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Anterior tuberculosis lesion debridement and bone grafting combined with short-segment internal fixation in the treatment of thoracolumbar tuberculosis

Zhengting Lei¹, Ming Wang¹, Zhun Xu¹, Wang Cheng¹, Yiguo Yan¹ and Jingbo Xue^{1*}

Abstract

Study design This was a retrospective study.

Objective To retrospectively analyze the safety and efficacy of anterior lesion debridement and bone grafting combined with short-segment internal fixation for the treatment of patients with thoracolumbar tuberculosis.

Summary of background data There is currently no unified standard in the academic community for surgical treatment of spinal tuberculosis. This study proposes a new surgical approach for specific thoracolumbar tuberculosis.

Methods Patients (n = 65) who underwent anterior lesion debridement and bone grafting combined with shortsegment internal fixation at our institution between January 2011 and January 2021 were included in this study. The patients were followed up for at least 2 years. During each follow-up, patients were graded using the American Spinal Injury Association (ASIA) neurologic deficit grading system, and postoperative conditions were evaluated using the Oswestry Disability Index (ODI) and pain visual analog scale (VAS).

Results All patients successfully completed the surgery without serious complications. Four patients had unstable vital signs during the operation, 3 patients had a water–electrolyte imbalance in the postoperative period, 5 patients had transient neurological symptoms in the postoperative period, 1 patient had cerebrospinal fluid leakage after the operation, 1 patient had a transient nerve injury, and 1 patient had delayed healing. The patient with recurrence was treated regularly with quadruple antituberculosis drugs for three months after surgery and then maintained with two oral antituberculosis drugs for the following period. The CT examination was repeated half a year later, and all the indexes showed that the prognosis was good. The patients' mean postoperative VAS and ODI scores were significantly better than the preoperative scores.

Conclusion Anterior tuberculosis lesion debridement and bone grafting combined with short-segment internal fixation in the treatment of thoracolumbar tuberculosis has certain advantages over other Surgical Procedures, and can achieve corresponding clinical results.

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Introduction

Tuberculosis (TB) is an infectious disease dating back to 9,000 B.C. Currently, TB continues to jeopardize the health and lives of human beings worldwide. TB is more common in developing countries, and China still has the second highest infection rate in the world [1]. The

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and emphasize that the correct and appropriate surgical approach is crucial for the treatment of this disease.

Materials and methods Patient population

In this study, we selected a total of 65 patients with thoracolumbar tuberculosis, including 38 males and 27 females, who underwent anterior lesion debridement and bone grafting combined with short-segment internal fixation at the Department of Spine Surgery at the First Affiliated Hospital of the University of South China from January 2011 to January 2021. Table 1 shows the preoperative data of the patients. with the suspected diagnosis of active spinal tuberculosis was based on clinical symptoms, laboratory test results (erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP)) and radiological examination results (including X-ray, computed tomography (CT) scan, and magnetic resonance imaging results). The definitive diagnosis of tuberculosis was ultimately made by pathologic examination (such as microscopic examination of sputum smear, Mycobacterium tuberculosis nucleic acid detection and Mycobacterial culture). The patient inclusion criteria were as follows: (1) had short-segment thoracolumbar tuberculosis (less than or equal to two segments) without lumbar spinal stenosis, lumbar spondylolisthesis or instability, tumors, or infections; (2) had residual bone from the diseased vertebrae still available and could be sufficient for anterior internal fixation with screws and rods placement; (3) had no history of lumbar spine surgery; and (4) had complete preand postoperative follow-up data. The patient exclusion criteria were as follows: (1) had a poor general condition and an inability to tolerate surgery; (2) had infected segments with a history of spinal surgery; (3) had spinal diseases such as scoliosis or ankylosing spondylitis; (4) had

 Table 1
 General information about the patients

Chracteristic	Result
Age	37.3 ± 7.5
Sex(M/F)	38/27
VAS	7.36 ± 1.28
ESR	53.36 ± 18.21
Duration of follow-up(month)	34.27 ± 21.34
Disease location site	
T11-T12	13
T11-L1	7
T11-L2	8
T12-L1	19
T12-L2	8
L1-L2	10

severe osteoporosis; or (5) lacked preoperative and postoperative follow-up data.(6) Patient with severe kyphosis.

All surgical procedures in this study were performed with continuous intraoperative neuromonitoring (IONM) to assess real-time neurological integrity. This protocol effectively minimized the risk of iatrogenic neural injury while providing critical feedback to guide surgical maneuvers during high-risk anatomical dissection.

Preoperative management

All patients received preoperative antituberculosis treatment with isoniazid, rifampicin, ethambutol, and pyrazinamide for $2 \sim 4$ weeks. The preoperative hemoglobin and ESR levels needed to be higher than 100 g/L but lower than 40 mm/L, respectively.

Operative technique

Anterior lesion debridement and bone grafting combined with anterior short-segment internal fixation

After the induction of general anesthesia, the patient was placed in the lateral position, the chest and abdomen were padded with soft pillows, the skin of the operation field was disinfected with 0.5% complex iodine, the towel was spread out, and the incision membrane was pasted. The C-arm machine was used to assist in locating the target segment, an oblique incision was made at the corresponding intercostal space to expose the subcutaneous tissues and intercostal muscles, and the rib spreader was used to spread the wound at the corresponding intercostal space to expose the lateral part of the spine. The C-arm was positioned at the diseased vertebral interspace, and the thoracolumbar section was opened according to the lesioned segments. Tuberculosis may require an incision at the diaphragmatic angle to completely expose the lesion vertebral body and the soft tissues on the lateral side of the vertebral body. The lesion must be debrided, and the vertebral canal must be completely decompressed before flushing the wound with large amounts of saline and applying gelatin sponge tamponade for hemostasis. Part of the tissues must be sent to paraffin section pathological examination. A total of four pedicle screws were inserted into the lesioned vertebrae with intact bone (generally two lesioned vertebrae), and the corresponding iliac bone was taken from the left anterior superior iliac spine posteriorly and implanted into the intervertebral space. A longitudinal connecting rod was used to connect the vertebral screws in the same direction, locking the top wire and placing the scales; the position of the built-in and bone mass was subsequently determined via fluoroscopy via the C-arm machine. After complete hemostasis, a drainage tube was placed in the wound, along with an injection tube, and one piece of rubber drainage membrane was removed from the iliac



Fig. 1 Anterior lesion debridement and bone grafting combined with anterior short-segment internal fixation



Fig. 2 Anterior lesion debridement and bone grafting combined with posterior percutaneous transpedicular fixation

bone wound before the surgical incision was closed layer by layer. The patient was subsequently sent to the anesthesia resuscitation room for resuscitation.

Anterior lesion debridement and bone grafting combined with posterior qpercutaneous transpedicular fixation

After general anesthesia, the patient was placed in the prone position, and the C-arm machine was used for positive and lateral fluoroscopy. The pedicle projections of the corresponding vertebrae were depicted on the body surface with marking pens, and four percutaneous pedicle screws and connecting rods Figs. 1, 2, 3 and 4.



Fig. 3 A 56-year-old female with a L3-4 TB lesion was treated with Anterior lesion debridement and bone grafting combined with posterior percutaneous transpedicular fixation. **A-D** Preoperative anteroposterior and lateral x-rays, and CT showed vertebral destruction. **E–G** Postoperative CT showed good internal fixation and bone grafting conditions

The patient was then placed in the right lateral recumbent position and routinely disinfected and toweled. An 'S'-shaped incision approximately 5 to 8 cm in length was made in the left iliolumbar region.During the operation, the skin and subcutaneous tissues were incised layer by layer. The posterolateral peritoneum was bluntly dissected in an anterior direction to expose the lateral aspect of the lesioned vertebral body. The abscess within the interspace of the lesioned vertebral body was then incised, and both the abscess and necrotic tissue were thoroughly debrided to reveal the underlying healthy bone surface.A bone block of the same size was later taken from the anterior superior iliac spine, after which the iliac bone block was driven into the bone defect of the lesioned vertebral body. After the surgical instruments were used, a drain was placed in the wound, the incision was closed layer by layer, and the wound was subsequently dressed.

Clinical assessment

The following preoperative information was collected from the patient's records: sex, age, symptoms and symptom duration, neurological deficit status, conservative treatment (anti-tuberculosis drugs), and segment of the spinal tuberculosis lesion. The following intraoperative and postoperative information was collected from the patient's records: operative time, lesion debridement status, postoperative bone grafting, intraoperative pain (VAS)score, first time out of bed, postoperative discharge, complications, and recurrence.

Preoperative and postoperative assessments included the visual analog scale (VAS) for low back pain and the Oswestry Disability Index(ODI) for functional assessment. Clinical outcomes were categorized as excellent, good, fair, or poor according to the modified MacNab criteria [7], and clinical efficacy was statistically evaluated by the results at the last follow-up visit. All followup visits were performed on an outpatient basis.

Data analysis

All the statistical analyses were performed using SPSS 25.0 (Chicago, IL, USA). Quantitative data are expressed as the mean and standard deviation. Descriptive assessment and analysis statistics were calculated. A t test was used to compare the VAS and ODI scores before and after surgery. The difference between the two groups was statistically significant (p < 0.05).



Fig. 4 A59-year-old male with a T12-L1 TB lesion was treated by Anterior lesion debridement and bone graft resorption combined with anterior short-segment internal fixation. **A-D** Preoperative anteroposterior and lateral x-rays,MRI and CT showed vertebral destruction. **E-G** Postoperative CT showed good internal fixation and bone grafting conditions. **H–I** X-rays and CT presented a favorable alignment and satisfactory bone fusion at 12-month follow-up

Results

A total of 65 patients with tuberculosis of the thoracolumbar spine were included in this study; 38 (58.4%) were male patients, and 27 (41.5%) were female patients. The age of the patients ranged from 17-58 years, and the mean age at the time of surgery was 37.3 ± 7.5 years. The follow-up period ranged from 36 to 99 months, with a mean follow-up of approximately 5.5 years, and no patients died or were lost to follow-up. No patient had internal fixation loosening or pseudoarthrosis at the last follow-up visit. All patients were treated with antituberculosis drugs (basic quadruple therapy) for at least two weeks before surgery, and none of the patients had serious liver or renal impairment before surgery. Postoperatively, one patient had cerebrospinal fluid leakage, one patient had transient nerve injury, and one patient had delayed healing. All patients healed after conservative treatment, but one patient experienced recurrence of tuberculosis. Therefore, we opened the patient's wound to drain pus, and the cultures showed drug-resistant bacteria. The patient was cured by an adjusted regimen of anti-tuberculosis drugs. The patients' ESR values were measured preoperatively, postoperatively and at the final follow-up visit and are shown in Table 2. The mean preoperative mean ESR value was $53.36 \pm 18.21 \text{ mm/h}$ (range 3–79 mm/h). The mean values measured postoperatively and at the final follow-up visit were $18.32 \pm 3.43 \text{ mm/h}$ (range 0–30 mm/h) and $6.38 \pm 3.74 \text{ mm/h}$ (range 0–15 mm/h), respectively, which were within the normal range. A statistical analysis revealed a significant difference between the preoperative ESR values and the ESR

Та	ble 2	2	Intraoperative a	nd posto	perative eva	luation
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variable	result	Level of significant		
Operation time(min)	207 ± 58.34 min			
Blood loss(ML)	327 ml ±238 ml			
Follow-up time(months)	79.83 ±11.74			
VAS				
Preoperative	7.36 ± 1.28	<i>P</i> < 0.05		
Post-op two weeks	2.13 ± 0.35			
ESR				
Preoperative	53.36 ± 18.21	<i>P</i> < 0.05		
Post-op six months	6.38 ± 3.74			

values at 12 weeks after surgery (P < 0.05). The difference in blood sedimentation between 12 weeks after surgery and at the final follow-up visit was statistically significant (P < 0.05). The patients' VAS and ODI scores are shown in Table 3. The patients' VAS score on the first postoperative day decreased from 7.36 ±1.28 before surgery to 3.15 ± 0.72 , and the score at the last follow-up visit was 1.34 ± 0.36 . The ODI score on the first postoperative day decreased from 70.82 ±5.46 before surgery to 26.05 \pm 6.18, and the score at the last follow-up visit was 15.56 \pm 5.62. The differences were statistically significant (P< 0.05) when comparing the VAS and ODI scores at each postoperative follow-up time point with those before surgery, indicating that the patients' postoperative symptoms had significantly improved. A comparison of the VAS and ODI scores at each postoperative follow-up time point with the preoperative scores revealed that the difference was statistically significant (P < 0.05), indicating that the patient's symptoms improved significantly after surgery. The mean time to bone healing was 6-9 months (mean, 6.80 ±1.34 months), and postoperative neurological function was restored. Surgical outcomes according to the MacNab criteria were excellent in 47 (72.3%) patients, good in 12 (18.4%), fair in 5 (7.6%), and poor in 1 (0.15%), with fair and poor patients having more severe neurologic dysfunction preoperatively.

Discussion

Tuberculosis has attracted the attention of various authors in recent years, as its incidence has been increasing annually. Spinal tuberculosis accounts for 50% of osteoarticular tuberculosis cases, and Rajasekaran et al. reported that spinal tuberculosis is the most common cause of severe kyphosis [8]. When trauma or tuberculosis results in the destruction of two consecutive vertebrae, the spine is usually considered unstable. Therefore, performing the necessary surgical interventions to relieve clinical symptoms and achieve favorable long-term outcomes is particularly important. The treatment strategy for spinal tuberculosis includes standard antituberculosis chemotherapy with careful debridement of the lesion to alleviate neurologic compression symptoms, correct kyphotic deformity, and restore spinal stability. Anterior debridement, bone grafting, and anterior or posterior internal fixation procedures are considered standard approaches for treating spinal tuberculosis; however, these approaches invariably result in more severe surgical trauma. Currently, there is no standardized surgical procedure for treating thoracolumbar tuberculosis. Each approach has its advantages and disadvantages, and there are many studies evaluating the clinical outcomes of different surgical approaches; however, there are few studies on anterior lesion debridement and bone grafting combined with short-segment internal fixation. In this study, we found that anterior lesion debridement and bone grafting combined with short-segment internal fixation is more beneficial than other procedures in terms of recovery time, safety, and costs. Anterior debridement + bone grafting has always been the gold standard for the treatment of spinal tuberculosis. Since most tuberculosis lesions accumulate in the anterior column of spine, anterior debridement yields more extensive debridement of tuberculosis lesions without destroying the posterior column of the spine and maximizes the extent of spinal stability. Most approaches to lesion debridement via the posterior approach have limitations because most TB lesions are located in the anterior column of spine and are at risk of spreading to the posterior healthy regions; additionally, posterior lesion debridement does not completely resolve these lesions. Instead, posterior lesion debridement can lead to the spread of infection and the development of fistulae, possibly resulting in compromised spinal stability because the normal spine structures are compromised due to debridement and decompression during the process. Posterior column structures can also be compromised. Zhao et al. concluded that the posterior approach is more capable of correcting kyphotic deformities than the anterior approach is; the most significant disadvantage of this approach is incomplete lesion clearance and implants that are not as strong as those of the anterior approach [9]. In contrast, anterior short-segment internal fixation involves a smaller incision and smaller fixed segments than the posterior approach, which ensures both postoperative mobility of the spine and, to the greatest extent possible, that the posterior column of spine is not damaged. Hassan K compared the surgical outcomes of anterior and posterior surgery for the treatment of thoracolumbar spondylolisthesis and reported that the anterior approach was superior to the posterior approach in terms of operative time and bleeding volume [10]. The anterior approach also enables the surgical procedure to

Table 3 Assessment of postoperative VAS and ODI scores

	Preoperative Score	1 day	3 months	6 months	12 months	Final follow-up visit
VAS	7.36 ± 1.28	3.15 ±0.72	2.45 ±0.56	1.86 ± 0.43	1.37 ±0.34	1.34±0.36
ODI	70.82 ± 5.46	26.05 ± 6.18	23.43 ± 4.63	19.37 ± 3.35	17.26 ± 3.46	15.56 ± 5.62

be performed under the surgeon's direct vision, thereby reducing the difficulty and duration of the procedure. Additionally, fewer incisions were needed for anterior internal fixation than for combined anterior and posterior internal fixation, which shortened the operative time and decreased the intraoperative blood loss volume.

Moreover, the choice of internal fixation method for bone grafting in spinal tuberculosis reconstruction has long been discussed, and there is no uniform standard. Most authors choose to fix multiple standard motion segments on top of the fixed diseased motion segments [11]. For thoracolumbar tuberculosis, long-segment internal fixation was the first method to be used in the clinic, but longer-segment internal fixation also implies poorer postoperative spinal mobility and a poorer prognosis. Gotzen et al. first introduced the concept of shortsegment fixation, also known as diseased intervertebral fixation, which is based on the principles of reducing fusion reducing the number of segments to be fixed, and maintaining the motor performance of other segments [12]. In basic [13–15] and clinical [16, 17] studies, many physicians reported excellent clinical results of shortsegment fixation of injured vertebrae for the treatment of spinal fractures. Pu et al. [13] used combined anterior debridement, interbody autografting, and internal fixation in 22 patients, all of whom showed osseous fusion and neurologic improvement [18]. Lü et al. 14 used a thoracoscopically assisted small-incision approach. Anterior debridement and reconstruction were used to treat 50 patients with tuberculosis of the thoracic spine, 92% of whom achieved good or excellent subjective patientreported outcomes, and no recurrence was observed [7]. In this study, we used anterior direct anterior internal fixation with screws and rods or posterior percutaneous pedicle screws for internal fixation. When the tuberculosis lesion damages only the intervertebral space without destroying the bony structure of the pedicle, posterior percutaneous pedicle screws are preferred because posterior percutaneous pedicle screws for internal fixation involve three-dimensional fixation, which theoretically has strong holding power and biomechanical stability. When the tuberculosis lesion is destroyed not only in the intervertebral space but also in the bony structure of the pedicle, as determined by preoperative threedimensional CT, the upper and lower endplates of the adjacent vertebrae also contain bony structures for the vertebral anterior internal fixation with screws and rods, and the vertebral body can be stabilized by direct anterior fixation(In cases of severe infection-induced vertebral destruction, the fixation technique employed in this approach is debated owing to compromised mechanical stability and hostile biological microenvironments, with notable surgical risks including residual vertebral fractures and avascular necrosis.). This also demonstrates the versatility of this procedure in the management of short-segment tuberculosis lesions, allowing internal fixation in a variety of situations.

Many experts believe that anterior surgery is associated with more intraoperative blood loss than posterior surgery and that anterior surgery is not as effective as posterior surgery for correcting kyphosis. However, compared with short-segment thoracolumbar tuberculosis, tuberculosis lesions are limited to one or two segments, and kyphosis is not severe; therefore, kyphosis urgently needs to be corrected. Therefore, anterior lesion debridement and bone grafting combined with short-segment internal fixation followed by combined antituberculosis treatment can often achieve better results. In the present study, we evaluated the outcomes of 65 patients with thoracolumbar tuberculosis who underwent anterior lesion debridement and bone graft fusion combined with short-segment internal fixation. The mean intraoperative blood loss volume of the patients was 327 ±238 ml, which was lower than the mean blood loss volume of 419 mL reported by Rawall et al. [19]. Follow-up imaging showed that the patients had relatively good bone grafts after 2 months of follow-up, confirming the feasibility of this procedure. The ASIA scale scores recorded at the final follow-up visit in the present study were significantly better than the preoperative scores (p < 0.05). Neurologic function also improved significantly, with 91.36% of the patients showing complete neurologic recovery. The VAS scores of these patients decreased from 6.0 ± 2.0 preoperatively to 1.0 ± 0.5 at the final follow-up visit, and very few patients in this study had intraoperative complications. Thus, our study demonstrated that patients with thoracolumbar tuberculosis treated with anterior lesion debridement and bone grafting combined with shortsegment internal fixation have satisfactory postoperative recovery.

Conclusion

Anterior tuberculosis lesion debridement and bone grafting combined with short-segment internal fixation for the treatment of thoracolumbar tuberculosis yielded good clinical and imaging results; moreover, this approach avoids extensive internal fixation and ensures the mobility of the thoracolumbar spine during the postoperative period. In addition, the amount of intraoperative blood loss and the mobility of the thoracolumbar spine during the postoperative period of this approach have obvious advantages over those of other conventional approaches, and according to the clinical data, short-segment internal fixation via the anterior approach has also yielded the same clinical results.

Authors' contributions

Yiguo Yan and Jingbo Xue designed experiments; Zhengting Lei, Jingbo Xue and Zhun Xu carried out experiments; Zhun Xu were in charge of contacting the patient. Cheng Wang, and Ming Wang analyzed experimental results. ZhengTing Lei wrote the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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