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Original Article

Single-stage posterior articular process approach in surgical treatment of thoracic spinal tuberculosis by internal fixation, debridement and fusion

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Abstract: Objective: To evaluate the clinical effects and feasibility of single-stage posterior articular process approach in surgical treatment of thoracic spinal tuberculosis by internal fixation and fusion. Method: This is a retrospective study including 32 patients with thoracic spinal tuberculosis and vertebral destruction in our hospital from November 2012 to August 2015. All patients were treated with the one-stage posterior articular process approach to focus on debridement, bone autograft and posterior pedicle screw fixation and fusion. Then the antitubercular drugs were taken strictly post-operation. We measured the radiographic parameters, including kyphosis (Cobb) angle and sagittal balance, and evaluated the America Spinal Injury Association grade (ASIA), the Japanese Orthopaedic Association Scores (JOA), the visual analog scale score (VAS), and the long-term complications and symptoms. Meanwhile, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were detected to evaluate the activity and recurrence of tuberculosis (TB). Result: There were 18 males and 14 females with an average age of 48.9 years (ranging 10 to 76 years). The 32 patients underwent a mean follow-up period of 25.6 months (ranging from 12 to 45 months). According to the preoperative ASIA score, there were 5 cases grade B, 9 grade C, 10 grade D, and 8 grade E. The involved segments included 23 cases in 1 segment, 4 cases in 2 segments, 4 cases in 3 segments, and 1 case in 4 segments. The kyphosis Cobb angle ranged from 13.3° to 50.5° (mean 27.6°). The 30 patients were completely cured with no recurrence, and 2 patients (6.25%) were recurrent. One was cured with a second surgery and the other was cured under conservative therapy. The mean time of the operation was 158±86 min (120-220 min) and intraoperative blood loss was 324±286 mL (200-750 mL). At the last follow-up day, 9 cases (30%) improved by two grades, 13 cases (43.3%) improved by one grade, and 8 cases (26.7%) did not improve according to the ASIA grade. The mean improvement rate of ASIA is 73.3% (including an improved 1 or 2 grades). There was a significant difference between pre-operation day and the final follow-up (P<0.01). The Kyphotic cobb angle decreased to 6.2-18.9° (mean 10.5°) (t=12.267, P<0.01), with an average correction angle of 17.1°, average correction rate of 62%, and loss of correction of only 1.8° at the final follow-up (t=11.687, P<0.01). The JOA score increased from 5.5±3.3 to 8.8±3.3 (t=-7.287, P<0.01) and the mean rate of improvement was 60%. The VAS decreased from 6.8±1.6 to 1.7±2.3 (t=14.739, P<0.01) and the average rate of improvement was 75%. Finally, the ESR and CRP dropped from 35.5±20.0 mm/h and 45.3±46.8 mg/L to 8.6±5.8 mm/h (t=9.876, P<0.01) and 8.8±7.4 mg/L (t=11.324, P<0.01). Conclusion: This treatment is an efficient and feasible method, and it causes low trauma and destruction of the posterior structure of the thoracic vertebrae. However, careful selection of patient is critical to the successful outcome of this technique.

Keywords: Thoracic tuberculosis, articular process approach, intervertebral foramen approach, posterior surgical approach

Introduction

Since 2010s, the incidence and morbidity of tuberculosis significantly raised with the increase of tuberculosis resistance and HIV infection rate. Especially in poor developing countries, it has been an important factor that influenced the human health [1]. Spinal tuberculosis is the most common type of the bone and joint tuberculosis, accounting for approximately 50% to 70%. The focus could damage vertebral stability and then lead to spinal kyphotic deformity,

which could also compress the medulla spinalis causing dysneuria, paraplegia and even death [2, 3]. Antituberculosis drugs are critical to cure tuberculosis, in which the first choice is multiple drug combination chemotherapy for spinal tuberculosis. However, surgical intervention is necessary for the complications induced by treating tuberculosis, especially the severe neurological dysfunction, rest pain and severe spinal kyphotic deformity [4]. At present, the operation of thoracic tuberculosis includes anterior, posterior and anterior combined posterior approach (posterior spinal fusion followed by anterior spinal fusion). Anterior approach to the thoracic spine is challenging, and the posterior approach is preferred, especially with the use of minimally-invasive surgery, which provides the smaller wound [5]. However, the traditional posterior approach requires the resection of the transverse process of the thoracic vertebra, a part of the ribs, the vertebral plate, spinous process, and even the corresponding nerve root beside the lesion in the traditional posterior approach. So, we came up with posterior articular process approach that was modified from the traditional posterior approach decreasing the resection range. There are a few reports on the treatment of thoracic spinal tuberculosis using a similar method. The present study aims to assess the clinical and radiographic outcomes of the one-stage surgical treatment for thoracic spinal tuberculosis through internal fixation, debridement and fusion via the posterior articular process approach.

Materials and methods

Sample

A total of 32 patients with thoracic spinal tuberculosis and vertebral destruction were included in the investigation at Lanzhou University Second Hospital from November 2012 to August 2015. Most symptoms were chest and back pains, marasmus, fever, hypodynamia and significant spinal kyphosis. Some patients also presented with different degrees of neurological deficits. Patients met the following indications of surgery: (1) progressive neurological deficit, (2) persisting pain due to instability, (3) severe kyphosis or kyphosis likely to progress, and (4) poor outcomes following conservative treatment.

Diagnosis of tuberculosis mainly depended on typical symptoms (such as low-grade fever, night sweat, weight loss and anorexia), laboratory examinations (such as CRP and ESR), rachiterata and bone damage observed by X ray, CT and MRI, and combined the results of acid-fast stain of postoperative lesions, mycobacterium tuberculosis cultivation and pathological examination with one-state surgical treatment by internal fixation, debridement and fusion via the posterior articular process approach, and strictly combined with chemotherapy according to the 3HRES+9HRE (H: Isoniazid, R: rifampicin, E: ethambutol, S: streptomycin; 3 months; 9 months) [6]. Patients could stop the drugs when no active TB was found.

Preoperative preparation

After confirmed diagnosis of thoracic tuberculosis, patients were regularly treated with antituberculosis drugs, and treated with operations after 2 weeks if the patients had no neurological deficit or mild neurological dysfunctions and aggravation. Meanwhile, if they had neurological deficit which reflected an aggravating trend, they were treated with antituberculosis drugs and received an emergency care. The patients were first treated with medical treatment when they experienced severe hypertension, diabetes mellitus or severe heart, lung, liver and kidney dysfunctions at the same time, until they had no contraindication risks for operation.

Interventions

After general anesthesia, the patient was placed in prone position and provided with a hollow cushion and abdominal suspension. The pathological vertebral body was considered as the center, and then a posterior median incision was made, and treated with upper and lower incisions to extend to a normal vertebral body separately. The bilateral paravertebral muscles were dissected to expose the vertebral plate and processus transversus, and pedicle screws were implanted into the cranial and caudal adjacent vertebrae. If the vertebral body was seriously damaged, the temporary pedicle screw was used to prevent the collapse of the vertebra aggravating the nerve damage during focal cleaning. Along the lateral border of the articular process, gun bone rongeur was used to bite the facet joint of the segments beside the lesions layer by layer in order to expose the

nerve root under it. The nerve roots were moved to the side and then protected closely from the foramen intervertebrale to the focal intervertebral space. Nucleus pulposus forceps and spatula were used to completely resect the necrotic tissue and the osteonecrosis of the upper and lower vertebrae. Meanwhile, the angle head nucleus pulposus forceps and the spatula were used to strike the lesions off, clean the focus and intervertebral disk as well as the soleplate of corresponding segments (**Figure 1**). Provided that the anterior spinal cord was oppressed, the vertebral plate could be excised partly. The lateral spinal canal firstly needed to reduce the pressure, and the anterior lesion of the dural sac was taken out by pushing it from the outside to the forward position to achieve the pressure reduction. After clearing the tuberculous necrotic tissue completely, a 200-300 mL 3% H_2O_2 solution and normal saline were used to wash the lesions, and then implanted into the biting autogenous bone. If the lesion had multiple segments or a bilateral abscess, the above method was applied to handle other segments and contralateral lesions. Then the pedicle screw was used to fix the upper and lower segments that were adjacent to the disease vertebrae. If the residual part of the diseased vertebral body was located in the upper vertebral body, it could be controlled using the screw, or be fixed with a nail on the diseased vertebrae. After firm fixation, drainage tube was implanted and the incision was sewed up.

Postoperative management

During the first postoperative week, we routinely observed the wound drainage, altered neural function state and postoperative complications of patients. When no liquid was drained from the drainage tube after 4 to 7 days of the operation, the tube was pulled out before leaving the hospital. Additionally, if the patients continued to be treated with antituberculosis drugs for at least 12 months after the operation, they should lie in bed for 3 to 4 weeks. If not, they should sit and walk supported by the fixation equipment for a period of 12 weeks. Postoperative X-rays were obtained for all patients, and partial cases described above also needed to be checked by the CT to evaluate the operative conditions and inter fixed position. Few patients required a postoperative CT-scan in order to evaluate the local situation and the instrumentation. Additionally, ESR, C reaction protein (CRP), liver and kidney functions and imaging examination were measured monthly.

Statistical analysis

The SPSS 19.0 software (SPSS, Inc., Chicago, IL, USA) was used to statistically analyze the preoperative and postoperative observation indexes. The paired t test was used to analyze the JOA scores, VAS scores, Cobb angles, ESR and the CRP of preoperative, postoperative as well as the follow-up. Meanwhile, the nonparametric rank sum test was conducted to analyze the ASIA degree, and the enumeration data was presented as percentages and analyzed by the χ^2 test. $P<0.05$ was considered the differences with statistical significance.

Results

This study included 18 males and 14 females with an average age of 48.9 years (range 10 to 76 years). All 32 patients underwent a follow-up period with a mean of 25.6 months (ranging from 12 to 45 months). According to the preoperative ASIA score, 5 cases were in grade B, 9 cases in grade C, 10 cases in grade D and 8 cases in grade E. The involved segments were as following: 23 cases located in 1 segment, 4 cases in 2 segments, 4 cases in 3 segments, and 1 case in 4 segments. The kyphosis Cobb angle ranged from 13.3° to 50.5° (mean 27.6°). The operation time was 120-220 min with an average of 158±86 min. The operative bleeding volume was 200-750 mL with an average of 324±286 mL (**Table 1**). The patients presented no acute complication, such as postoperative spinal cord compression or intercostal nerve injury. After the operation, all 30 cases were relieved, whose pains of chest and back relieved postoperative 1 to 3 weeks, and their CRP and ESR gradually recovered to normal postoperative 1 to 2 months (mean ± SD). 2 patients (6.25%) showed tuberculosis recurrence, aged 74 and 69 years old, whose courses of disease were 36 and 38 months respectively. Involved segments were T5/6, T6/7, T7/8, T8/9, and T9/10, and their preoperative ASIA degrees were B and C. Postoperative nerve function all improved to D degree, and the sinus tract was formed postoperative 6 to

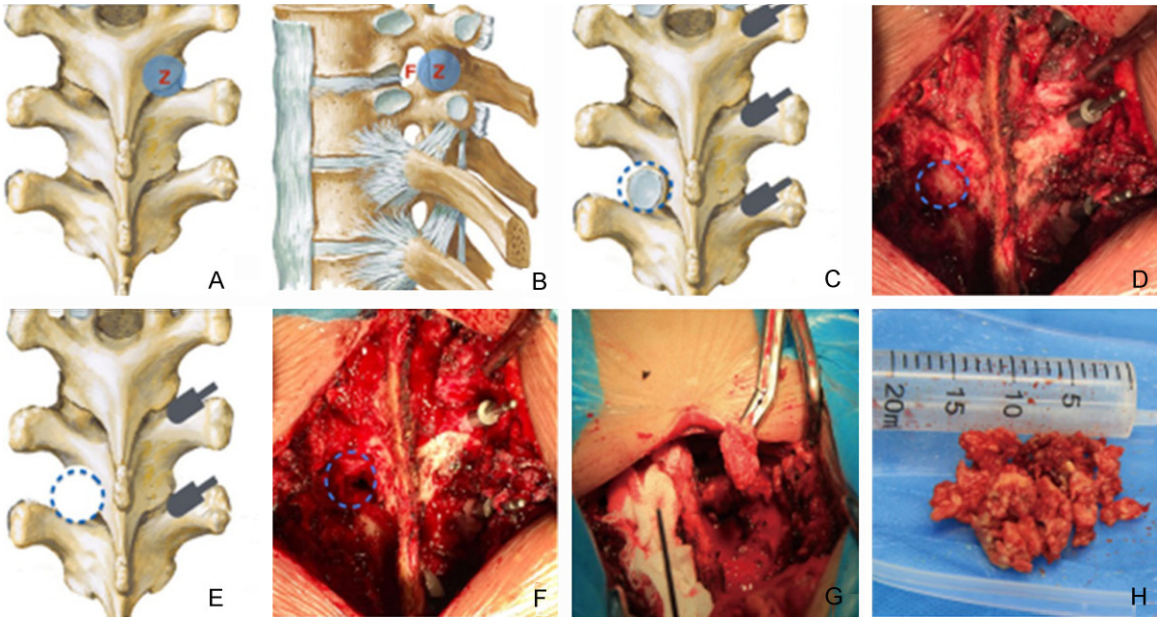

Figure 1. Mode pattern and pictures of surgery via posterior articular process approach. (A, B) Mode pattern for osteotomy range of articular process and location at posterior view (A) and lateral view (B), the blue area is the range of osteotomy (F: intervertebral foramen A: articular process); (C, D) Seeing superior articular process after cutting the inferior articular process on mode pattern (C) and picture (D); (E, F) Cutting articular process completely on mode pattern (E) and picture (F); (G, H) Using elbow nucleus pulposus clamp to resect necrotic tissue in intervertebral tuberculous focus through above approach.

Table 1. The demographics, number of involved segments, operation time, amount of bleeding and the follow-up time

Gender (N)		Involved segments amount				Age	Operation time	Bleeding volume	Followed-up
Male		1	2	3	4				
Female	18	N=23	N=4	N=4	N=1	48.9 years	158±86 min	324±286 ml	25.6 months

Table 2. ASIA grade of neurological function at preoperation and followed-up

ASIA grade of preoperation	N	ASIA degree of last time follow-up				
		A	B	C	D	E
B	6		1	2	3	
C	9			1	2	6
D	10				1	9
E	8					8
Overall improvement rate*	73.3%					

Overall improvement rate*= the case number of ASIA score rising at least a degree/ overall cases × 100%.

10 months. Reexamination imaging results revealed that tuberculosis recurred, local abscess formed while there was no column abscess. One patient was treated with the above operation again and cured, and the other case showed sinus closure after expectant treatment but did not need a second operation.

The nerve function and pains all significantly improved in the 30 cases of cured patients after the operation than before the operation. All 30 patients were completely cured with no recurrences, but 2 patients (6.25%) were recurrent. One was cured by a second surgery and the other was cured by conservative theapy. The ASIA scores improved from 2 degrees in 9 cases (30%), 1 degree in 13 cases (43.3%) (Shown in **Table 2**), and overall improvement rate was 73.3%. The JOA sc-ore improved from preoperative 5.5± 3.3 to postoperative 8.8±3.3. There was a sta-

Table 3. JOA scores, VAS scores, Cobb angle, ESR and CRP at preoperation and followed-up

	JOA	VAS	Cobb angle	ESR (mm/h)	CRP (mg/L)
Preoperation	5.5±3.3	6.8±1.6	27.6±8.8°	35.5±20.0	45.3±46.8
Followed-up	8.8±3.3	1.7±2.3	12.3±2.7°	8.6±5.8	8.8±7.4
Improvement rate	60%	75%	55.4%		
t	-7.287	14.739	11.687	9.876	11.324
*P	<0.01	<0.01	<0.01	<0.01	<0.01

Improvement rate of JOA score = (followed JOA score-preoperative JOA score)/(11-preoperative JOA score) × 100%; Improvement rate (VAS, ESR, CRP and Cobb angle) = (preoperation-followed-up)/preoperation × 100%; *P<0.05 presented that the differences were statistically significant between preoperative and postoperative scores.

tistically significant difference (t=-7.287, P< 0.01), and its overall improvement rate was 60%. The VAS score improved from preoperative 6.8±1.6 to postoperative 1.7±2.3, and there was a statistically significant difference (t=14.739, P<0.01) (Shown in **Table 3**). The preoperative anterior curvature Cobb angle was 27.6°±8.8° and it decreased to the postoperative 10.5°±2.5°; the difference had a statistical significance (t=12.267, P<0.01). During the last follow-up, the Cobb angle was 12.3°±2.7°, and the lost average angle was 1.8°; the difference showed statistical significance (t=11.687, P< 0.01) (See **Figure 2**). Preoperative ESR and CRP were 5.5±20.0 mm/h and 45.3±46.8 mg/L respectively. The ESR increased to 8.6± 5.8 mm/h (t=9.876, P<0.01) and CRP decreased to 8.8±7.4 mg/L (t=11.324, P<0.01) at the last follow-up (See **Table 3**).

Discussion

Following the recent development of the surgical concept, surgical operation has been gradually accepted to treat spinal tuberculosis. Although the key is also the strong antituberculosis drug to treat tuberculosis, the lesion could seriously damage the bones due to the crypticity of this disease confirmed in some patients. It led to the collapse of vertebra or a nerve root compression caused by peripheral abscess, and conservative treatment could not effectively relieve the symptom. Therefore, the tuberculous focus must be cleared using surgical means to correct the malformation, and to release the nerve roots compression keeping the stability of the spine. Nowdays, surgical treatment is controversial. Hodgson and Stock first reported the anterior surgery for spinal tuberculosis in 1960 [7]. This approach permitted to broadly expose the lesions and resect it under the direct visual control. However, more investigations were needed [8] and it might be widely accepted to treat tuberculosis of thoracic vertebra [9]. In the anterior approach, the pleura, intercostal nerve and vessels were needed to be opened [10], which might cause the aerothorax, pneumonia and the injury of blood vessel because it would pass the pleural cavity and needs one-lung ventilation. Moreover, it causes more blood loss and a long operative time. So, it is prohibited for patients with poor health and lung function [11-13].

The posterior approach could avoid some disadvantages of anterior approach especially with the further development of the spinal screw system. Posterior focus debridement and bone graft fusion combined with an internal fixation system could carry out posterior spinal decompression, improve the oppression symptoms of the nerve, and correct the kyphotic deformity [14]. Current clinical options are divided into 1) extended rib transverse projection approach: resect the transverse process of the thoracic vertebra, rib, the vertebral plate, the spinous process and the condyloideus mandibulae processus, and also resect the corresponding nerve root beside the lesion, clear the lesions along the posterolateral part of the vertebral body to the forward part, which provides a 270° wide-bound surgical field to clear lesions completely under the direct look [15]; 2) transpedicular approach: resect the superior and inferior articular processes, processus tranversus, spinous process and the vertebral plate but preserve the rib, and then clear the tuberculous focus in the vertebral body and intervertebral space [16]. Even though the traditional posterior approach attained therapeutic effects in treating tuberculosis and performed well in releasing neurothlipsis and the correction of malformation, some researchers implemented different operations according to the disease degree in order to achieve minimal trauma but the best efficacy. Based on this, Nussbaum et al determined that

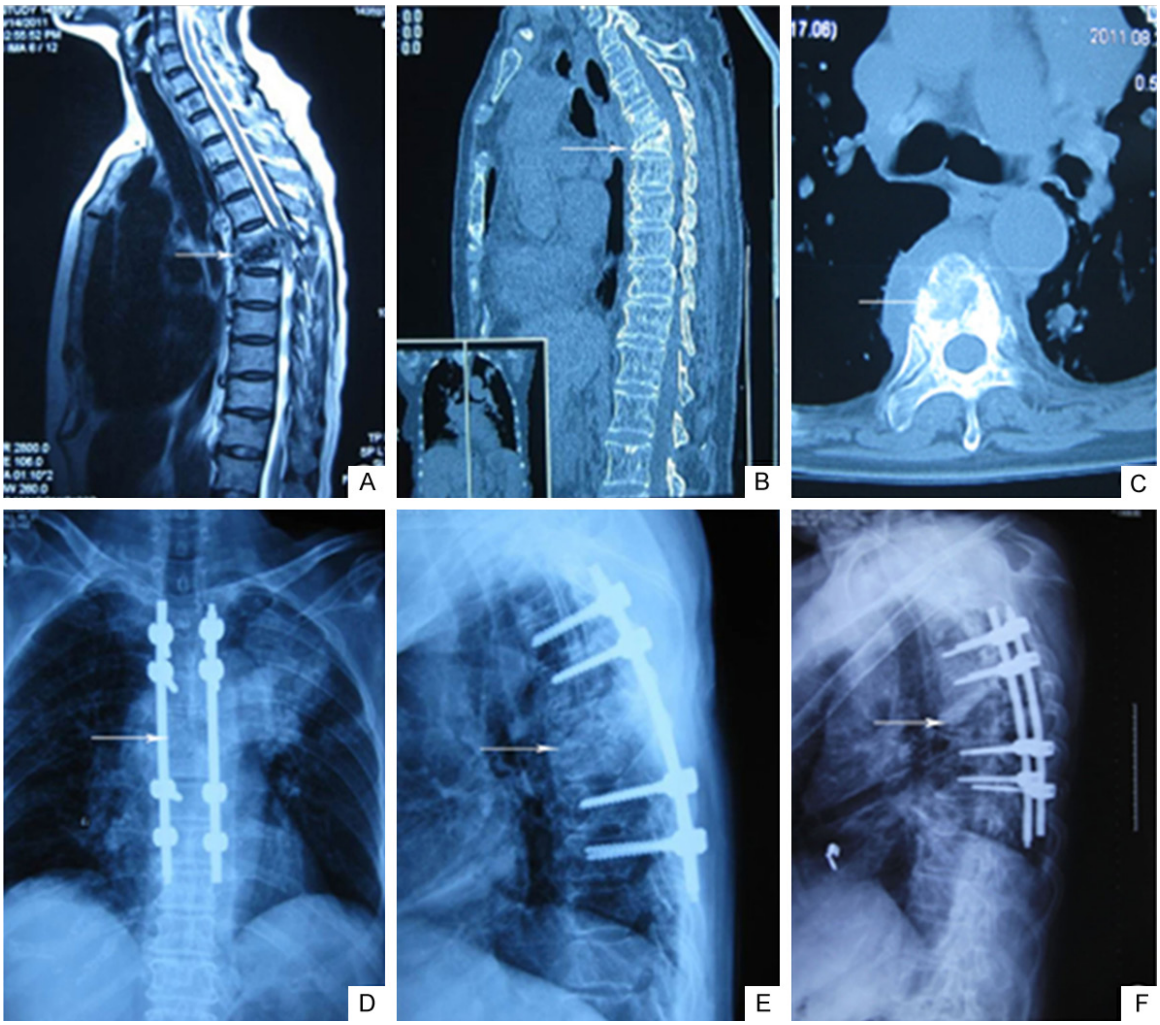

Figure 2. A 70-year-old female patient with thoracic spinal tuberculosis. Chief complaint: Coughing for 6 months, back pain for 2 months, activity limitations of both lower limbs for 10 days. Physical examination: hypoesthesia below bilateral nipple plane, myodynamia of bilateral lower limbs was 0-1 grade. Babinski sign (+); (A-C) Thoracic MRI and CT showing T4 vertebrae destroyed and collapsed (white arrow). Kyphotic Cobb angle was 31.2°, intervertebral abscess compressed the front of the spinal, no gravitation abscess; (D, E) Anterioposterior and lateral X-ray films at post-operation showed good position of internal fixation, Kyphotic Cobb angle was 12.6°; (F) Lateral X-ray film at 3-year post-operation showed slight loss of kyphotic Cobb angle 13.8° and interbody.

extensive and thorough debridement can be only suitable for patients with larger lesions, heavier degree and significant vertebral erosion [17]. Rezai et al also noted that thorough debridement was only suitable for patients with over 50% vertebral destruction [18]. Some researchers showed that one-stage surgical treatment for upper 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 [19-21]. Zeng et al [22] found that One-stage posterior-only transpedicular debridement, interbody fusion, and posterior fixation followed by chemotherapy seems to be adequate for obtaining satisfactory healing of single-segment thoracic spinal tuberculosis with neurological deficits. Our surgical option had comparable results [22]. Based on the transthoracic transforaminal approach (TTIF) technique [23], we improved the operative common thoracic tuberculosis by the posterior approach, in which we preserved the rib and processus transversus as well as the integrity of the posterior column of the spine at a large degree. It is notable to prevent touching pleura from the risk of pleural rupture. Additionally, we conducted the fusion of the bone graft between the lamina, the articular process and the spinous process during the surgery,

and then fixed them with pedicle screws of three columns after the operation. It provided immediate stabilization, but also showed long term torsion resistance and flexural resistance. Therefore, this approach preserved the spinal stability to a large extent and provided assurance for bony fusion of lesion segments.

Our surgical approach was improved on the basis of traditional posterior approach surgery and took advantages of the physiological channel thoracic intervertebral space to resect smaller tissue, thus maximally keeping the normal structure of the posterior spine.

This study has some limits. Two recurrent patients had a long course of disease and more invading vertebral segments. They showed immunodepression and enlarged exposed space and the lesions were cleared completely. Therefore, the disease was recurrent after the operation. Our experience suggested that the patients should be treated with the anterior or classical posterior approach using wider exposure when there is a long course, poor immune function, tuberculosis resistance, more invading vertebral segments and larger abscess or column abscess around it. On the other hand, the retrospective case study had poor quality due to the limited cases and short follow-up time.

Conclusions

One-state surgical treatment by internal fixation debridement and fusion via posterior articular process approach is a safe and effective therapy for thoracic spinal tuberculosis. It provides the correction of spinal deformity and good clinical results with low damage to the posterior elements of the spinal column, and less damage to the posterior column of the spinal column. However, it is mainly suitable for cases with a focus of tuberculosis confined to the posterior side of the vertebral body, invaded 1 to 2 segments as well as short course of disease, and it is also needed to strictly define the surgical efficacy and safety.

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Disclosure of conflict of interest

None.

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