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Outcome of Transpedicular Decompression and Interbody Fusion with Posterior Spinal Fixation in Thoracolumbar Spinal Tuberculosis: A Prospective Study

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Abstract

Background: Spinal tuberculosis (STB) often causes neurological deficits, kyphosis, or paraplegia. Anti-tubercular therapy is it's mainstay of treatment modality and surgery is indicated for neurological deficits, abscess, or instability. This study evaluated the efficacy and safety of transpedicular decompression, fusion, and instrumentation for thoracic/lumbar tuberculosis.

Methods: A prospective observational study was conducted in Bangabandhu Seikh Mujib Medical University, Dhaka, with a study period of 2.5 years. Twenty-seven patients meeting selection criteria were included. Pain, neurology, and function were assessed pre-operatively and at three weeks, three months, six months, and 12 months postoperatively.

Results: Patient had a mean age of 43 ±17.47 years, with a male predominance (M: F ratio 1.5:1). Forty percent were from low-socioeconomic backgrounds. Neurological and functional improvement was statistically significant in 24 patients (96%). At the final 12-month follow-up, 88% achieved an excellent functional outcome; one patient had poor results without improvement. Complications included one case each of CSF leakage, postoperative hemorrhage, and surgical site infection.

Conclusion: The study demonstrates that posterior transpedicular decompression with interbody fusion and instrumentation is a safe and effective treatment for thoracic and lumbar tuberculosis in Low-middle income countries (LMICs). It results in significant neurological recovery, substantial pain relief, and excellent functional outcomes in the majority of patients, with a low rate of postoperative complications.

Keywords: Low-middle income countries, Posterior stabilization, Spinal fusion, Spinal tuberculosis, Transpedicular decompression

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Introduction

Tuberculosis (TB) is persistently burdensome in developing nations and remains a global health priority. Spinal tuberculosis (STB) is the most frequent extra-pulmonary manifestation.[1] This insidious infection often leads to devastating neurological deficits, kyphotic deformities, and instability, necessitating surgical intervention alongside chemotherapy in advanced cases.[2,3] The optimal surgical strategy, particularly for thoracolumbar involvement, is continually refined. Recent evidence strongly supports single-stage posterior-only approaches as effective and safe.[4,5] Specifically, transpedicular decompression combined with interbody fusion and posterior instrumentation offers significant advantages: thorough debridement, direct neural decompression, robust stabilization, and improved kyphosis correction while minimizing morbidity.[4-7] STB is more prevalent in Low-Middle income countries (LMICs); therefore, evaluating it in resource-limited settings provides a more comprehensive assessment. This study evaluates the outcomes of this integrated technique in LMICs.

Methods

A prospective observational study was conducted in Bangabandhu Seikh Mujib Medical University, Dhaka through the Department of Orthopedics for 2.5 years, where 27 patients with spinal tuberculosis with or without paraplegia requiring surgical treatment meeting the inclusion criteria were enrolled in the study. The purposive sampling technique was used, where patients meeting the selection criteria were enrolled during the study period and subsequently followed up for 12 months. The selection criteria are based on similar studies.[3,4,8,9,10]

Inclusion criteria were: spinal TB with paraplegia or paraparesis, spinal TB that failed to improve with conservative treatment, progressive neurological impairment, kyphotic angle <30 degrees, progressive spinal deformity, and persisting back pain attributed to spinal instability. Exclusion criteria were multi-segment (>1 Functional Segment Unit [FSU]) involvement with severe destruction of vertebral bodies, STB with skip lesion, and previous thoracic or lumbar surgery.

Sample size (n): The estimated population was calculated by using the following statistical formula:

$n = z^2 [(SD1)^2 + (SD2)^2]/d^2$

Here, n = Sample size

SD = Standard Deviation

z = 1.96 with 5% level of significance and a 95% Confidence Interval

SD1 = SD of VAS score from previous study[12] = 1.2

SD2 = SD of VAS score from previous study[12] = 0.9

d = (Difference in two means x10%)= (7.1 -1.1) x 10%= 0.6

$n = 1.96^2 [(1.2)^2 + (0.9)^2] / (0.6)^2 = 24$

Considering a 10% dropout, our final sample size was kept at 27.

Purposive Sampling technique is used where all the cases of spinal tuberculosis at the outpatient department are evaluated by the expert or the researcher, and those meeting the selection criteria by purposive sampling are included in the study.

The ethical clearance was taken from the institutional review board with reference no BSMMU/2018/11637. All patients participated voluntarily after providing informed consent, with no future obligations imposed.

Surgical Technique

After induction of general anesthesia, the patients were placed in the prone position on the spinal table. A standard midline incision was performed after confirmation of the involved level through fluoroscopy guidance, and the posterior elements were exposed subperiosteally. Pedicle screws were inserted using standard landmarks and techniques. The two superior and two inferior healthy vertebrae were embedded into the pedicle screw to ensure rigid spinal stability. A pre-bent rod was temporarily fixed on one side where the lesion was comparatively mild to avoid spinal cord injury during contralateral focal debridement. Transpedicular decompression was performed on the more severely affected side as shown in Figure 1.[11] Through the transpedicular space, granulation tissue, caseous necrosis, sequestra, abscess, necrotic discs, and endplates were radically debrided. When necessary, the thoracic nerve roots on the focal segment were resected for better exposure and debridement. After washing with povidone-iodine and a large quantity of saline, an appropriate irrigation tube was inserted into the deep part of the lesion, and the pus and necrotic tissue were drained as thoroughly as possible. Then, a temporary pre-bent rod was stabilized on the contralateral side. The temporary pre-bent rod is brought slightly anteriorly and secured under controlled tension so the anterior column and spinal cord are protected. This prevents collapse or sudden translation of the vertebral column during aggressive debridement.

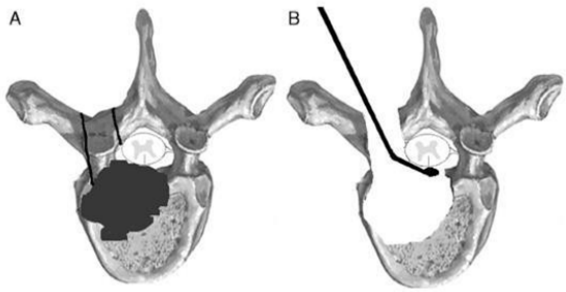

Figure 1 A. Axial section of diseased vertebrae with marked area for removal;
B. After decompression[11]

The same process was performed on the opposite side of the lesion. Compression techniques achieved interbody fusion, and an allograft was used in cases of severe vertebral body destruction. Before tightening the contoured rods, the kyphosis and scoliosis were gradually and carefully corrected with the help of the compression and stretch of the internal fixation instrument. Cross-links were applied in all patients to improve the stability of posterior spinal constructs. Before closing the wound, a local drainage tube was placed. The debrided material from each patient was sent for histopathologic examination.

Five sets of data for each were collected, compiled, and tabulated according to key variables at preoperative, three weeks, three months, six months, and 12 months using a predefined proforma by the principal investigator. The outcome of the intervention was evaluated by kyphotic angle measurement, degree of correction, functional assessment (Frankel grading for neurological assessment; VAS for pain[12]; Kirkaldy-Willis criteria for recovery[13]), vertebral fusion at 12 months was assessed using Bridwell criteria[14], and post-operative complications were recorded. The analysis of different variables was done according to standard statistical analysis. Qualitative data were expressed as frequency & percentage, and quantitative data were expressed as mean & standard deviation. VAS score was analyzed by student paired t-test or Mann-Whitney U test, and Frankel grading and Kirkaldy-Willis criteria by chi-square test. Data was processed and analyzed using software 'Statistical Package for Social Science' version 20. All personal identifiers were anonymized. For all analyses level of significance was set at 0.05, and a p-value <0.05 was considered significant.

Results

The outcome was evaluated based on pain, neurological status, deformity, functional recovery, and complications of the procedure. A total of 27 patients were enrolled in the study, but two patients were lost in follow-up and dropped out. So, a total of 25 cases were included in this study analysis with a mean follow-up of 12 months. The mean age was 43.84 ±17.47 years (Range: 22 -72 years). The male-to-female ratio was 1.5:1. Most of the patients were Farmers/manual laborers (40%), followed by sedentary workers (28%), household workers (6%), and students (8%). 20 cases (80%) were thoracic tuberculosis and the lower thoracic region were most common with 12 cases (48%). There were five cases where the lumbar vertebra was involved, which is 20% and details description given in Table 1.

Mean preoperative kyphotic angle was 18.44 ±4.18° and mean postoperative kyphotic angle was 8.72 ±2.76°, with a degree of correction of 10.04 ±3.27°. At 12-month follow-up, the loss of correction was 1.68 ±0.62°. The difference in the mean of pre-operative and post-operative kyphotic angle was statistically significant (p-value <0.001). Table 2 shows the preoperative and postoperative neurological status of the patients according to Frankel grading. All the patients showed neurological recovery except one case (4%), who had Frankel A neurological status. At final follow-up, 18 patients (72%) showed full recovery, whereas 16% had Frankel D neurological status. Comparing preoperative Frankel grade with 12-month Frankel grade, improvement in neurological grade was statistically significant with a p-value <0.001. One case with the poorest neurology of Frankel grade A did not improve at 12 months. The rest of the patients all recovered neurologically, which was statistically significant. The mean pre-op VAS was 7.52 ±1.50, which significantly decreased to 2.44 ±0.76 at 12-month follow-up. The difference in the mean of the VAS score between the preoperative and postoperative periods is statistically significant. There were very few major postoperative complications. Two cases (8%) developed postoperative complications. One patient (4%) had postoperative hemorrhage, which later developed into superficial infection and recovered with regular dressings. Another patient had a dural tear intraoperatively, which was repaired primarily, but later developed CSF leakage. The same patient's neurological condition also did not improve, and later developed a bedsore. This patient later had re-surgery, and complications were managed subsequently, and CSF leakage stopped after re-surgery. There were no cases of implant failure until 12 months follow-up however, longer follow-up would be required to evaluate longevity of fixation. Vertebral fusion grades according to Bridwell criteria at 12-month follow-up. One case (4%) achieved grade I fusion, 23 cases (92%) achieved grade II fusion, and one case achieved grade III fusion. All cases achieved fusion by 12-month follow-up. Table 3 shows functional status after surgery graded excellent, good, fair, and poor. Overall, 88% had excellent functional outcome at 12 months follow-up, 8% had a fair outcome and one patient (4%) did not improve after surgery. The improvement in functional outcome measured by Kirkaldy-Willis criteria show excellent improvement, which is statistically significant.

Table 1: Region of involvement in patients. (N=25)

Region	Frequency	Percentage
Upper Thoracic (D1-D4)	5	20%
Middle Thoracic (D5-D8)	3	12%
Lower Thoracic (D9-D12)	12	48%
Lumbar (L1-L5)	5	20%
Total	**25**	**100%**

Discussion

Spinal tuberculosis remains a significant health burden in resource-limited settings, where delayed

Table 2: Preoperative and Postoperative neurological status of the patients according to Frankel grading (N=25)

Grade	Preoperative	3 weeks	3 months	6 months	12 months
A	1 (4%)	1 (4%)	1 (4%)	1 (4%)	1 (4%)
B	5 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
C	5 (20%)	2 (8%)	2 (8%)	2 (8%)	2 (8%)
D	12 (48%)	5 (20%)	5 (20%)	4 (16%)	4 (16%)
E	2 (8%)	17 (68%)	17 (68%)	18 (72%)	18 (72%)

Table 3: Functional Status according to Kirkaldy-Willis criteria at different follow ups (N=25)

Grading	Postoperative			
	3 weeks	3 months	6 months	12 months
Excellent	2 (8%)	2 (8%)	21 (84%)	22 (88%)
Good	20 (80%)	20 (80%)	1 (4%)	0
Fair	2 (8%)	2 (8%)	2(8%)	2 (8%)
Poor	1 (4%)	1 (4%)	1 (4%)	1 (4%)
p-value	0.001[s]	0.001[s]	0.001[s]	0.001[s]

Chi-square test was used for statistical analysis. [s]*= statistically significant.*

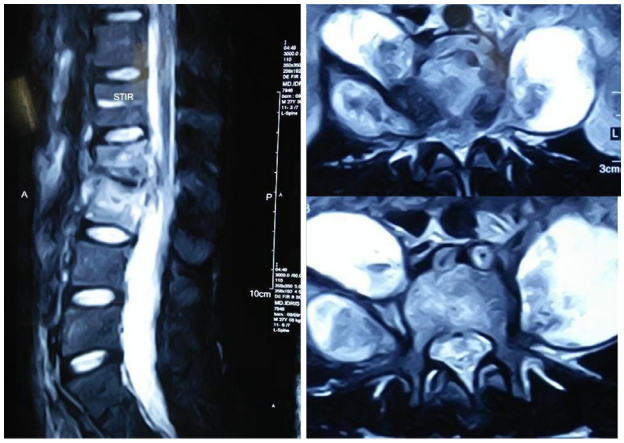

Figure 2 MRI of spine sagittal and axial views showing vertebral collapse and cord compression

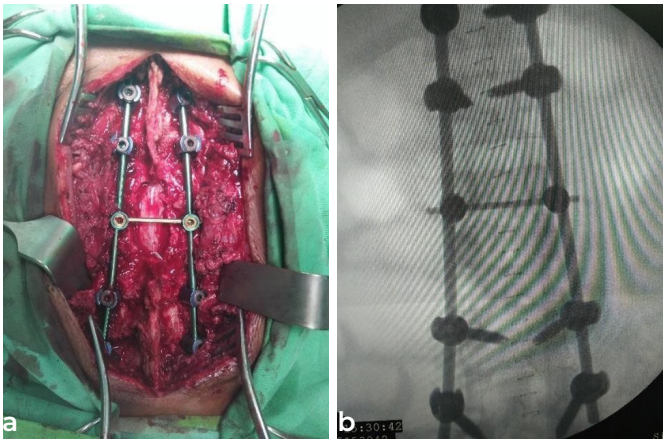

Figure 3 (a) Intraoperative picture (b) fluoroscopy showing pedicle screw, rods and decompressed segment

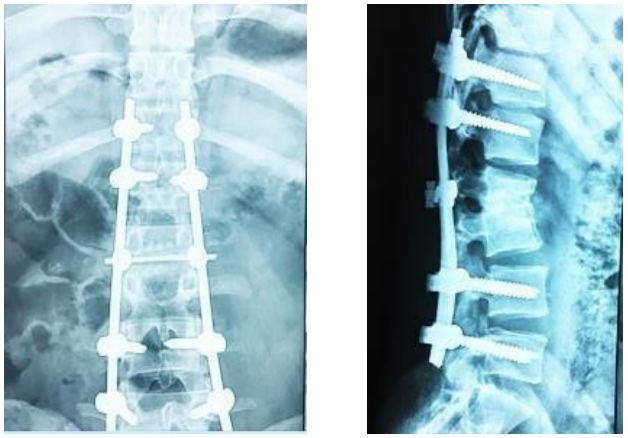

Figure 4 X-rays at 12-month follow-up showing anterior vertebral body fusion. (AP and Lateral views)

Figure 5 Three week follow-up images of the patient with spinal brace

diagnosis often leads to severe neurological deficits and kyphotic deformities. While anti-tubercular chemotherapy (ATT) is the basis for medical therapy against tubercular infection, advanced imaging such as Magnetic Resonance Imaging (MRI) and Computed Tomography scan (CT) now enables earlier detection and intervention. The MRI image of one of the patients is shown in Figure 2, where a paradiscal lesion in the lumbar vertebra with cord compression can be appreciated.

Our study reinforces that posterior transpedicular decompression with instrumentation is a viable, single-stage solution for thoracolumbar spinal TB, particularly in regions with constrained healthcare resources.

As shown in the image (Figure 3), a surgical dissection was performed where the spinous process and adjoining ligaments could not be preserved due to a degenerative spine and pathological involvement. This also shows an intraoperative construct with a fluoroscopy image, where two healthy vertebrae were incorporated above and below the lesion. In this case, we did not include the pedicle from the involved segment, which might be possible in some cases where short-segment fixation would be possible.

Demographic and Socioeconomic Context

Consistent with global patterns, our cohort (mean age 43.8 years) reflected spinal TB's predominance in economically active adults. Similar age distributions were reported in Bangladesh[15] and China[3]. Notably, 60% of patients were male, a trend echoed in Nigerian[16], Indian[11], and other Bangladeshi studies.[15,17] Occupational data revealed high representation of manual laborers (40%) and low-income groups (66%), underscoring links between spinal TB, physically demanding work, and socioeconomic disadvantage. This aligns with Gupta et al., where 44% of patients were laborers, and highlights the critical need for accessible surgical care in LMICs.[18]

Surgical Efficacy: Kyphosis Correction and Neurological Recovery

Our results demonstrate significant deformity correction: preoperative kyphosis (18.4 ±4.0°) improved to 8.7 ±3.1° postoperatively ($p < 0.001$), with minimal correction loss (1.7 ±0.6°) at 12-month follow-up. This parallels Sahoo et al. and reinforces posterior instrumentation's superiority in kyphosis management over anterior approaches.[11,19,20] Recent meta-analyses confirm posterior techniques achieve 8–12° correction with better stability.[21]

Neurological outcomes were equally promising: 96% (24/25) of patients improved, with 72% achieving Frankel Grade E (normal function). This exceeds Lee's (1999) 83% improvement rate and aligns with Li et al., who reported 89–94% neurological recovery in posterior only surgeries.[9,22] The lone non-responder (Frankel A) had intraoperative CSF leakage, a reminder that severe preoperative deficits pose higher risks.

Pain, Function, and Fusion

Most cases reported substantial pain relief: VAS scores dropped from 7.5 ±1.5 to 2.4 ±0.8 ($p < 0.001$), consistent with Zhang et al., and Sahoo et al.[3,11] Functionally, 88% achieved excellent outcomes (Kirkaldy-Willis criteria), supporting posterior surgery in rapid rehabilitation. Fusion success was high: 92% achieved Bridwell Grade II fusion by 12 months, comparable to rates in Islam et al. (2017) and Yu et al. (2016).[17,23] Recent advances like BMP-2-augmented grafts may further accelerate fusion in TB cases.[24] Figure 4 shows a 12-month follow-up of the above-discussed case, where interbody Grade I fusion can be appreciated. The use of allografts in the advanced destruction of segments can provide shorter operative time, less donor site morbidity, and could achieve a similar response as an autologous graft. However, this study has different objectives; this can be studied separately and may have future implications and support the need for the establishment of bone banks at resource limited countries where such devastating bony lesions are more profound, especially in cases presenting at later stages of disease progression.

Safety and Complications

Complications occurred in only 8% (2/25): one CSF leak (attributed to dural adhesion to necrotic tissue) and one surgical site infection. Both were resolved with intervention. This low rate mirrors Garg et al., and Ma et al., who noted fewer complications with posterior versus anterior approaches.[19,25] Recent studies attribute this to reduced soft-tissue disruption and biomechanical stability of transpedicular constructs.[22,26,27] Figure 5 shows a patient with a spinal brace at three weeks post-operatively, and all patients underwent rehabilitation with braces for three to six weeks. Since the study is a single-center study, the rehabilitation protocols were the same in all cases.

Implications for LMICs

In Bangladesh, an LMIC with a high TB burden; single-stage posterior surgery offers practical advantages: shorter operative time, reduced transfusion needs, and earlier mobilization. This is critical where hospital beds and rehabilitation resources are limited. As LMICs like Bangladesh and Nepal are also transitioning toward universal health coverage (UHC), such cost-effective techniques align with the WHO surgical system strengthening goals.[1] Future efforts should integrate percutaneous instrumentation to minimize tissue damage and optimize ATT regimens for drug-resistant TB. Although resources and proper rehabilitation facilities are challenging in LMICs, patients enrolled in studies used braces for three to six weeks, and Figure 4 shows an elderly gentleman

at three weeks follow-up, along with a spinal brace after surgery.

Limitations

Our study has limitations: a small single-center cohort, short follow-up, and inclusion of both thoracic/lumbar TB. Larger multi-center trials with longer follow-up are needed to assess implant longevity and MDR-TB challenges.

Conclusions

This prospective study demonstrates that single-stage posterior transpedicular decompression with interbody fusion and instrumentation is a highly effective treatment for thoracolumbar spinal tuberculosis in resource-constrained settings. Significant improvements were observed across all outcome domains: neurological recovery, pain reduction, functional restoration, and deformity correction. Robust fusion (92% Bridwell Grade II) and low complication rates (8%) further validate this approach. Given its procedural efficiency, reproducibility, and minimal infrastructure requirements, this technique represents a recommended surgical strategy for spinal TB in LMICs, where disease burden intersects with systemic healthcare challenges.

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