

Mid- to Long-Term Follow-up Outcomes of One-Stage Posterior Lumbosacral or Lumbopelvic Fixation in the Management of Lumbosacral Junction Tuberculosis in Adults

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Abstract

Background: This retrospective study aimed to evaluate the mid- to long-term outcomes of surgical management of lumbosacral junction tuberculosis in adults.

Methods: A total of 38 adult patients were treated by one-stage posterior debridement, interbody fusion, lumbosacral or lumbopelvic fixation, and postural drainage. All cases were followed up for at least five years. Clinical and radiographic outcomes were gathered and analyzed.

Results: All patients achieved clinical cure at the last follow-up. Erythrocyte sedimentation rates decreased to normal levels within three months postoperatively. Postoperative scores measuring pain (visual analog scale), neurological status (Japanese Orthopedic Association score), and patient quality of life (Oswestry Disability Index) all significantly improved compared to preoperative values. Patient-reported outcomes as measured by Kirkaldy-Willis criteria were excellent in 21 cases, good in 16 cases, and fair in 1 case; there were no poor outcomes. Lumbosacral angle increased from the preoperative values of $21.7^\circ \pm 1.8^\circ$ to the postoperative values of $26.4^\circ \pm 1.4^\circ$, with an angle loss of $1.2^\circ \pm 0.7^\circ$ at the last follow-up. Bone fusion occurred on average 12.8 ± 1.9 months after surgery. No nonunion, pseudarthrosis, loosening or fracture of instruments occurred at the last follow-up.

Conclusion: For patients with lumbosacral junction TB, a treatment protocol including one-stage posterior debridement, interbody fusion, lumbosacral or lumbopelvic fixation, and postural drainage according to the severity of sacral destruction is a relatively nontraumatic and highly safe procedure. It can be used to reconstruct lumbosacral or lumbopelvic stability and facilitate the healing of TB.

Background

According to the Global Tuberculosis Report released by the World Health Organization in 2019, there were approximately 10 million new cases of tuberculosis (TB) worldwide in 2018, making it one of the top ten causes of death in the world [1]. The spinal column is the most common site of infection for extrapulmonary TB, accounting for approximately 50% of osteoarticular TB [2]. This severe spinal disease often causes spinal instability, kyphotic deformity, neurological dysfunction, and even paraplegia [3]. Spinal TB involving the lumbosacral junction is rare, and only accounts for 2–3% of the total number of spinal TB cases reported in the literature [4]. Conservative treatment with anti-TB drugs is the primary approach for the condition [5]. However, simple drug therapy is often insufficient as the disease progresses and patients show complications with vertebral collapse and severe deformity, which may lead to lumbosacral malunion and chronic lower back pain. Hence, surgeons are increasingly adopting chemotherapy with surgery to solve this dilemma [6].

Various surgical methods including an anterior approach, a combined anteroposterior approach and a posterior approach have been described for treating lumbosacral junction TB [7–9]. Surgery promotes the quiescence of the abscessed area by lesion clearance, bone grafting and internal fixation, so that the infection can be clinically eliminated [10]. However, as the transition zone between the lumbar vertebrae and the sacrum, the unique anatomical structure and biomechanical characteristics of the lumbosacral segment bring challenges to the operation. The adjacent organs in the lumbosacral area not only need to be protected from damage, but one also needs to pay special attention to the reconstruction of lumbosacral stability after lesion removal [11]. Due to a lack of evidence and guidelines regarding optimal treatment and management strategies, the treatment of lumbosacral junction TB remains a difficult and challenging decision-making process. Currently, reports on the management of lumbosacral junction TB are relatively scarce due to its low incidence rate.

In this study, 38 patients with lumbosacral junction TB who underwent one-stage posterior lumbosacral fixation or lumbopelvic fixation, and postural drainage were followed up for more than five years. We evaluated the mid- to long-term

clinical outcomes and effectiveness of surgical management in helping these patients eliminate the infection, regain lumbosacral or lumbopelvic stability, resolve neurological impairments and restore normal quality of life.

Methods

Patient diagnosis, inclusion and exclusion criteria

A total of 38 adult patients with lumbosacral junction TB were enrolled in this study from February 2008 to July 2015. Written informed consent was obtained from all patients prior to the study, and the ethics committee of Xiangya hospital approved the study protocol. The primary diagnosis of tuberculous spondylodiscitis or spondylitis was made on the basis of clinical, neurological, hematologic, imaging and laboratory data. Final confirmation of diagnosis was achieved through histopathologic analysis of a biopsied sample or a positive tubercle bacillus culture.

The inclusion criteria for surgery were the following: (1) persistent lower back pain caused by instability; (2) severe or progressive neurological impairment; (3) unpreventable progressive deformity; or (4) weak efficacy of anti-TB drugs, as confirmed by drug sensitivity testing. The exclusion criteria were individuals who had (1) already undergone lumbosacral surgery and thus showed unclear morphology in the area, (2) had history of congenital scoliosis or ankylosing spondylitis, or (3) showed multi-level lumbosacral junction TB (exceeding two segments that required surgical treatment) with iliac fossa or anterior abscess formation. A total of 38 patients were included and followed for at least five years with complete data.

Preoperative procedure

Anti-TB treatment with the HREZ chemotherapy regimen was routinely carried out for at least two weeks prior to surgery. The dosages of each drug were the following: isoniazid (H; 5 mg/kg/day, < 300 mg/day), rifampicin (R; 10 mg/kg/day, < 1200 mg/day), ethambutol (E; 15 mg/kg/day, < 2500 mg/day), and pyrazinamide (Z; 30 mg/kg/day, < 2000 mg/day). Nutritional support therapy was administered to correct hypoproteinemia and anemia. Surgery was postponed until erythrocyte sedimentation rate (ESR) values, which indicated the activity level of the TB infection, either decreased significantly or returned to normal. If a patient experienced cauda equina syndrome or dramatic aggravation of neurological impairment during the anti-TB treatment, emergency surgery was performed regardless of the ESR value.

Surgical methods

The key surgical procedure included mounting pedicle screws on one or two segments above the infected vertebra through a posterior median incision. Pedicle screws were inserted in the S1 vertebra in cases where the vertebral body was slightly damaged so that the integrity of the pedicles was preserved. If the S1 vertebra and pedicle channel were severely damaged, iliac screws were fixed to the iliac wings. A hemi-laminectomy or laminectomy was performed on the severely damaged side of the lesion segment. The superior and inferior articular processes of the pathologic vertebrae were partially resected to expose the affected vertebral bodies. Curettes of varying angles were used to remove the lesion, including sequestrum, necrotic intervertebral disc and tuberculous granuloma. Pus and necrotic tissue were removed by negative pressure irrigation and negative pressure suction via a soft catheter, which was placed deep into the lesion. The same procedure was performed on the other side, if necessary. The bony surfaces of the vertebral body were repaired by bone grafts. Installation of permanently contoured rods and compression with a cantilever bending technique under vision were employed to achieve local spinal alignment. A suitable allogeneic bone block was implanted between the vertebrae to complete the reconstruction of the anterior middle column. Moreover, autologous and allogeneic particulate bone was implanted between the bilateral transverse processes. Streptomycin (1 g) combined with isoniazid (0.3 g) were used locally in the focal area, and the incision was closed in layers after a drainage tube was placed.

Histopathologic examinations and *Mycobacterium* cultures were performed on the surgical specimens of each patient.

Postoperative procedure

Typically, the drainage tube was removed once the volume of drainage became less than 30 mL within 24 hours. All patients continued with the HREZ chemotherapy regimen for 12–18 months after surgery. Intravenous antibiotics and nutritional support were administered to prevent infection. Rehabilitation training and physical therapy were provided to all patients as early as possible to help them regain neurological function and prevent thrombosis. With the assistance of a rigid lumbosacral brace, the patients were permitted to walk gradually after strict bed rest for four weeks post-surgery. The external brace was removed when imaging data from the patients revealed formation of a callus. Routine blood and hepatorenal function tests, as well as ESR tests, were performed to monitor the side effects and to evaluate the clinical efficacy of the treatment. Regular re-examinations through outpatient services were conducted every three months in the first year postoperatively, and every six months thereafter. At least five years of follow-up were carried out for each patient to obtain clinical and radiologic data.

Evaluation standards

ESR was measured to indicate the activity level of the TB infection perioperatively and postoperatively. Imaging approaches including radiography, computed tomography (CT), and magnetic resonance imaging (MRI) were used to detect narrowing of the intervertebral space, vertebral body collapse, spinal instability, bone destruction and paravertebral and epidural abscess formation during diagnosis and preoperatively. Routine radiography and CT scans were also carried out postoperatively and at follow-up to assess the placement of instruments and extent of decompression, as well as to classify bone fusion based on the modified radiologic criteria by Lee et al. [12]. The visual analog scale (VAS) score was used to assess pain intensity. The Japanese Orthopedic Association (JOA) score [13] and Oswestry Disability Index (ODI) [14] were used to evaluate neurological function and quality of life in patients, respectively. VAS, JOA and ODI together with lumbosacral angle were measured preoperatively, postoperatively, and at the last follow-up. Finally, the Kirkaldy–Willis criteria [15] was used to determine the functional outcome at the end of the observation period for each patient.

Statistical analysis

Statistical analyses were performed using SPSS version 20.0 (IBM Corp., Armonk, NY). The clinical and radiographic data collected preoperatively, postoperatively and at the final follow-up were compared using a paired t-test. Discrepancies of the normal distribution were evaluated using the rank sum test. A p value < 0.05 was considered statistically significant.

Results

The patient demographic data and disease characteristics are detailed in Table 1. Among the patients who met the inclusion criteria, 24 were male and 14 were female. The mean age at time of surgery was 48.0 ± 13.0 years. All cases presented with TB symptoms such as low back pain, weakness, weight loss and low fever. In addition, 18 cases (47.4%) had radicular pain, 9 cases (23.7%) showed lower limb dysfunction, and 1 patient (2.6%) suffered from cauda equina syndrome. The ESR values were found to be raised at the initial stage before surgery. Histopathologic examinations of surgical specimens from all 38 patients confirmed the presence of tuberculous granuloma or caseous necrosis. Of these, 11 cases showed positive culture for *Mycobacterium tuberculosis*. The average length of the postoperative follow-up was 66.2 ± 4.4 months; all patients had completely resolved their infections at the final follow-up.

Table 1
Patient demographic, disease characteristics and operative information.

Total patients (n)	Gender		Age (years)	Duration of symptoms (months)	Intraoperative blood loss (mL)	Operative time (min)
	Male (n)	Female (n)				
38	24	14	48.0 ± 13.0	4.7 ± 2.5	726.3 ± 151.9	137.6 ± 22.5
Data expressed as mean ± standard deviation.						

The average intraoperative bleeding amount was 726.3 ± 151.9 mL, and the average operative time was 137.6 ± 22.5 minutes (Table 1). The ESR values were 67.9 ± 21.9 mm/h preoperatively, which significantly decreased to 11.8 ± 2.6 mm/h at three months post-surgery ($p < 0.05$).

The VAS score significantly decreased from an average of 6.8 ± 1.1 preoperatively to 0.8 ± 0.7 at the final follow-up ($p < 0.05$). Similarly, scores for neurological function (JOA) and quality of life (ODI) at the last visit showed significant improvement when compared with preoperative scores ($p < 0.05$). At the end of the follow-up period, patients' functional outcome was assessed using the Kirkaldy–Willis criteria; 21 cases reported excellent results, 16 cases reported good results, and 1 case reported fair result. There were no reports of poor outcomes (Table 2).

Table 2
Clinical evaluation indices for preoperative and postoperative follow-ups.

ESR (mm/h)			JOA		VAS		ODI		Kirkaldy-Willis criteria			
Pre	TMP	FFU	Pre	FFU	Pre	FFU	Pre	FFU	Excellent	Good	Fair	Poor
67.9 ± 21.9	11.8 ± 2.6*	7.6 ± 2.1*	18.5 ± 2.9	26.9 ± 1.1*	7.2 ± 0.9	0.8 ± 0.7*	44.3 ± 6.7	9.3 ± 1.9*	21	16	1	0
* Analyzed by paired t test, compared with preoperative value, $p < 0.05$. Data expressed as mean ± standard deviation.												
Abbreviations: Pre, preoperative; TMP, three months postoperative; FFU, final follow-up; ESR, erythrocyte sedimentation rate; JOA, Japanese Orthopedic Association score; VAS, visual analog scale; ODI, Oswestry Disability Index.												

The lumbosacral angle significantly increased from the preoperative average of 21.7° ± 1.8° to an average of 26.4° ± 1.4°, postoperatively. At the last visit, the lumbosacral angle was an average of 32.8° ± 3.6°, with a correction loss of only 1.2° ± 0.7°. There was no statistically significant difference between the lumbosacral angle measurements made immediately post-surgery and at the last follow-up. Spontaneous intervertebral bone fusion was achieved at 12.8 ± 1.9 months after surgery (Table 3). Nonunion, pseudoarthrosis, loosening or fracture of instruments had not occurred at the time of the final follow-up (Figs. 1 and 2).

Table 3
Radiographic outcomes of preoperative and postoperative follow-ups.

Lumbosacral angle				Correction rate (%)	Fusion time (months)
Pre	Post	FFU	Lost		
21.7° ± 1.8°	26.4° ± 1.4°*	25.3° ± 1.3°*	1.2° ± 0.7°	22.3 ± 6.2	12.8 ± 1.9
* Analyzed by paired t-test, compared with preoperative values, p < 0.05. Data expressed as mean ± standard deviation.					
Abbreviations: Pre, preoperative; Post, postoperative; andFFU, final follow up.					

None of the patients died or suffered permanent neurological damage. Two cases experienced superficial incisional infection, which was successfully controlled with antibiotics. Anti-TB drug-induced liver dysfunction occurred in a single patient, and was subsequently managed using modified chemotherapy combined with hepatic protection treatment.

Discussion

The lumbosacral spine is at the junction of a lordotic motion segment and a kyphotic fixed end, an area where the stress of the entire torso is concentrated. The intact facet joints and intervertebral discs of the lumbosacral segment are the main structures that resist the shear force of the L5 vertebral body forward. Hence, spondylolisthesis of the lumbosacral region can easily bring about force imbalance, such that firm internal fixations are usually required. Lumbosacral TB is relatively rare, and has an insidious onset and atypical symptoms. Individuals with the condition often report nonspecific symptoms, which are easily mistaken for spinal degenerative disease at the initial stage [16]. As the disease progresses, *M. tuberculosis* erodes the vertebrae to the point of sequestrum and abscess formation, leading to spinal instability or deformity. Additionally, nerve compression from TB lesions that invades the spinal canal potentially cause radicular pain, and even acute paralysis, which has deleterious effects on the patient's overall quality of life [17].

Standard systemic anti-TB chemotherapy remains the basic strategy throughout the entire treatment period [18, 19]. In our study, normative anti-TB treatments were carried out on all patients for two weeks preoperatively and for 12–18 months postoperatively. Common indications for surgery in lumbosacral junction TB are ineffective conservative measures, persistent pain unrelieved by chemotherapy, progressive neurological deficits, relatively massive cold abscesses, and extensive vertebrae destruction with instability or deformity. The surgery is specifically carried out with the goal of removing the lesion, relieving nerve compression and rebuilding spinal stability, all of which aid the maintenance of normal lumbar lordosis and sacral kyphosis. This also ensures that the normal physiological line of force transduction is preserved. For patients who require surgery, the key techniques for surgical treatment of spinal TB include complete debridement, adequate bone grafting and firm internal fixation.

The surgical method for the treatment of TB in the lumbosacral junction is still controversial [20–22]. An anterior approach has been conventionally preferred since most TB lesions involve the vertebral body and intervertebral discs. The anterior approach allows for direct access where thorough debridement of the affected tissue and intervertebral reconstruction can be performed [23, 24]. Nevertheless, the anterior approach is associated with anteriorly related complications. In particular, the lumbosacral region is an area with complex local anatomical structures and is adjacent to numerous vital organs, including major blood vessels, nerve plexi, and ureters [22]. Tribus et al. [25] reported that the distance from the bifurcation of iliac vessels to the top of the L5-S1 disc averaged 18 mm, and the average space available between the left common iliac vein and the right common iliac artery is 33.5 mm, a result they surmised from studying 37 human cadavers. This means that it is too risky to perform the surgery via the anterior approach, due to the close proximity of the vasculatures that this approach exposes. In addition, anterior instruments may be inadequate since the presence of the TB infection is associated with osteoporosis that renders the vertebrae increasingly fragile, thereby potentially causing graft failure and loss of correction after surgery [26]. These existing objective factors pose significant challenges to anterior fixation of the

lumbosacral segment, while carrying the risk of damage to major neurovascular structures. Some surgeons report that anterior debridement combined with posterior instrumentation in the management of lumbosacral TB can obtain favorable clinical efficacy [27, 28]. This approach overcomes the stability-related shortcoming when the anterior approach is used alone and encompasses a broader surgical vision and higher bone graft fusion rate. However, it also results in superimposed surgical trauma and increased complications. Taking the above factors into account, we favor the posterior approach for treating lumbosacral junction TB when surgery is indicated.

With the widespread application of pedicle screw-rod internal fixation systems, the satisfactory safety and clinical efficacy of the posterior-only approach for the treatment of lumbosacral TB has increasingly attracted the attention of orthopedic surgeons for many reasons [7, 17, 26, 29, 30]. Firstly, the posterior approach is less invasive and avoids damage to vital nerves and blood vessels. In addition, pedicle screws provide better holding force, and are thus superior to the anterior approach in correcting severe kyphosis. Zeng et al. [7] successfully treated 15 cases of lumbosacral TB with paraspinal abscess using the posterior approach. Similarly, Xu et al. [17] also reported that kyphotic deformity significantly improved with complete recovery of neurological function by interbody fusion and posterior lumbopelvic fixation for lumbosacral TB. In this study, all 38 cases showed complete resolution from TB infection by the last follow-up. The patients who suffered preoperative neurological deficit had satisfactory recovery at the final follow-up. In terms of spinal stability, over the five years of the observation period, patients presented an average loss of the correction angle of only $1.2^{\circ} \pm 0.7^{\circ}$ with a $22.3\% \pm 6.2\%$ correction rate after surgery. Pain intensity as measured by VAS dropped by over 80%, while at the last follow-up, 21 patients (55.3%) reported excellent status, and 16 patients (42.1%) reported good status based on Kirkaldy-Willis criteria.

The surgical treatment of lumbosacral TB should follow an individualized protocol. A routine CT scan and MRI examination are essential before surgery to map out the details of the lesion. When the S1 vertebral body is severely damaged, the use of sacral pedicle screws cannot obtain sufficient bony support. The physiological force transmission line in the lumbosacral region is subsequently affected, which brings challenges to surgical reconstruction. The sacrum forms the posterior wall of the pelvis and is connected to the ilium through the sacroiliac joints. Physiologically, gravitational force is transmitted from the lumbosacral joint to the upper part of the sacrum, and then to the pelvis through the bilateral sacroiliac joints. Due to the special role it plays in pressure bearing and force transduction, the sacrum is considered the keystone of the pelvic ring [31]. For cases when S1 is severely damaged, lumbopelvic fixation can effectively relieve the stress on the diseased vertebra and promote its healing. In addition, iliac screw fixation can immediately stabilize the lesion and restore the normal lumbosacral angle [32]. For patients with an S1 vertebral body lesion that is not serious and with an intact pedicle channel, sacral pedicle screw fixation can effectively reconstruct local stability and cross spinopelvic fixation can be avoided.

M. tuberculosis tends to infect the anterior and middle column of the spine. The controversy with regard to surgical treatment of lumbosacral TB with the posterior approach mainly centers around whether this approach can allow for complete debridement given its limited field of view. Indeed, the posterior approach offers no advantage in lesion clearance. Nonetheless, resection of both sides of the lamina and facet joints, and moderate stretching of the dura mater and nerve roots can provide enough operating space for the removal of the lesion. Then, through intraoperative pressure washing, negative pressure suction and postoperative postural drainage, the sequestrum, necrotic tissue and most abscesses can be removed. The remaining small areas of infection can be resolved by standardized anti-TB chemotherapy after surgery [33]. Some surgeons are concerned that this surgical method destroys the posterior column and may cause spinal instability. However, pedicle screws, which allow for three-column fixation, can effectively restore the normal physiological curvature of the spine, and overcome the instability caused by column damage within a short time period. Sufficient intervertebral and transverse bone grafting provide long-term bone support for spine stability [34]. During the postoperative follow-up of this study, there were no cases of TB recurrence from incomplete lesion removal. In terms of structural recovery, all patients achieved satisfactory bone fusion at an average of 12.8 ± 1.9 months after surgery without a single incidence of instrument failure.

This study has some limitations. Firstly, this is a retrospective study, which may lead to biased results. Furthermore, this study is a single-center study with a relatively small sample size. Prospective studies with larger sample sizes are required to confirm the findings, although given the rarity of this condition, it may take considerable time and coordination for such studies to take place.

Conclusion

For patients with lumbosacral junction TB where anti-TB chemotherapy is ineffective, or with worsening neurological deficits and pain, one-stage posterior debridement, interbody fusion, lumbosacral or lumbopelvic fixation, and postural drainage, according to the severity of sacral destruction, is a relatively less traumatic and highly safe procedure. It can lead to reconstruction of lumbosacral or lumbopelvic stability, while facilitating healing from TB-related inflammation.

Abbreviations

CT: Computed tomography; ESR: Erythrocyte sedimentation rate; JOA: Japanese Orthopaedic Association; MRI: Magnetic resonance imaging; ODI: Oswestry Disability index; TB: Tuberculosis; VAS: Visual analog scale

Declarations

Acknowledgements

Not applicable.

Authors' contributions

ZC Xu and Z Z participated in the design of this study, performed statistical analysis, and drafted the manuscript. YL Z and YQ W collected the clinical data and follow-up details of the study and conducted the study. XY W directed the study design and manuscript drafting. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets and materials generated or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study protocol was approved by the Ethics Committee of Xiangya Hospital and the written informed consent was obtained from all patients.

Consent for publication

All patients signed informed consent forms to publish their personal details in this article.

Competing interests

The authors declare that they have no competing interests.

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Figures

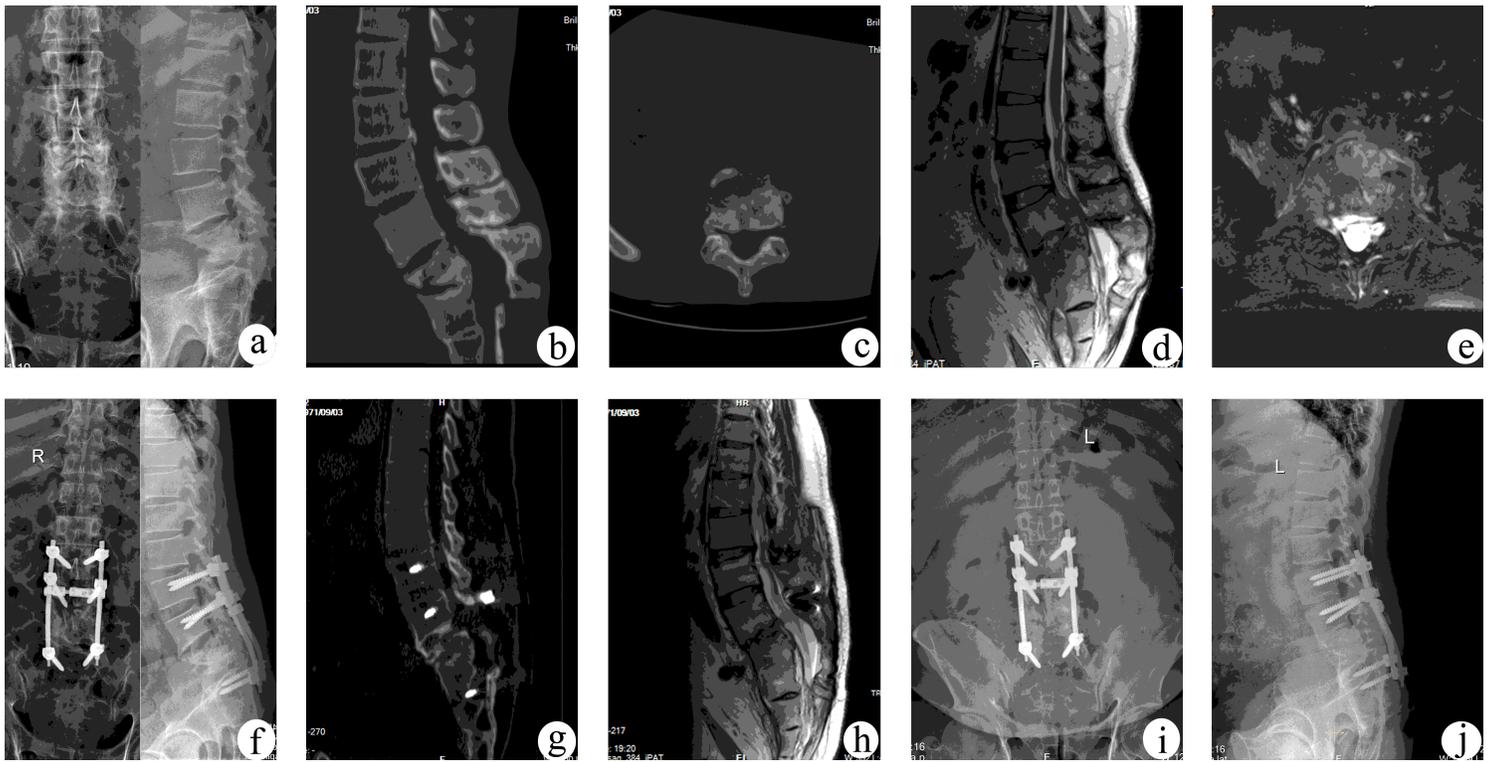


Figure 1

A 39-year-old male with L5/S1 TB underwent one-stage posterior debridement, interbody fusion, and lumbosacral fixation. (a) Anterior and lateral radiographs of the lumbar spine showing the affected vertebrae with a lumbosacral angle of 22°. (b-e) Preoperative CT and MRI demonstrating that the L5 vertebral body was severely damaged and collapsed, with cold abscess formation in the spinal canal. (f) Postoperative X-ray showing good internal fixation position with a lumbosacral angle of 28°. (g-h) Postoperative CT and MRI showing satisfactory bone fusion at 15 months and an unobstructed spinal canal. (i-j) X-ray displaying solid bone fusion and no displacement of instruments, with the correction loss of 1° throughout 63 months of follow-up. Abbreviations: TB, tuberculosis; CT, computed tomography; MRI, magnetic resonance imaging.

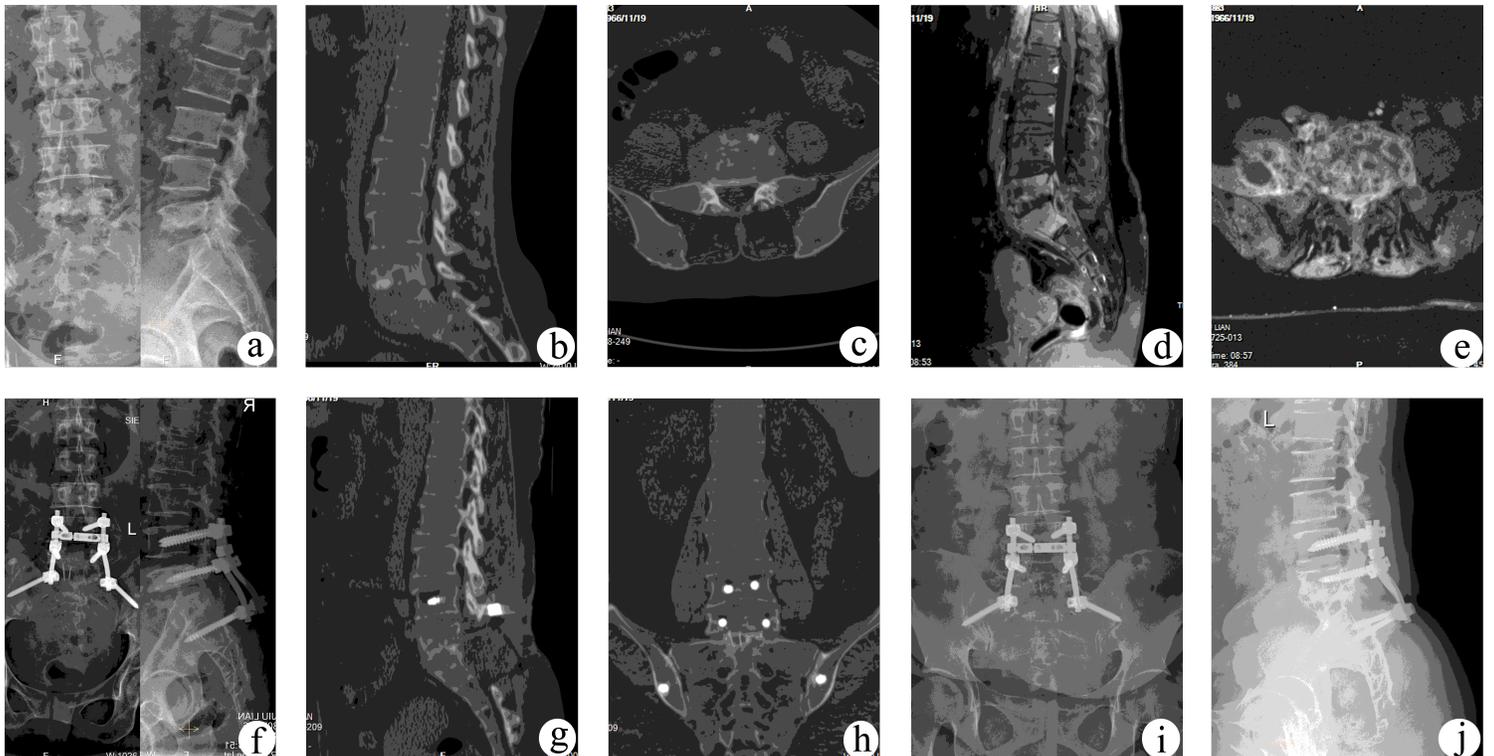


Figure 2

A 52-year-old female with L5/S1 TB underwent one-stage posterior debridement, interbody fusion, and lumbopelvic fixation. (a-e) Preoperative images showing that the TB lesion was located at L5/S1 and the lesion involved vertebral body destruction (the pedicle of S1 was also affected) and abscess formation. The lumbosacral angle was 23°. (f) Postoperative radiograph depicting correction of the deformity and the lumbosacral angle at 28°. (g-h) CT showing solid bone fusion was achieved at 15 months. (i-j) X-ray displaying the instruments in the correct a position, with a lumbosacral angle of 27° at the follow-up period of 60 months. Abbreviations: TB, tuberculosis; CT, computed tomography.