Tuberculosis is an emerging international problem, despite advances in diagnosis and treatment. The resurgence of tuberculosis is likely to be associated with a concomitant increase in the incidence of extrapulmonary tuberculosis, including Pott’s disease.\(^1\)\(^3\) Approximately 10% of patients with extrapulmonary tuberculosis have skeletal involvement. The spine is the most common skeletal site affected, followed by the hip and the knee. Spinal tuberculosis accounts for almost 50% of cases of skeletal tuberculosis and 1% to 3% of tuberculosis infections.\(^4\)\(^5\) Contiguous or adjacent vertebral involvement is the usual pattern; skipped, remote involvement is rare. Multilevel skipped spinal tuberculosis is atypical, and case reports are published as rarities. Pandit et al\(^6\) reported an incidence of skipped spinal tuberculosis of 15%. Other authors reported an incidence of 16.3%.\(^7\) China ranks second among the 22 countries with the highest burden of tuberculosis. The goals of this study were to evaluate the clinical outcomes of treatment of skipped multisegmental spinal tuberculosis and to investigate the selection strategy for the optimal procedure based on focal characteristics. From March 1999 to December 2013, 24 patients with skipped multisegmental spinal tuberculosis were enrolled in this study. Ten patients underwent an anterior procedure (anterior group). Four patients underwent a combined anterior and posterior procedure (combined anterior and posterior group). Ten patients underwent a posterior procedure (posterior group). All patients were evaluated according to clinical presentation and radiographic, computed tomography, and magnetic resonance imaging findings. The focal tissues of all patients underwent drug susceptibility testing. The patients underwent clinical and radiologic follow-up an average of 18.6 months postoperatively. The cohort included 13 male and 11 female patients (age range, 15-69 years). The patients showed significant improvement in deformity and neurologic deficits. All patients had graft union 6 to 12 months postoperatively. No patient had surgical complications. Postoperative recurrence occurred in 1 patient in the combined anterior and posterior group. Two patients had strains that were resistant to at least 1 anti-tuberculosis drug. One patient had multidrug-resistant strains. All 24 patients had achieved cure at final follow-up. This study showed that the 3 procedures can safely and effectively achieve nerve decompression, graft fusion, and kyphosis correction. The procedure should be chosen according to the patient’s general condition, focal characteristics, and type of complication, and the surgeon’s experience. [Orthopedics. 2016; 39(1):e19-e25.]

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The authors have no relevant financial relationships to disclose.

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Received: February 8, 2015; Accepted: May 13, 2015.

doi: 10.3928/01477447-20151218-04
Compared with patients with adjacent multisegmental spinal tuberculosis, those with skipped multisegmental spinal tuberculosis have more destruction of the anterior or middle column of multiple adjacent levels and an increased risk of progression to kyphosis and paraplegia. This is because skipped multisegmental spinal tuberculosis is difficult to identify unless whole spine magnetic resonance imaging is performed. In the treatment of multilevel skipped spinal tuberculosis, surgery is frequently needed to resolve neurologic deficits, restore spinal stability, and prevent vertebral collapse or kyphosis progression. Several surgical techniques are used to treat tuberculous spondylitis, including the anterior, posterior, and combined anterior and posterior approaches and modified transformaminal thoracic debridement, limited decompression, interbody fusion, and posterior instrumentation. However, because of various factors, including variability in the level and extent of the skipped lesion, the neurologic status, and the extent of the abscess, choosing the right surgical procedure is often difficult. Each patient should be considered individually, and there is no standard procedure reported in the literature. The goal of this study was to evaluate clinical outcomes of the treatment of skipped multisegmental spinal tuberculosis. This study also used retrospective analysis to investigate the strategy for selecting the optimal procedure based on individual focal characteristics.

**Materials and Methods**

**Patients**

From January 1999 to December 2013, a total of 967 patients with clinically and histopathologically confirmed spinal tuberculosis were admitted to the authors’ hospital. Of these patients, 33 had radiologic confirmation of skipped multisegmental spinal tuberculosis. The eligibility criteria were as follows: (1) involvement of more than 2 vertebrae; (2) involvement of non-contiguous or skipped vertebrae; and (3) minimum follow-up of 12 months. Patients who met all of the study criteria were included, and those who were lost to follow-up were excluded. Overall, 24 patients with skipped multisegmental spinal tuberculosis who met the eligibility criteria were enrolled in this study. All surgical procedures were performed by 2 senior surgeons (F.L., J.X.), and they reached preoperative consensus on surgical planning. The choice of surgical procedure depends on many factors, including focal characteristics, the location of vertebrae involved, the patient’s general condition, and the surgeon’s expertise. There were no well-defined preoperative selection criteria.

**Operative Procedures**

**Anterior Group.** Patients in the anterior group underwent a procedure with the transperitoneal or extraperitoneal route for lumbar and lumbosacral tuberculosis, with the patient in the supine or lateral position. The focus of thoracic and thoracolumbar spinal tuberculosis was exposed with either a thoracotomy or the thoracoabdominal approach. Debridement and nerve decompression were performed meticulously. Screws were inserted into the cephalad and caudal ends of the involved vertebrae. If the unbroken height of the affected vertebrae was insufficient to allow insertion of the screws, then the screws were inserted into the vertebrae. If destruction of the vertebrae was too great to allow screw insertion, then screws were inserted into the adjacent normal vertebrae. Bone grafting was performed with titanium mesh or bone grafts of suitable length (Figure 1).

![Figure 1: Preoperative magnetic resonance imaging scans showing severe collapse of T7 (A) and mild destruction of T9 (B). The patient underwent anterior corpectomy of T7, with debridement, decompression of infection out of the thoracic canal, autograft fusion, instrumentation, and standard chemotherapy. There was no compression of the thecal sac from the anterior mass, the neurologic deficit recovered from an American Spinal Injury Association score of D to a score of E postoperatively, and radiographs (C, D) and magnetic resonance imaging scans (E, F) showed satisfactory bony fusion.](image-url)
Patient in the prone position. Pedicle screws were first inserted into adjacent normal segments. If the pedicle was not damaged and sufficient space remained for screw implantation, then shorter screws were also placed in the diseased vertebrae to enhance fixation strength. A prebent titanium rod was inserted and shaped. A bone graft mixed with isoniazid and rifampicin sodium was implanted after decortication of the vertebral lamina. The surgical incision was subsequently closed, and the patient’s position was changed to supine or lateral. The focus was exposed with the anterior approach. Afterward, the most seriously damaged vertebrae were debrided. The surgeon removed pus and caseous tissue in the vertebrae with less severe destruction with a curette, and the area was washed repeatedly. Bone grafting was then performed, and a drainage tube was inserted before the wound was closed (Figure 2).

Posterior Group. With the patient in the prone position, a posterior midline incision was made. First, pedicle screws were inserted into the cephalad and caudal ends of the adjacent normal segments, and a single titanium rod intended for temporary fixation was implanted. Second, a unilateral or bilateral costotransversectomy was performed, with debridement of the affected vertebrae of the thoracic spine. For the lumbar spine, the surgeon performed unilateral or bilateral facetectomy and pediculectomy, with debridement of the most badly damaged vertebrae. The exposed dura mater was protected meticulously. The pus, caseous tissue, sequestrum, and granulation tissue were thoroughly cleaned. The catheter was inserted deep into the abscess cavity to flush the abscess. A posterior osteotomy was performed for patients with severe kyphosis. A bone graft was implanted in the intervertebral space with the posterior approach. A prebent titanium rod was used to correct the kyphosis. Bone particles mixed with anti-tuberculosis drugs were implanted in the bilateral decorticated vertebral lamina. A negative-pressure drainage tube was inserted routinely, and the incision was closed. For extensive paravertebral abscesses, 2 drainage T-tubes were placed at the front of the vertebral body. In addition, debridement was performed in patients with a flow injection abscess of the psoas (Figure 3).

Postoperative Management

The drainage tube was removed when drainage volume reached 20 to 50 mL 48 to 72 hours after surgery. Standard chemotherapy with isoniazid (6 mg/kg), rifampicin (15 mg/kg), ethambutol (25 mg/kg), and pyrazinamide (25 mg/kg) was administered for 3 months, and then the same regimen of isoniazid/rifampicin/ethambutol/pyrazinamide was continued for 9 to 15 months. If drug susceptibility testing results showed resistance to any first-line drug, individualized chemotherapy was tailored based on the patient’s chemotherapy history and drug susceptibility profile.
Evaluation of Clinical Outcomes

The medical records and follow-up data for the study population were reviewed. The following information was recorded preoperatively and at 1, 3, 6, 9, and 12 months of follow-up and every 6 months thereafter: (1) clinical presentation and (2) radiographic, computed tomography scan, and magnetic resonance imaging scan findings. Bone fusion was assessed according to the criteria defined by Lee et al.\(^\text{12}\) Postoperative erythrocyte sedimentation rate, hepatic function, and renal function were monitored monthly.

Drug Susceptibility Testing

Drug susceptibility testing was performed according to the proportional method recommended by the World Health Organization. Concentrations of drugs in media were as follows: isoniazid, 0.2 μg/mL; rifampicin, 40 μg/mL; ethambutol, 2 μg/mL; streptomycin, 4 μg/mL; rifapentine, 40 μg/mL; para-aminosalicylic acid, 1.0 μg/mL; amikacin, 30 μg/mL; capreomycin, 40 μg/mL; kanamycin, 30 μg/mL; levofloxacin, 2 μg/mL; prothionamide, 40 μg/mL; and dipasic, 0.1 μg/mL.

Drug resistance was defined as a growth rate of greater than 1% compared with the control. Multidrug-resistant tuberculosis strains were defined as those resistant to both isoniazid and rifampicin. Isolates resistant to rifampicin and isoniazid as well as any member of the quinolone family and at least 1 of the remaining second-line anti-tuberculosis injectable drugs were defined as extensively drug-resistant tuberculosis.

Results

This study included 24 patients (female, 11; male, 13) with skipped multisegmental spinal tuberculosis who were treated at the authors’ hospital. The male-to-female ratio was 1.2:1. Patient age ranged from 15 to 69 years, with an average of 31.4 years. The time from the onset of spinal tuberculosis to diagnosis was 7.4 months (range, 0-24 months) and to confirmation by physicians was 1.3 months (range, 0-10 months). The mean duration of symptoms was 8.8 months (range, 1-38 months). Average hospitalization was 26.5 days (range, 14-42 days) (Table 1).

Mean length of follow-up was 18.6 months (range, 12-25 months). At final follow-up, all patients were successfully treated with surgery and individualized chemotherapy, and the average erythrocyte sedimentation rate was 5.58 mm/h (range, 0-28 mm/h). All patients had satisfactory graft union at a mean of 8.2 months (range, 6-12 months), except 1 whose implant failed. Sites of vertebral involvement in all 3 groups are shown in Table 2. Mean operative time, blood loss, and length of hospital stay for each group are shown in Table 3. Pre- and postoperative neurologic status is shown in Table 4.
No patient had surgical complications. One patient in the combined anterior and posterior group had sinus formation at the incision after surgery, was treated with excision of the sinus and individualized chemotherapy, and recovered.

Of the 24 patients in the study, 2 had strains that were resistant to at least 1 anti-tuberculosis drug. One patient had multidrug-resistant tuberculosis.

**DISCUSSION**

The World Health Organization reported that China ranks second among the 22 countries with the highest burden of tuberculosis. Spinal tuberculosis is the most common form of extrapulmonary tuberculosis, and it remains a severe public health threat in China. Spinal tuberculosis often involves adjacent vertebrae and the intervening disk. Leaping and remote lesions are not common and are not characteristic of the disease. In the literature, skipped multisegmental spinal tuberculosis is mostly reported as episodic case reports. The incidence of skipped multisegmental spinal tuberculosis is reported as 1.1% to 71.4%. The current findings showed that, among the 967 patients with spinal tuberculosis who were admitted to the authors’ unit between 1999 and 2013, a total of 33 patients (3.4%) were classified as having skipped multisegmental spinal tuberculosis. Additionally, in this study, the average delay in the diagnosis of patients with skipped multisegmental spinal tuberculosis was 8.8 months.

**Surgical Strategy for Skipped Multisegmental Spinal Tuberculosis**

Because skipped multisegmental spinal tuberculosis is rare, there is little information on comprehensive therapeutic strategies. The treatment principles are basically derived from experience with contiguous spinal tuberculosis. Compared with single-focus treatment, there are several noteworthy differences in the treatment of skipped multisegmental spinal tuberculosis. Multilevel surgical interventions result in more surgical trauma and complications than are associated with single-focus disease. Therefore, surgical indications should be controlled more strictly for each lesion. Severe surgical trauma and complications associated with multilevel surgical interventions should be reduced with minimally invasive surgical techniques, debridement rather than radical surgery, and conservative treatment. In the current study, for the lesion without epidural compression, spinal instability, kyphosis, and compression of vital organs, surgical treatment was not the first choice, and protection with a brace was sufficient.

**Choice of Surgical Procedure for Skipped Multisegmental Spinal Tuberculosis**

The single-stage anterior approach simultaneously allows direct access to the focus and stabilization of the spine. All 10 patients in the anterior group had good clinical outcomes, with no complications. In a patient with 1 or 2 seriously...
damaged vertebrae and sufficient space in the adjacent vertebral bodies to accommodate screws, single-stage anterior surgery can achieve satisfactory outcomes, with shorter operative time and less blood loss, compared with combined anterior and posterior procedures. In patients with more than 2 consecutive vertebrae with severe damage and no space for screws, the screws must be inserted into the adjacent vertebrae. In this situation, the anterior instrumentation spans more than 3 residual vertebrae, and both proximal and distal screws must withstand significantly greater stress; therefore, the screws are more prone to breakage or loosening.19,20

The 4 patients in the combined anterior and posterior group underwent a combined anterior and posterior procedure. Follow-up results showed favorable outcomes. The advantages of combined anterior and posterior procedures, compared with the posterior procedure, include more thorough debridement and nerve decompression via the anterior approach and ease of use of large bone grafts. Moreover, when multiple segments are involved, posterior pedicle screw instrumentation is more reliable than anterior instrumentation. Potential drawbacks of this procedure include the need to change the intraoperative position, increased surgical trauma, and longer operative time, compared with the anterior or posterior procedure. In this group, 1 patient had local relapse as a result of multidrug-resistant tuberculosis.

Recently, several authors reported that single-stage posterior debridement, bone grafting, and instrumentation produced satisfactory results in patients with localized foci at no more than 3 levels, without severe vertebral collapse and large cold abscesses.21-24 In the current study, all 10 patients in the posterior group had favorable results with kyphosis correction and neurologic restoration. This surgical modality is indicated for patients with skipped multisegmental spinal tuberculosis with the following characteristics: (1) no extensive abscess or obvious spinal cord compression; (2) a segment with significant destruction and only slight infiltration of the adjacent vertebrae; and (3) poor general condition. The advantages of this approach include simultaneous debridement and stabilization of the spine with the same incision, decreased surgical trauma, shorter operative time, and no need for a change in surgical position.

**Limitations**

Limitations of this study include its single-center retrospective nature and the small sample size. Moreover, selection of the optimal procedure was based on the retrospective analysis.

**Conclusion**

All 3 procedures described in this study can achieve satisfactory outcomes in patients with skipped multisegmental spinal tuberculosis and have their own relative indications. Individualized surgical modalities should be considered according to different focal characteristics (eg, number of vertebrae involved, extent of bone destruction, and suitability of the residual vertebrae for instrumentation), the patient’s general condition, and the surgeon’s expertise. Long-term follow-up of a prospective cohort is needed to confirm the current findings and evaluate the selection criteria.

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**Table 3**

<table>
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<tr>
<th>Group</th>
<th>Parameter</th>
<th>Anterior</th>
<th>Combined Anterior and Posterior</th>
<th>Posterior</th>
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<tr>
<td></td>
<td>Operative time, mean±SD, min</td>
<td>233.5±152.4</td>
<td>496.8±142.7</td>
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<td>Blood loss, mean±SD, mL</td>
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<td>1115.0±1034.4</td>
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<td>Fusion rate</td>
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**Table 4**

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<td>0</td>
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<tr>
<td></td>
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<td>0</td>
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<tr>
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Abbreviations: Post, postoperative; Pre, preoperative.
REFERENCES


