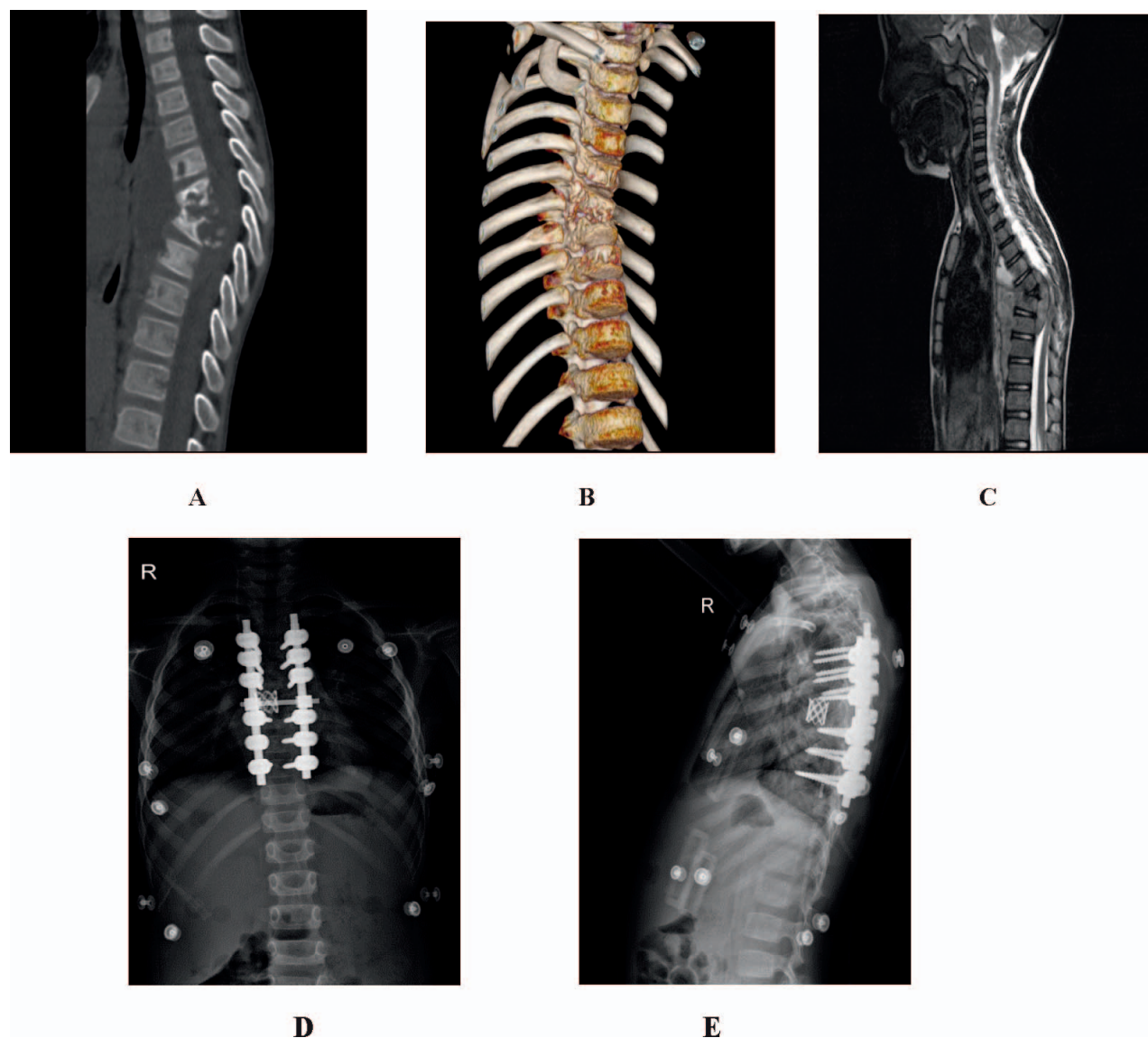


Fig. 2 A 12-year-old child with thoracic tuberculosis related to T6~7 disc. (A and B) CT before operation showed that the substance of bone in the vertebral body of T6~7 was destructive, accompanied by narrowing of intervertebral space and kyphosis deformity of the spine column. (C) MRI before operation showed the spinal cord was compressed by tuberculosis lesion and the perispondylitic abscess formed around a long disc. (D and E) Anteroposterior X-ray film and lateral X-ray after operation showed the kyphosis angle recovered and internal fixation position was normal.

thoracic Cobb angle and that at final follow-up ($P > 0.001$).

CT was performed as a routine examination to evaluate bone fusion. Achievement of bone fusion was based on Bridwell standard⁵: adjacent surface without gaps, obvious trabecular bone through the graft surface, and displacement of $B \leq 3^\circ$ on dynamic X-ray films. All patients obtained intervertebral and posterior bone fusion within 48 months (mean, 5 months).

Discussion

The purpose of spinal surgery involves removal of the focus, complete decompression of nerves, correction of spinal deformity, and reconstruction of spinal stability. The radiographic criteria of thoracic spinal instability were as follows: (1) sagittal translation was greater than 2.5 mm in lateral X-rays; (2) subluxation or dislocation of the facet joint at the apex of the kyphosis; (3) translation

Table 1 Clinical data of patients

Case no.	Age, y/sex	Follow-up, mo	Diseased segments	Kyphotic Cobb angle, °			ASIA		ESR, mm/h	
				Preoperative	Postoperative	Final follow-up	Preoperative	Final follow-up	Preoperative	Three-month postoperative
1	39/M	24	T5–T6	59	28	27	C	E	51	11
2	12/F	32	T6–T7	67	18	17	A	D	62	8
3	48/F	29	T7–T8	38	30	28	C	E	48	5
4	21/M	48	T7–T8	72	12	12	C	E	78	12
5	60/M	30	T7–T8	35	17	16	B	D	72	10
6	45/M	42	T6–T7	66	22	20	D	E	65	7
7	38/M	46	T8–T9	43	15	14	C	E	50	15
8	53/F	29	T7–T8	34	29	28	C	E	49	7
9	60/M	37	T6–T7	57	18	17	B	D	55	6
10	57/M	25	T8–T9	67	17	15	D	E	72	11
11	33/F	27	T7–T8	59	16	15	C	E	50	10
12	47/M	33	T5–T6	41	15	14	D	E	52	13

of the vertebral column in coronal plane; and (4) segmental kyphosis angle was greater than 30° in the lateral X-rays. Because spinal tuberculosis mostly involves the spinal anterior column, surgical treatment through an anterior approach was long considered to be the “gold standard” because it can provide direct access to vertebral body lesions, allowing for efficient reconstruction of the anterior spinal column.⁵ Nevertheless, in thoracic tuberculosis, anterior exposure of the lesions is blocked by the thoracic bones, clavicle, costal bone, and mediastinal organs.⁶ It is difficult to reveal the thoracic vertebrae by thoracotomy because of obstruction of complex anatomic structures.⁷ Issack and Boachie-Adjei⁸ used an anterolateral transthoracic approach for upper thoracic vertebral tuberculosis. This procedure requires massive transaction of muscle tissue and causes great injury. The procedure of thoracotomy requires going through the pleural cavity, which may result in perioperative complications, including respiratory insufficiency, hemopneumothorax, pneumonia, and vascular risk.⁹ Thoracotomy is considered to be contraindicated in patients with extensive pleural adhesions. Kim *et al*¹⁰ used an anterior transsternal approach to treat upper thoracic vertebral tuberculosis while avoiding the pleural cavity. However, the approach involved complex and vital structures and injured the recurrent laryngeal nerve, vagus nerve, phrenic nerve, thoracic duct, and other important structures, and the consequences were disastrous. The thoracic posterolateral surgical approach supplies a limited operative field, and it is inconvenient to install vertebral body screws; moreover, the orthopedic effect and stability of internal fixation are dissatisfactory. Although video-assisted thoracoscopic sur-

gery is a minimally invasive procedure with which to expose the anterior thoracic column, video-assisted thoracoscopic surgery is associated with a steep learning curve for orthopedic surgeons to master the thoracoscopic surgical technique.¹¹ It is also inconvenient to perform debridement and instrumentation for the upper thoracic vertebrae.

An “easy, effective, and minimally invasive” surgical treatment for thoracic spinal tuberculosis to achieve simultaneous debridement, deformity correction, and bone graft fixation has been debated. Over the years, many scholars believed that posterior laminectomy for removal of the lesion destroyed the normal structure of the posterior column, making the spinal column more unstable. Many have also supposed that the posteriorly exposed space was limited, the lesion may not be completely clear, and there is a risk of spinal cord injury. Thus, most scholars do not advocate adoption of the posterior approach for thoracic tuberculosis.¹² Removal of a single costotransverse joint and facet joint slightly affects spinal stability for the following reasons: (1) Activities of the thoracic spine are limited, and spinal stability is maintained by the supporting role of the ribs and fixed effects of the sternum.¹³ (2) Fixation of pedicle screws with 3 columns supplies good support force, including antitorsion and antibuckling capabilities, corrects the deformity, and stabilizes the lesion level. (3) With intertransverse and posterior bone grafting, reconstruction of the stability of the posterior column is actually achieved. Some scholars have expressed concern that lesions confined to the vertebral body could spread to the lamina of the vertebra and spinous process to result in infectious meningitis. However, standard antituberculosis chemotherapy can prevent recurrence and metastasis of

tuberculosis,¹⁴ and the current relevant literature and our study show that such complications are rare.¹⁵ Compared with patients treated with anterior approach, patients treated with posterior approach are more conducive to drainage of residual lesions postoperatively in the supine position because of gravity.

The results of this study revealed that compared with other surgical procedures, surgical treatment of thoracic spine tuberculosis has unique advantages.

1. Debridement, spinal cord decompression, correction of deformities, bone grafting, and internal fixation can be completed in one incision and surgical position and iatrogenic spinal injury can be avoided while turning over, which is similar to the best results obtained via anterior decompression.¹⁶
2. Without one-lung ventilation, the interference of pulmonary function is relatively small, and there are fewer postoperative complications, such as atelectasis, lung infection, and chylothorax, because of fewer traumas. Even if there are severe pleural adhesions, the operation can be performed safely.
3. Under direct vision, spinal canal decompression from the anterior, lateral, and posterior aspects (decompression at the 270°) can be thoroughly performed. Removal of the ribs, transverse process, and small joints on one side can supply enough operative space for exposure of lesions to perform internal fixation, debridement, and interbody thoracic fusion. In our study, neurologic function of patients with paraplegia was significantly improved postoperatively.
4. Pedicle screws used in surgery can not only strengthen the spinal 3-column stability with the normal physiologic curvature of the spine, but can also be pressurized to correct kyphosis. Use of the “bowstring principle” to further relieve spinal cord compression and intraoperative pressure on the graft bone mass solidifies the graft.¹⁷ However, for patients with spinal tuberculosis with large prevertebral abscesses or destruction of consecutive multisegmental vertebrae, it is difficult to achieve satisfactory debridement by the posterior approach.

Conclusion

Surgical treatment of thoracic spinal tuberculosis by internal fixation, debridement, and combined inter-

body and posterior fusion via a posterior-only approach is feasible. It is minimally traumatic, has a high correction rate, and prevents the progression of kyphosis. The decompression of the spinal cord can be satisfactory. To date, the clinical and radiographic outcomes have been good. Of course, further study with a large number of patients and longer follow-up will be required.

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